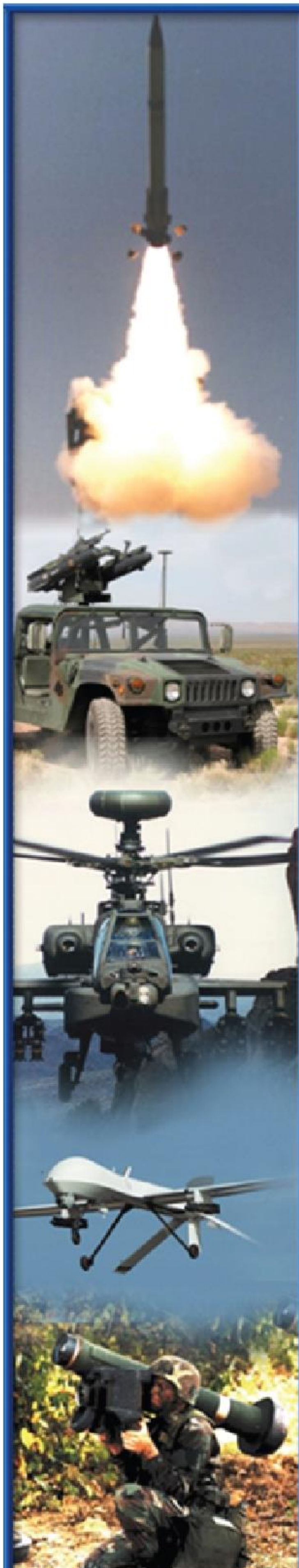

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EVALUATION OF AERONAUTICAL DESIGN STANDARD – 33 USING A UH-60A BLACK HAWK

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December 2018

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13. ABSTRACT *(Maximum 200 Words)*
A flight test assessment of Aeronautical Design Standard–33 (ADS-33D-PRF) was conducted using a UH-60A Black Hawk helicopter. Eighty hours of flight tests were performed to assess the required compliance testing and evaluate the rotorcraft handling qualities criteria in ADS-33D-PRF in a good visual environment. Quantitative tests were performed for two aircraft loading configurations at hover and at forward flight. Formal handling qualities evaluations were conducted in three aircraft configurations, including that with an external slung load. Comparisons of predicted (quantitative) and assigned (qualitative) handling qualities are discussed. Lessons learned are given and recommendations are provided for future flight testing. Future areas of investigation and proposed updates to ADS-33 are discussed.

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Preface

This report documents a flight test assessment of Aeronautical Design Standard–33 (ADS-33D-PRF) using a UH-60A Black Hawk helicopter. The flight test was conducted in 1999 at Moffett Field, CA. There were many important lessons learned, and most of these that impacted the Quantitative and Qualitative criteria were included in the ADS-33 update (ADS-33E-PRF). However, there were other significant lessons learned that were not incorporated in the update or were not directly applicable, such as flight test technique recommendations, or comparisons between the Quantitative and Qualitative results. These important lessons learned and insights are still relevant and should be distributed; hence, the publication of this report.

Many of the organizations supporting the flight test in 1999 have changed names, or no longer exist. For example, the Aeroflightdynamics Directorate (AFDD) is now the Aviation Development Directorate – Ames; the Flight Control and Cockpit Integration Branch and the Army-NASA Rotorcraft Division no longer exist. However, to give credit to those who supported and contributed to the overall effort, their organizational names remain in this report. Also, Mr. David Arterburn was a Major in the Army when the flight test was conducted; he is now retired from the Army and is Director of the Rotorcraft Systems Engineering and Simulation Center at the University of Alabama in Huntsville (UAH).

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November 2018

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Contents

1 Introduction

1.1 Background

In 1982, the U.S. Army Aeroflightdynamics Directorate (AFDD), then assigned under the U.S. Army Aviation Systems Command (AVSCOM), began development of a new handling qualities specification for military rotorcraft. This development effort resulted in the U.S. Army's initial Aeronautical Design Standard–33 (ADS-33A), "Handling Qualities Requirements for Military Rotorcraft," published in May 1987 (ref. 1). It was initially applied to the RAH-66 Comanche Helicopter program and, therefore, the handling qualities requirements generally related more to scout and attack classes of rotorcraft. As more data became available and lessons learned emerged from using ADS-33A, refinements were implemented into ADS-33B (ref. 2) and ADS-33C (ref. 3). In 1990, ADS-33C was assessed using an AH-64A Apache by the U.S. Army's Airworthiness Qualification Test Directorate (AQTD) at Edwards Air Force Base, California. Testing was performed during the day and at night in the Degraded Visual Environment (DVE). The results of the test (ref. 4) included comments on the performance standards and test techniques and had a major impact in the development of the next version of the specification, ADS-33D (ref. 5). In addition, there were other flight test assessments that made significant contributions to ADS-33D (refs. 6 and 7).

ADS-33D incorporated significant improvements to the flight test maneuvers in Section 4 along with a few improvements to the quantitative requirements in Section 3. However, this version was still focused primarily on scout and attack rotorcraft, and hence did not provide sufficient performance standards to evaluate the full spectrum of Army missions and aircraft. Consequently, AFDD began working to broaden ADS-33D into a specification capable of providing helicopter handling quality standards suitable for a range of missions and rotorcraft classes. This has included ground-based simulations and flight tests to develop criteria that are applicable to cargo helicopters, with and without external slung loads. In 1994–95, AQTD conducted an assessment of ADS-33 using a CH-47D Chinook helicopter (refs. 8 and 9). These tests were planned and initiated using ADS-33C; later in the testing, ADS-33D was introduced. Tests were conducted with and without an external slung load in the day and at night in the DVE with night vision goggles. The results suggested over a dozen cargo helicopter flight test maneuvers, or Mission Task Elements (MTEs), for incorporation into the next update of ADS-33D. In another flight test assessment of ADS-33D, a very comprehensive evaluation using a BO 105 (ref. 10) provided many recommendations and a detailed comparison between the quantitative and qualitative results.

In 1996, the U.S. Army Aviation and Troop Command found ADS-33D met the definition of a performance specification, and issued a new designation, ADS-33D-PRF (ref. 11). Other than the re-designation, no updates or changes were made. (As many paragraphs in reference 11 are referred to throughout this report, reference 11 is contained in Appendix B.) Subsequently, AFDD expanded their handling qualities flight research work to include utility helicopters, so the next version (ADS-33E-PRF) would incorporate criteria for the Utility class of helicopter (with and without external slung loads) in addition to the criteria previously established for Scout, Attack, and Cargo classes of rotorcraft. To better understand the applicability and compliance testing issues of applying ADS-33D-PRF to utility helicopters, a flight test assessment was planned and conducted with a UH-60A Black Hawk; this report presents the results from this 80-hour flight test effort. Initial results were reported in reference 12. The results presented herein also aid in understanding the UH-60A handling qualities and may help define the handling quality standards by which future utility helicopters are evaluated. It should be noted that ADS-33 was not in effect at the time of the development of the specifications and contract for the UH-60A Black Hawk aircraft, and therefore was not a contractual requirement for the UH-60A.

1.2 Test Objectives

The specific objectives of this flight test were: a) to assess the required compliance testing and evaluate the criteria in ADS-33D-PRF to determine if it adequately addresses the utility helicopter mission; b) to tailor existing ADS-33D-PRF Section 4 MTEs in a good visual environment and develop new flight test maneuvers specifically designed to adequately evaluate the handling qualities of utility helicopters, with and without external slung loads; c) to correlate the results of quantitative testing with those from the qualitative evaluations; d) to establish a handling qualities baseline of the UH-60A (using the general criteria outlined in ADS-33D-PRF) against which the effects of future modifications to the aircraft may be better compared or quantified; and e) to document the UH-60A response characteristics in order to provide data to support refinement of AFDD's UH-60A mathematical models.

1.3 Description

The test aircraft, U.S. Army serial number 82-23748, was a sixth-year production UH-60A Black Hawk. The UH-60A is a twin turbine engine, single rotor, semi-monocoque fuselage, rotary-wing aircraft. The main rotor system has four blades made primarily of titanium and fiberglass. The propulsion system has two T700-GE-700 engines without the hover infrared suppressor system installed. The non-retractable landing gear consists of the main landing gear and a tail-wheel. The aircraft is equipped with a cargo hook capable of carrying up to 8000-lb external loads.

Dual cockpit controls consist of the cyclic stick, collective stick, and pedals. Pilot flight control inputs are transferred from the cockpit to the rotor blades by mechanical linkages and hydraulic servos. The aircraft is equipped with an Automatic Flight Control System (AFCS), which enhances the stability and handling qualities of the helicopter. It is comprised of four basic subsystems: stabilator, stability augmentation system (SAS), trim systems, and flight path stabilization (FPS). The stabilator system improves flying qualities by positioning the stabilator through electromechanical actuators in response to collective, airspeed, pitch rate and lateral acceleration inputs. The SAS provides short-term rate damping in the pitch, roll, and yaw axes. Trim and FPS systems provide control positioning and force gradient functions as well as basic autopilot functions with FPS engaged, i.e., pitch and roll attitude hold, heading hold, airspeed hold, and coordinated turns in forward flight. In addition, the pitch bias actuator was installed on the aircraft but electrically disconnected from the AFCS and set to a fixed length. The tail rotor was rigged with three degrees of bias that is standard for currently fielded UH-60A aircraft. A more detailed description of the aircraft is presented in Appendix C and reference 13.

The research instrumentation and data acquisition system for this test consisted of sensors, signal conditioners, pulse-code modulation (PCM) encoder, time code generator, and data recorder. The helicopter sensors included air data, accelerometers, rate and attitude gyros, and control position sensors at several points in the control system. These sensor signals were passed through filters, digitized, and encoded in a PCM stream, which was recorded onboard and simultaneously transmitted to the ground telemetry (TM) station. A time code generator received the broadcast time from the TM station and supplied this to the on-board recorder and the PCM stream. Externally-mounted test instrumentation included a nose boom incorporating a sideslip sensor and airspeed probe, a low airspeed detection system, laser reflectors attached to the left and right step fairings, and a telemetry antenna attached to the fairing below the stabilator. Appendix C contains a detailed listing of the test parameters and the characteristics of the instrumentation system.

Flights requiring operation at or near heavy mission gross weight configurations for the UH-60A were initiated with full main fuel tanks and 3,753 lb of internal ballast. The internal ballast was placed in two ballast boxes secured to standard cabin floor tie-down points. The ballast boxes were mounted symmetrically about the aircraft's longitudinal axis, loaded equally, and placed in a longitudinal position that resulted in a middle center of gravity (c.g.). The aircraft engine-start gross weight with full main fuel tanks and internal ballast was 18,242 lb. For comparison, the UH-60A structural design gross weight was 16,825 lb. The maximum alternate or design alternate gross weight was 20,250 lb (ref. 13).

The dense external test load was comprised of a 5000-lb (approximate weight) block plus two 500-lb steel blocks secured to the top surface of the main block. The total weight of the external test load was 6,297 lb. The load was fitted with lift points at the corners of the top surface and was carried with a standard 4-leg military sling rated at 10,000 lb. The sling weighed 55 lb. The load and sling were rigged in accordance with FM 10-450-3, Multiservice Helicopter Sling Load (ref. 14).

This paragraph provides a brief description of the ground-based telemetry (TM) station and associated laser tracking system operated by NASA's Western Aeronautical Test Range at Moffett Federal Airfield. The TM station, located adjacent to the taxiway on which most of the tests were performed, provided not only PCM-stream recording, processing, and real-time presentation, but also video coverage from a "pan and tilt" camera located on an antenna tower. The laser tracker system provided helicopter position data with accuracies to within ±6 inches. Aircraft position data were further transformed from the laser reflector located on the side of the helicopter to the pilot's eye position by including the aircraft attitudes and distances from the reflector to the pilot. Aircraft control positions, angular rates, and attitudes, along with aircraft ground speed and position information from the laser, were presented on four 8-channel, thermal-paper strip charts. This setup allowed real-time monitoring of control inputs and aircraft responses for the Section 3 quantitative tests and monitoring of task performance parameters during the Section 4 qualitative MTE assessments. The ability to monitor the control inputs and aircraft responses at the TM station during the test was found to be essential. The quality of the data and the frequency and magnitude of the input and response can be assessed in real time. This data monitoring ability provided an opportunity to repeat questionable data points and terminate test points when sufficient compliance data had been collected. Also, the real time monitoring of the frequency sweeps allowed for clear termination when the 2-Hz limit was reached.

1.4 Test Scope

The testing was conducted from Moffett Federal Airfield, Moffett Field, California (field elevation 35 ft msl). Eight of the nine MTE evaluations and all of the ADS-33 Section 3 quantitative tests at hover were performed over the airfield. The Slope Landing MTE was performed at a remote landing site (3900 ft msl). The forward flight Section 3 quantitative tests were performed over the San Francisco Bay, just north of Moffett Field. For the MTEs performed at the airfield, the course cueing was set up on a closed taxiway and is described in Appendix D.

This flight test was conducted in a good visual environment (GVE), in three aircraft configurations, and in three phases. Phase 1 consisted of course set-up and refinement, pilot training, pilot evaluation and refinement of existing ADS-33D-PRF MTE performance parameters, and development of new MTEs appropriate to the utility mission.

Table D-1 (shown in Appendix D) presents the MTEs and the aircraft configurations that were initially selected for the Phase 1 evaluation. Phase 2 consisted of formal handling quality evaluations of the MTEs developed or refined in Phase 1. These MTEs were evaluated in three aircraft configurations: empty (approximate average mid-mission gross weight of 13,500 lb), labeled Configuration "A"; with an internal ballast (17,300 lb), labeled Configuration "B"; and with a 6,297-lb external slung load (19,300 lb), labeled Configuration "D". Phase 3 consisted of engineering flight tests outlined in Section 3 of ADS-33D-PRF. Two aircraft configurations were evaluated in this phase: empty and with the internal ballast. The Hover and Low Speed flight tests and test conditions are presented in Table D-2. The Forward Flight tests and test conditions are presented in Table D-3. Note that not all of the Section 3 paragraphs of ADS-33D-PRF were evaluated; some were either not applicable or were beyond the scope of this test, while others have already been evaluated in other tests (ref. 15). While it was desirable to complete these phases in order, after Phase 1 was completed, tests from the remaining two Phases could be completed in an optimized order. In actuality, the testing was sequenced with the empty and external load configurations interleaved followed by the internal ballast configuration; this allowed the ballast to be installed and removed only one time.

Although the test was organized and conducted by the Flight Control and Cockpit Integration Branch of the Army-NASA Rotorcraft Division and the Flight Project Office (FPO) of the Aeroflightdynamics Directorate, there were many other participants. Raytheon Aerospace played a key role in maintaining the aircraft and marshalling the external loads. Researchers (pilots and engineers) from NASA Ames Research Center, the U.S. Naval Test Pilot School, Naval Air Systems Command (NAVAIR), U.S. Army National Guard, and Sikorsky Aircraft participated in course setup and gathering of the flight test data. All evaluation pilots for the Phase 2 and 3 testing were graduates of a military test pilot school. The visiting pilots from the Naval Test Pilot School were instructors at the school.

1.5 Test Methodology

The test aircraft was crewed by two pilots and one or two flight-test engineers/crewmembers. For the external slung load configuration, two on-board crewmembers were used in the load hook-up/release and in-flight load monitoring during maneuvering flight. Preflight briefings were conducted jointly by the test director and the project pilot for each flight. These briefings covered the overall goal of each flight, including the specifics on each test point for the applicable data card, the data required, limitations, test techniques, and expected results. The upper wind limit was set at 15 knots for all tests.

As previously mentioned, the flight testing was conducted in three Phases. The first Phase 1 flight was in late July 1999, and the last Phase 3 flight was in early November 1999. During Phase 1, two operational and four experimental test pilots evaluated and developed maneuvers and standards that were considered relevant to the utility helicopter mission during 16-hours of flight testing. Based on a consensus of these pilots, the final descriptions of the relevant MTEs and the performance standards for these tasks were developed in detail. Flight cards for each MTE were generated and made compatible for use in the cockpit (sized for the pilot's knee boards).

Phase 2 consisted of the evaluation of the Phase 1 developed MTEs using the test aircraft. Eight pilots participated during 44.5 hours of flight testing. Phase 2 began with initial training for evaluation pilots that did not participate in the Phase 1 testing. Training was provided on the visual cues, task standards, and task technique for empty and external load MTEs. Upon completion of training on the MTEs, the evaluation pilots conducted at least three data runs before providing subjective comments and a handling qualities rating for each MTE. Each evaluation pilot was encouraged to conduct additional data runs for any MTE that resulted in inconsistent performance during the first three data runs. After each data run, the pilots were asked to comment on their perception of meeting the Desired or Adequate performance standards. Engineers in the TM station evaluated available laser tracker data to confirm the standards perceived by the pilot. Following completion of the formal data runs, the evaluation pilots answered a questionnaire (Appendix F) to elicit in-depth comments on the task performance, aircraft characteristics, and demands on the pilots prior to giving a Cooper-Harper Handling Qualities Rating (HQR) (ref. 16). At least three pilots provided comments and ratings on each MTE, except for the Slope Landing MTE, which only two pilots rated.

Phase 3 consisted of those tests previously outlined in Table D-2 and Table D-3. The assessment was conducted during 18.1 hours of flight testing and included data collection and evaluation of the flight test techniques required to collect the data outlined in Section 3 of ADS-33D-PRF. ADS-33D-PRF introduces the concepts of an Operational Flight Envelope (OFE) and a Service Flight Envelope (SFE). The UH-60A was not designed to ADS-33 specifications and there is no defined OFE or SFE for the aircraft. For the purposes of this test, the aircraft was flown within existing limits published in the operator's manual (ref. 13) and refined by the current airworthiness release. In addition, a chase aircraft was used with the forward flight Section 3 engineering tests and a torque margin was imposed for the external slung load configuration, i.e., a hover out-of-ground-effect (HOGE) torque margin of 10% was required. Also, a 30-degree bank angle was imposed while carrying the external slung load. Test control inputs were made in a standard buildup technique, i.e., starting with quarter or half-inch inputs and increasing to the maximum allowed or whenever compliance was achieved, whichever was less. Cyclic and pedal fixtures were used for all step inputs to control the shape and quality of the inputs. For the Phase 3 tests, self-imposed limits on the magnitude of aircraft attitudes (see Table D-2 and Table D-3) and the magnitude and frequency of the control inputs were established. These included a maximum frequency of 2 Hz for all frequency sweeps and a maximum of 2 inches for all cyclic control step inputs. The 2-Hz maximum frequency was monitored and called from watching the real-time data in the TM station. The allowable maximum cyclic step input size was increased to 4 inches for this test to properly evaluate the Attitude Quickness response of the aircraft. Step input size was increased only after the aircraft response due to these larger inputs was evaluated from simulation data and observing the control input and aircraft response from data collected during the aggressive MTE evaluations.

2 Overview of Results and Discussion

Sections 1 and 2 of ADS-33D-PRF cover the scope, compliance, and definitions. Section 3 includes the required response types, and Section 4 covers the flight test maneuvers. The results, as related to the assessment of ADS-33D-PRF with a UH-60A, are presented for each of the three Phases of the flight test. Phase 2 and 3 results include the flight test data identifying the UH-60A performance relative to the performance standards outlined in ADS-33D-PRF. These results are presented in a construct paralleling the format of ADS-33; that is, initially the quantitative test results will be presented against the ADS-33D-PRF hover/low speed and forward flight requirements. Then the results from the flight test maneuvers will be presented; initially presenting the results and recommendations from the maneuver development, followed by the results from the formal evaluations of these maneuvers.

2.1 Definitions

Section 2 of ADS-33D-PRF contains a list of phrases and words that have specific meaning to its application and usage. For example, three Levels of handling qualities are defined which are tied to the Cooper-Harper handling qualities rating (HQR) scale. Level 1 is the best, is associated with HQRs 1 to 3.5, and can be categorized as "satisfactory without improvement." Level 2 is degraded from Level 1, is associated with HQRs between 3.5 and 6.5, and can be categorized as "adequate performance attainable with tolerable pilot workload." Level 3 is the worst, is associated with HQRs between 6.5 and 8.5, and can be categorized as having major deficiencies that require improvement.

Within Section 2 of ADS-33 is the definition of flight envelopes, the Operational Flight Envelope (OFE), and the Service Flight Envelope (SFE). The OFE defines the boundaries within which the vehicle must be capable of operating in order to accomplish operational missions. With no component or system failures, the ADS-33 specifies that Level 1 handling qualities shall be achieved in the OFE, while only Level 2 handling qualities are required in the SFE. The OFE is derived from the operational requirements and is established by the procuring activity. The SFE is derived from aircraft limits. As the UH-60A Black Hawk helicopter was procured prior to the development of ADS-33, there is not a defined OFE. For this evaluation, the OFE was construed to include all flight regimes within the operating limits, restrictions, and performance capabilities defined in the UH-60A operator's manual (ref. 13).

3 Requirements

3.1 General

Quantitative tests were performed for two aircraft configurations at hover and at forward flight. It should be noted that not all test points were completed for the empty configuration, whereas the ballasted configuration was thoroughly evaluated. To provide some scope, Table 3.1 shows a brief list of the data collected on each flight. The total flight time for the five hover data flights was about 11.5 hours, and the total flight time for the three forward-flight data flights was about 6.6 hours. Table 3.2 summarizes the flight times for the configurations and airspeeds investigated. Overall, it appears that about two data flights are needed to acquire the quantitative data for a particular flight condition.

Table 3.1 Scope of Testing

Flight #	Flt Condition – Configuration	Flt Time (min)	Axis	Test Input(s) or Test
189	Hover – A	142	Lateral	Frequency Sweeps, Doublets, Attitude Quickness, Coupling, Achievable Rate, Pulses
			Long.	Frequency Sweeps, Doublets, Attitude Quickness, Coupling, Achievable Rate, Pulses
			Pedal	Frequency Sweeps, Doublets
198	Hover – A	125	Pedal	Frequency Sweeps, Pulses, Attitude Quickness
			Coll.	Step-Up/Down
199	60 knots – A	124	Long.	Frequency Sweeps, Doublets, Maneuvering Stability, Steady Pull-Ups & Pushes-Overs, Level Accel/Decel
211	Hover – B	104	Lateral	Doublets/Attitude Quickness, Frequency Sweeps, Coupling, Achievable Rates, Pulses
			Long.	Frequency Sweeps, Doublets, Attitude Quickness
212	Hover – B	212	Long.	Coupling, Achievable Rate, Pulses
			Pedal	Doublets, Frequency Sweeps, Pulses, Attitude Quick-ness, Achievable Rate
			Coll.	Steps
213	80 knots – B	136	Long.	Maneuvering Stability, Steady Pulls-Pushes, Coupling
			Lateral	Attitude Quickness, Achievable Rate
			Coll.	Steps
214	80 knots – B	134	All	Steady Trims - FPS on/off SAS1&2 on/off
			Long.	Frequency Sweeps, Doublets, Pitch Control Power
			Lateral	Frequency Sweeps, Pulses
			Pedal	Frequency Sweeps, Doublets, Yaw Control with Speed Changes, Steady Side Slips, Large Amplitude Heading Changes
215	Hover – B	109	Lateral	Attitude Quickness
			Pedal	Doublets, Pulses, Attitude Quickness, Large Amplitude Heading Changes
			Coll.	Steps

Table 3.2 Number of Flights and Flight Time

Configuration A:	Hover:	2 Flts;	267 min	60 kts:	1 Flt;	125 min
Configuration B:	Hover:	3 Flts;	425 min	80 kts:	2 Flts;	125 min
Totals:	Hover:	5 Flts;	11.5 hours	Fwd Flt:	3 Flts:	6.6 hours

3.2 Required Response Types

Section 3.2 of reference 11 specifies the minimum required control response type as a function of the mission task elements (MTEs) and the Usable Cue Environment (UCE). A UCE determination was not performed in the UH-60 during this flight testing. However, in UCE=2 the control response is required to improve from a rate command to an attitude command. As the UCE degrades to UCE=3, the control response is required to migrate to yet a higher level of stability, called a Translational Rate Command (TRC) control response. Since the UCE was not determined, the required response type could not be determined. However, the ADS-33D-PRF Table 1(3.2) (ref. 11) generally specifies a Rate Command control response for UCE=1, an Attitude Command control response for UCE=2, and a Translational Rate Command control response for UCE=3. In addition, there are requirements for adding heading-, altitude-, and position-hold features as the UCE deteriorates from one to three. The UH-60A flight test assessment of ADS-33D-PRF was performed only in the day, and hence the UCE was expected to be equal to one. The aim of this test was to evaluate and document the ADS-33 requirements using an instrumented UH-60A. Hence, the control response was evaluated to categorize it against the requirements.

Pitch. The pitch response at hover and 80 knots meets the criteria for a rate command response type by meeting the Level 1 bandwidth requirements (see Sections 3.3.2 and 3.4.2 of this document for the bandwidths at hover and 80 knots, respectively). The ADS-33D-PRF test to determine if an attitude hold response type exists could not be performed as a pulse input could not be inserted directly into the control actuator.

Roll. The roll response at hover and 80 knots meets the criteria for a rate command response type by meeting the Level 1 bandwidth requirements (see Sections 3.3.2 and 3.4.7 of this document for the bandwidths at hover and 80 knots, respectively). Although a pulse input could not be inserted directly into the control actuator for determination of an attitude hold response, pulse inputs into the lateral cyclic for the mid-term response to control inputs showed an attitude-hold like response at hover.

Yaw. The yaw response at hover and 80 knots meets the criteria for a rate command response type by meeting the Level 1 bandwidth requirements (see Sections 3.3.5 and 3.4.9 of this document for the bandwidths at hover and 80 knots, respectively).

The aircraft has a heading hold feature; however, a pulse input could not be inserted directly into the control actuator. The directional controls, i.e., the pedals, contain switches that, when pressed, disengage the heading hold feature of the FPS below 60 knots (ref. 13). In an attempt to assess the heading hold character, pulse inputs were made on the "dog ears" of the pedals, i.e., without depressing the pedal switches. Positive and negative pulse inputs of different magnitudes were conducted at hover for the empty configuration ("A") and internal ballast configuration ("B").

For relatively small pedal pulse inputs, on the order of a 6–10% pulse resulting in 1–6 degrees of heading change, the yaw rates were in the range of 3–7 degrees/second on recovery. In ADS-33D-PRF, the requirement on the character of the heading hold states that the heading shall return to within 10% of peak heading deviation within 10 seconds. To eliminate unreasonable accuracy tolerances resulting from returning to ±10% of displacement for small displacements, ADS-33E-PRF specified a minimum of ±1 deg. For the small 6–10% pulse inputs in the empty configuration, the heading returned to within ±1 deg of the original (pre-input) heading within 10 seconds. In the ballast configuration, the heading did not return to within ±1 deg within 10 seconds for either the small pulse inputs or for slightly larger pulse input (16–18%). The heading returned to either a larger offset, e.g., 1.5 deg within the 10 seconds, or returned to within ±1 deg in a time greater than 10 seconds. One large pulse input (23%) was performed in the empty configuration resulting in a 22.5 deg heading change with a peak yaw rate of 12 deg/sec. Upon release of the pedals and recovery to the original heading the system overshot the original heading and resulted in an oscillatory divergence. The pilot initiated recovery at about 30 deg/sec yaw rate following a couple of cycles.

Heave. Collective steps in both directions were performed while at hover in the empty configuration ("A"). For the up-collective steps, the response is clearly rate-like and can be classified as a rate command response. However, for the down-collective steps, the response sometimes appeared to be rate-like and other times acceleration-like. The down steps ranged in magnitude from 3.5% to 10% to 13%. Eleven seconds after the 3.5% down collective step (@ 130 ft AGL), the vertical velocity was not constant, but the vertical acceleration was steady around 1.12 ft/sec^2. Five seconds after the 10% down collective step (@ 130 ft AGL), the vertical velocity was constant around 25 ft/sec. About six seconds after the 13.5% down collective step (@ 470 ft), the vertical velocity was not steady, but the vertical acceleration was steady around 6.78 ft/sec^2. For up-collective inputs, the UH-60A clearly has an altitude rate response type. For down-collective inputs, UH-60A has a mixture of altitude rate and acceleration response.

3.3 Hover and Low Speed

3.3.1 Equilibrium Characteristics

Paragraph 3.3.1 of reference 11 specifies that the equilibrium pitch and roll attitudes required to achieve a no-wind hover, and to achieve equilibrium flight in a 35-knot relative wind from any direction, shall not result in pilot discomfort, disorientation, or restrictions to the field-of-view that would interfere with the accomplishment of the Mission Task Elements. The equilibrium characteristics were characterized by plotting trim attitudes and cyclic stick positions for a variety of aircraft weights encountered during the conduct of this test. Figure E-1 (shown in Appendix E) shows these data for the empty configuration and Figure E-2 shows these data for the internally ballasted configuration. The deviations in aircraft weight occur as the fuel is used in flight. Note that for the empty configuration there are three points that include the effects of a 13–16 knot wind from various directions. Data were not collected in higher wind conditions.

At no time during the conduct of the test did a pilot complain about discomfort or disorientation from the equilibrium characteristics of the aircraft. There was an issue related to the field-of-view for the Hover MTE. Specifically, the UH-60A has a "door post" that blocks the pilots view between approximately 48 and 68 degrees (zero degrees being straight ahead). As the ADS-33D-PRF requires the Hover maneuver to be performed from along a 45-degree line-up mark to the hover box, the door post interfered with the pilot's ability to consistently view the 45-degree line of traffic cones. To compensate for this, the Hover course was set up with the lead-in line of traffic cones set at about 40 degrees (relative to the Hover board/target). This extra margin of a few degrees allowed the pilots to view the lead-in line of traffic cones out of the front window for the entire maneuver, and was within the MTE heading tolerance of the diagonal run-in.

3.3.2 Small-Amplitude Pitch (Roll) Attitude Changes

Short-Term Response to Control Inputs (Bandwidth). Paragraph 3.3.2.1 and figure 1(3.3) from reference 11 present the requirements for small-amplitude, short-term attitude changes to control inputs. The requirements are in terms of bandwidth and phase delay as defined in figure 2(3.3) of reference 11. The flight test technique to acquire the data consists of performing frequency sweeps on the primary pilot inceptors. The frequency sweep testing was performed according to techniques and guidelines outlined in reference 17.

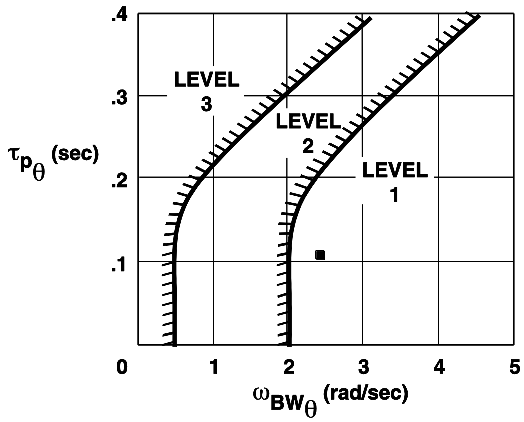
Three "good" sweeps per axis per flight condition were collected. A good sweep begins with two complete cycles at the beginning frequency (about 0.3 rad/sec for this test) followed by a smooth and continuous progression in frequency up to the limit frequency (2 Hz for this test). Additionally, there should be several seconds of static trim data at the beginning and end of the record. Maintaining the aircraft symmetrically about the reference condition throughout each sweep is essential toward obtaining satisfactory results. The total record lengths were about 90 seconds each. Before performing the frequency sweeps, the FPS and trim systems were turned off to eliminate correlated longitudinal and lateral cyclic inputs through the trim actuators due to roll-yaw and pitch-yaw coupling. Also, the horizontal stabilator control was set to: auto control ON.

Figure E-3 shows the time history from a typical "good" frequency sweep. All the frequency sweep data were analyzed using CIFER® (ref. 18). Figures E-4 and E-5 show the resultant frequency responses (Bode plots) for the pitch and roll axes, respectively. Shown in Figure 3.1 is the short-term response to control (Bandwidth) results for hover in the internal ballast configuration. The UH-60A data was plotted on both categories of the requirements, i.e., the Target Acquisition and Tracking boundaries and the All Other MTE boundaries – even though the UH-60A was not designed for Air Combat/Target Acquisition and Tracking requirements. As can be seen, the UH-60A in this configuration is well within the predicted Level 1 regions. In fact, the computed bandwidths have about a 1.5 rad/sec margin above the Level 1-2 boundary for "All other MTEs, UCE=1, and fully attended operations." Table 3.3 summarizes the bandwidth and phase delay values for the empty and internal ballast configurations.

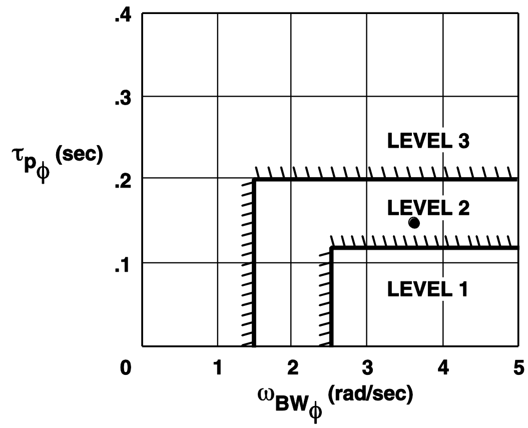
Table 3.3 Small-Amplitude, Short-Term Response to Control Inputs in Hover – Pitch and Roll

	Pitch		Roll	
	Config. A – Empty	Config. B – Internal Ballast	Config. A – Empty	Config. B – Internal Ballast
Gain Bandwidth, rad/sec	3.10	3.17	3.23	3.64
Phase Bandwidth, rad/sec	2.21	2.41	4.91	4.88
Phase Delay, sec	0.112	0.108	0.098	0.144

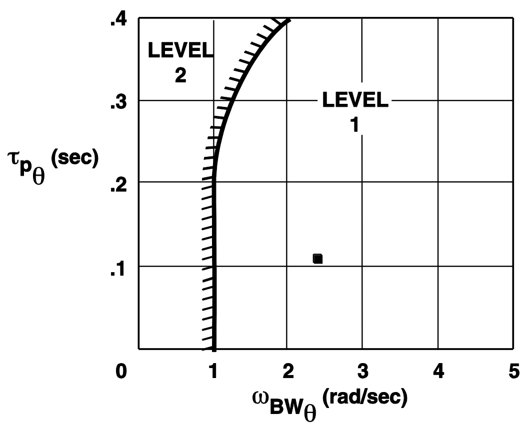
Short-Term pitch and roll responses to disturbance inputs. During this test, it was not possible to insert an input directly into the control surface actuator. Hence, this requirement was not assessed.



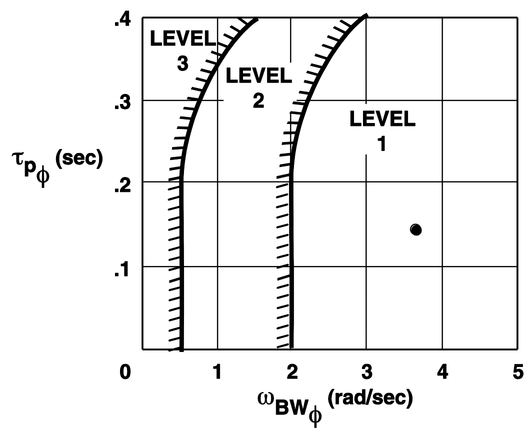
a) Target Acquisition and Tracking (pitch)



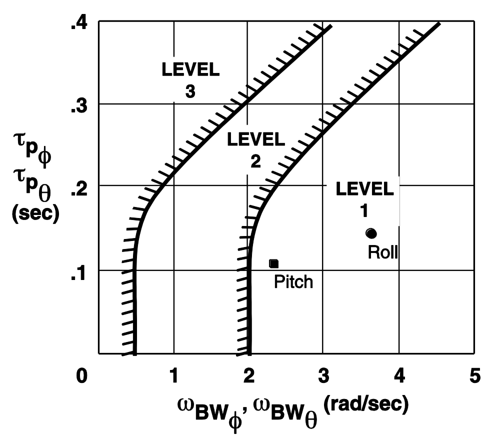
b) Target Acquisition and Tracking (roll)



c) All other MTEs - UCE=1 and Fully Attended operations (pitch)



d) All other MTEs - UCE=1 and Fully Attended operations (roll)



e) All other MTEs - UCE > 1
and/or Divided Attention operations (pitch and roll)

Figure 3.1 Small-Amplitude, Short-Term Response to Control Inputs (Bandwidth) in Hover for the Internal Ballast Configuration

Mid-Term Response to Control Inputs. Paragraph 3.3.2.2 and figure 3(3.3) from reference 11 specify the requirements for the mid-term response characteristics for all frequencies below the bandwidth frequency. If an attitude hold response type is available, an effective damping ratio of at least 0.35 is required for any oscillatory modes below the bandwidth frequency. If an attitude hold response type is not available, the applicable criterion depends on the degree of divided attention necessary to complete the MTEs; for fully attended operations, the limits in figure 3(3.3) from reference 11 apply; for divided attention operations, the limits of figure 3(3.3) apply except the Level 1 damping shall not be less than 0.35 at any frequency.

Pulse and doublet control inputs were performed in the pitch and roll axes. Figures E-6 through E-9 show the resultant time histories for the empty and internally ballasted configuration. In the pitch axis, the aircraft quickly returns to trim with no overshoot or oscillations. The response clearly satisfies the Level 1 damping requirements of 0.35. In the roll axis, the aircraft exhibits two superimposed responses. The primary forced response quickly dampens with no overshoot or oscillations and satisfies the Level 1 requirement.

However, there appears to be a very lightly damped high-frequency oscillation superimposed onto the primary response. This oscillation has a frequency (6.5 rad/sec) above the bandwidth frequency (~3.6 rad/sec) and appears intermittently in the roll response throughout the test. The oscillation has been traced to the roll SAS. Although when specifically asked, the pilots stated that they did not observe or feel this particular oscillation. However, there were pilot comments during the MTE evaluations that elude to roll oscillations (see Section 4.3.2). These roll oscillations fall into the Residual Oscillations requirements (3.1.11) from reference 11, which says any sustained oscillations in any axis in calm air shall not interfere with the pilot's ability to perform the specified mission-task-elements. For Level 1, oscillations in attitude and in acceleration at the pilot's station greater than 0.5 degrees and 0.05 g will be considered excessive for any response-type and mission-task-element. The roll oscillations in Figure E-6 are on the order of 3.5 degrees/sec (peak-to-peak) in roll rate, and about 1.0 degree/sec (peak-to-peak) in roll attitude. The accelerations at the pilot's station were not available. Hence, these residual oscillations are near the Level 1 limit, but based on pilot comments from performing the MTEs, these residual oscillations definitely impacted the pilot's ability to perform the maneuvers to desired standards—and therefore could be labelled as non-Level 1.

3.3.3 Moderate-Amplitude Pitch (Roll) Attitude Changes (Attitude Quickness)

Paragraph 3.3.3 of reference 11 specifies the moderate-amplitude requirements for the pitch and roll axes. These criteria are expressed as the ratio of peak angular rate to the change in angular attitude for rapid attitude changes from one steady attitude to another. It is not allowed to have significant control reversals in the sign of the cockpit controller input relative to the trim position. The initial attitudes and attitude changes required for compliance shall be representative of those encountered while performing the required MTEs. It is not necessary to meet this requirement for Response-Types which are designed as applicable only to UCE = 2 or 3.

The collection of the hover Attitude Quickness data was the most troublesome and time-consuming test. The Attitude Quickness requirement states that the attitude changes must be made from one steady attitude to another as rapidly as possible without significant reversals in the sign of the cockpit control input relative to the trim position. It should be noted that the attitude changes should be made "open-loop," i.e., without a specific target attitude, and as rapidly as possible (ref. 19). The recommended control input for a Rate Response-Type is to utilize spike (or very short duration pulse-like) inputs of varying magnitude to produce the necessary range of attitude changes. The ratio of peak angular rate to peak attitude change is reduced by utilizing longer duration inputs rather than larger magnitude inputs to achieve the same attitude change. The recommended control input for an Attitude Response-Type is to initially overdrive the commanded attitude, followed by an essentially steady value of the stick consistent with the achieved or steady attitude. The purpose of this control strategy is not to provide lead equalization, but simply to overcome the inherent stability of the attitude command response. On the other hand, misleading results can be obtained if significant control reversals from the trim position are allowed.

Initially, spike-like lateral control inputs were made, with the control returned to the trim value in order to acquire the roll Attitude Quickness data. However, due to the attitude retention function with the FPS engaged, the attitude tended to drift back to the initial trim value and, therefore, not meet the intent of changing "from one steady attitude to another." Figure E-10 shows the initial inputs and the modified inputs that generated good Attitude Quickness data. For the larger attitude changes it is acceptable to initiate the changes from a non-level equilibrium condition, provided the input is made with the aircraft near zero angular rate and minimum translation. The use of a control fixture allows the flight crew a margin of safety and a method for buildup to the maximum input size. The fixture was used effectively for up to 20-degree bank angles from equilibrium followed by 4-inch control inputs; that is, for a positive peak roll rate with a 50-degree roll attitude change, the maneuver was initiated from a negative 20-degree bank angle. Thus, the excursions in roll attitude were from −20 to +30 deg. Representative test data are shown in Figures E-11 through E-14 for the lateral axis and Figures E-15 through E-18 for the longitudinal axis.

Figure 3.2 shows pitch and roll Attitude Quickness results from the hover condition for both directions, i.e., pitch up and down along with roll right and left for the internally ballasted aircraft configuration on the All Other MTEs boundaries. As previously mentioned, some of the larger attitude changes were accomplished by initiating the test from a non-hover trim attitude. For example, in one data run the aircraft was initially banked and momentarily held at approximately 18 degrees to the right followed by a 48-degree bank angle change to the left. The control input for this bank angle change generated a 55 deg/sec peak roll rate and thus a ratio of peak angular rate to peak attitude change of 1.15 sec^{-1}. The UH-60A Black Hawk, at hover, was able to meet the Level 1 pitch and roll Attitude Quickness requirements for "All Other MTEs."

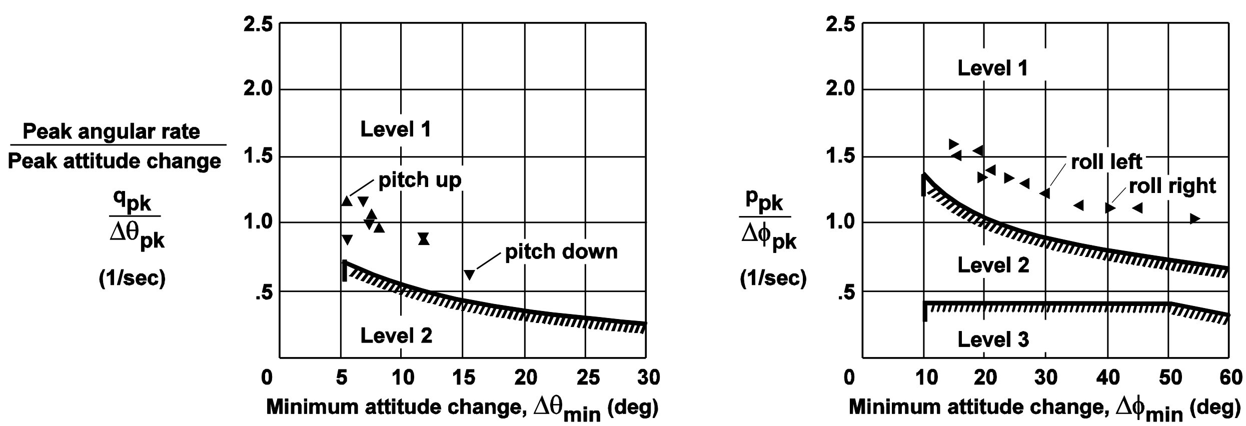


Figure 3.2 Pitch and roll attitude quickness data for the internally ballasted configuration at hover

3.3.4 Large-Amplitude Pitch (Roll) Attitude Changes

Paragraph 3.3.4 of reference 11 specifies the minimum achievable angular rate (for a rate-command Response-Type) or the minimum attitude change from trim (for an attitude-command Response-Type). The specified rate or attitude changes must be achieved in each axis while limiting excursions in the other axes with appropriate control inputs. The UH-60A has a rate command Response-Type, and hence, the necessary parameter is the minimum achievable angular rates.

Before performing specific test points to generate large-amplitude compliance data, data from prior test points were examined, e.g., data from performing the MTEs and the Attitude Quickness tests. For the UH-60A, Attitude Quickness data provided some of the needed data. Figures E-19 through E-22 show the time history data. Table 3.4 presents the demonstrated angular rate results compared to the reference 11 requirements. The internally ballasted UH-60A at hover meets the Level 1 Moderate Maneuvering requirements for pitch and roll. The roll axis met the Level 1 Aggressive Maneuvering requirement. The pitch axis nearly met (−30 and +28 deg/sec) the Level 1 Aggressive Maneuvering requirement of ±30 deg/sec.

Table 3.4 Requirements for Large-Amplitude Attitude Changes – Hover/Low-Speed

Mission Task Element (MTE)	ADS-33D-PRF Requirements for Minimum Achievable Angular Rate (deg/sec) (Rate response-types)						UH-60A Demonstrated Achievable Rate (Config. B – Hover) (deg/sec)		
	Level 1			Level 2 and 3					
	q	p	r	q	p	r	q	p	r
<u>Limited Maneuvering</u> All MTEs not otherwise specified	±6	±21	±9.5	±3	±15	±5			
<u>Moderate Maneuvering</u> Rapid transition to precision hover Slope landing Shipboard landing	±13	±50	±22	±6	±21	±9.5			
<u>Aggressive Maneuvering</u> Rapid accel/decel Rapid sidestep Rapid hovering turn Target acquisition and tracking Pull-up/push-over Rapid bobup – bobdown	±30	±50	±60	±13	±50	±22	+22 -31	+56 -58	+41 -47

3.3.5 Small-Amplitude Yaw Attitude Changes

Short-Term Response to Yaw Control (Bandwidth). Paragraph 3.3.5 and figure 5(3.3) from reference 11 present the requirements for small-amplitude, short-term yaw attitude changes to control inputs. The requirements are in terms of bandwidth and phase delay as defined in figure 2(3.3) of reference 11. The flight test technique to acquire the data consists of performing frequency sweeps on the primary pilot inceptors. The frequency sweep testing was performed according to techniques and guidelines outlined in reference 17. Before performing the frequency sweeps, the FPS and trim systems were turned off to eliminate correlated longitudinal and lateral cyclic inputs through the trim actuators due to roll-yaw and pitch-yaw coupling. Also, the horizontal stabilator control was set to: auto control ON.

Three "good" sweeps per axis per flight condition were collected. During the directional sweeps, it was found that a higher coherence, and hence a higher quality of data, was obtained when one pilot performed the pedal sweep and the other pilot controlled the cyclic and collective; this reduced the overall correlation between the controls from biodynamic interaction and improved the data. Figure E-23 shows a typical directional sweep and the corresponding Bode plot is shown in Figure E-24. Shown in Figure 3.3 is the directional short-term response to control (Bandwidth) results in hover for the internally ballasted configuration on the “All Other MTEs” boundaries. As can be seen, the UH-60A in this configuration is well within the predicted Level 1 region for “All Other MTEs.” In fact, the computed bandwidth has about a 1.25 rad/sec margin above the Level 1-2 boundary for “All Other MTEs.” Table 3.5 summarizes the yaw-axis bandwidth and phase delay values for both the empty and internal ballast configurations.

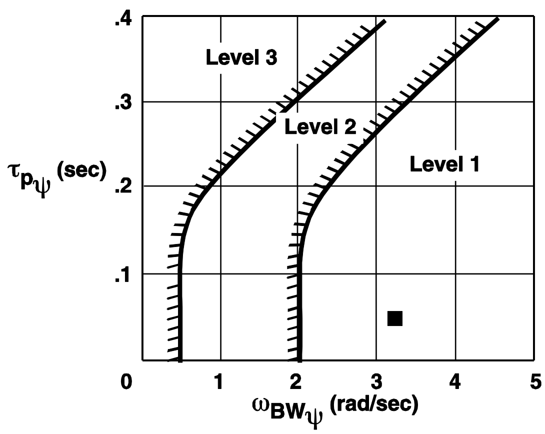


Figure 3.3 Short-Term Response to Yaw Control (Bandwidth) in Hover for the Internal Ballast Configuration

Table 3.5 Small-Amplitude, Short-Term Response to Control Inputs in Hover – Yaw

	Yaw	
	Config. A – Empty	Config. B – Internal Ballast
Gain Bandwidth, rad/sec	4.35	4.26
Phase Bandwidth, rad/sec	3.26	3.22
Phase Delay, sec	0.042	0.048

Mid-Term Response. Paragraph 3.3.5.2 and figure 3(3.3) from reference 11 specify the requirements for the mid-term response characteristics for all frequencies below the bandwidth frequency. If a heading hold Response-Type is available, an effective damping ratio of at least 0.35 is required for any oscillatory modes below the bandwidth frequency. If a heading hold response type is not available, the applicable criterion depends on the degree of divided attention necessary to complete the MTEs; for fully attended operations, the limits in figure 3(3.3) from reference 11 apply except the Level 1 limit on effective damping ratio for any oscillation is relaxed from 0.35 to 0.19; for divided attention operations, the limits of figure 3(3.3) apply except the Level 1 damping shall not be less the 0.19 at any frequency.

Figures E-25 and E-26 present the time history data for a pedal doublet from the empty and internally ballasted aircraft configurations, respectively. As can be seen, the heading response is very well damped with no oscillations and hence, meets the Level 1 requirements.

3.3.6 Moderate-Amplitude Heading Changes (Attitude Quickness)

Paragraph 3.3.6 and figure 6(3.3) of reference 11 specifies the moderate-amplitude requirements for the directional axis. These criteria are expressed as the ratio of peak yaw rate to the change in heading for rapid changes from one steady heading to another. It is not allowed to have significant control reversals in the sign of the cockpit controller input relative to the trim position. It is not necessary to meet this requirement for Response-Types which are designed as applicable only to UCE = 2 or 3.

Figures E-27 through E-29 show representative time histories from the directional Attitude Quickness test. Data were collected with the FPS OFF. Good data for this requirement were difficult to collect; for modest directional control inputs, the UH-60A yaw SAS saturates. Without the yaw damping provided by the yaw SAS, the aircraft response tends toward an acceleration-command Response-Type, thereby requiring the pilot to make control reversals to zero the yaw rate at the final heading. Without these control reversals, the yaw rate would not return to zero (see Figures E-27 and E-28) and hence, the heading change was not defined. Figure E-29 shows a typical control input required to get good data. Note that a 32% control reversal (compared to the size of the initial input) plus a control offset from trim was needed to maintain a constant heading change.

Figure 3.4 presents the hover yaw Attitude Quickness data for the empty and internally ballasted aircraft for left and right heading changes on the "All Other MTEs" boundaries. Only two data points are above the Level 1 boundary and both of these points have control reversals in the 32–42% range, which would be considered "significant." Therefore, the UH-60A does not meet the Level 1 moderate amplitude heading changes (Attitude Quickness) requirement.

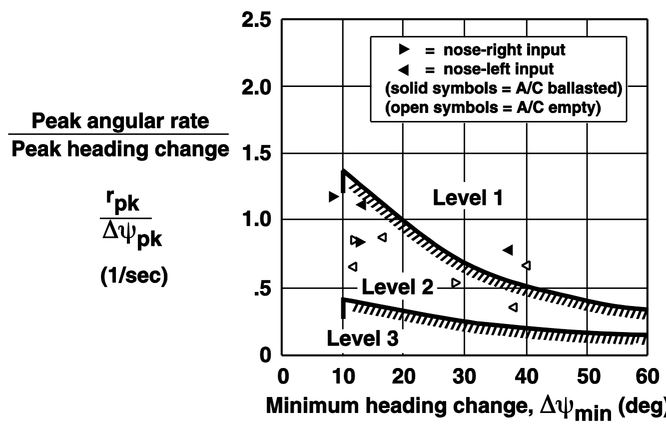


Figure 3.4 Yaw Attitude Quickness, Hover

3.3.7 Large-Amplitude Heading Changes

Paragraph 3.3.8 of reference 11 specifies the large amplitude heading change requirements. These are in terms of the minimum achievable angular rate (for a rate command Response-Type) and must be achieved about the yaw axis while limiting excursions in the other axes with appropriate control inputs. Reference 11 also states that demonstration of the minimum achievable angular yaw rate shall be with the main rotor RPM at the lower sustained operating limit. The UH-60A tests at Ames were conducted with the main rotor RPM set at its nominal operating point (100%).

Figures E-30 and E-31 show the time history records for quantifying the minimum achievable yaw rate at hover for the internally ballasted aircraft. With about a ±20% pedal step, the yaw rate reaches +41/−47 deg/sec. The UH-60A surpasses the Level 1 achievable rate for Moderate Maneuvering (±22 deg/sec).

3.3.8 Interaxis Coupling

Paragraph 3.3.9 of reference 11 covers requirements for interaxis coupling. There is an inclusive over-arching criterion that says control inputs in one axis shall not result in objectionable responses in other axes for control inputs up to and including those required to achieve the moderate amplitude responses (i.e., the Attitude Quickness). In addition, there are three specific requirements on interaxis coupling; yaw-due-to-collective, pitch-due-to-roll (and roll-due-to-pitch), and height-due-to-yaw control.

During the collection of the Attitude Quickness data for the pitch, roll, and directional axes, no objectionable comments were received from the pilots regarding off-axis responses.

Yaw-Due-to-Collective. Paragraph 3.3.9.1 of reference 11 states that the yaw rate response to abrupt collective inputs with the directional controller free shall not exceed the boundaries of figure 1(3.3.9.1). In addition, there shall be no objectionable yaw oscillations following the step or ramp collective change in the positive or negative directions. Oscillations involving yaw rates greater than 5 deg/sec shall be deemed objectionable. The criterion in figure 1(3.3.9.1) is in terms of the ratios of yaw rate to rate of climb.

Figures E-32 through E-35 show a variety of representative time history data from collective steps with the aircraft internally ballasted. The rate of climb was synthesized post-flight to improve its accuracy. Although there were yaw rate oscillations, these were below the 5 deg/sec objectionable limit and were not griped by the pilots. Figure 3.5 presents the results for both up and down collective steps and indicates that points lie within both the Level 2 and Level 1 regions.

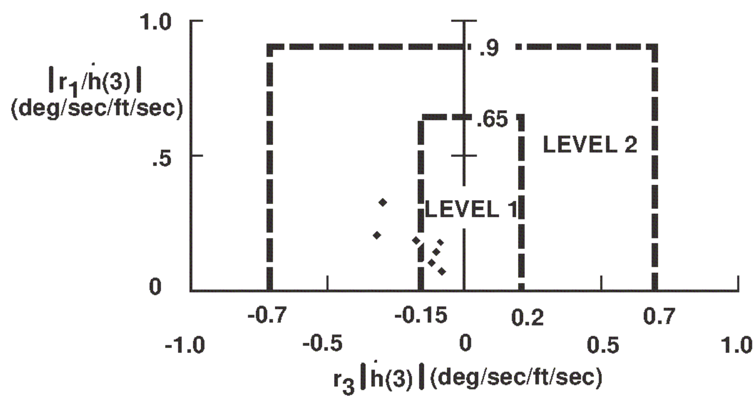


Figure 3.5 Yaw due to Collective Coupling

Pitch-to-Roll and Roll-to-Pitch Coupling During Aggressive Maneuvering. Paragraph 3.3.9.2 of reference 11 specifies limits on the ratios of off-axis attitude response from trim within four seconds to the desired on-axis attitude response following an abrupt on-axis control input. The Level 1 limit allows a 25% off-axis response and the Level 2 limit allows a 60% off-axis response. Heading excursions are to be limited during this test by use of the heading controller. The criteria apply to rotorcraft performing the Aggressive Maneuvering MTEs from Table 1 (3.3) in reference 11. These MTEs include the Acceleration/Deceleration, Sidestep, Hovering Turn, Slalom, Target Acquisition and Tracking, Pull-up/Push-over, and the Bob-up/Bob-down maneuvers.

During the initial maneuver evaluation, several maneuvers were deemed too aggressive or not applicable for the UH-60A. These included the Acceleration/Deceleration, Sidestep, Target Acquisition and Tracking, and the Pull-up/Push-over maneuvers. However, the Hovering Turn, the Slalom, and a slight variation of the Bob-up/Bob-down maneuvers were evaluated and deemed appropriate for the UH-60A. Hence, data were collected for the pitch-roll coupling criteria.

Acquiring good compliance data for the ADS-33D-PRF pitch-roll coupling requirements was also somewhat difficult. The peak off-axis response from trim occurs any time within the first 4 seconds, whereas the on-axis response from trim is measured at 4 seconds following the control input. Relatively small control inputs were needed to maintain the on-axis attitudes within the approved attitude excursion limit at four seconds after the step input, as defined in the test plan. With these on-axis inputs (built up from about 0.5 to 1.5 inches) there was almost always a small off-axis input. Figures E-36 through E-43 present representative time history data for the empty and internally ballasted aircraft configurations at hover. Shown are data from forward and aft pitch control inputs and right and left roll control inputs. Figure 3.6 shows the calculated results with the ratio of off- to on-axis control inputs varying from roughly 9% to 20%.

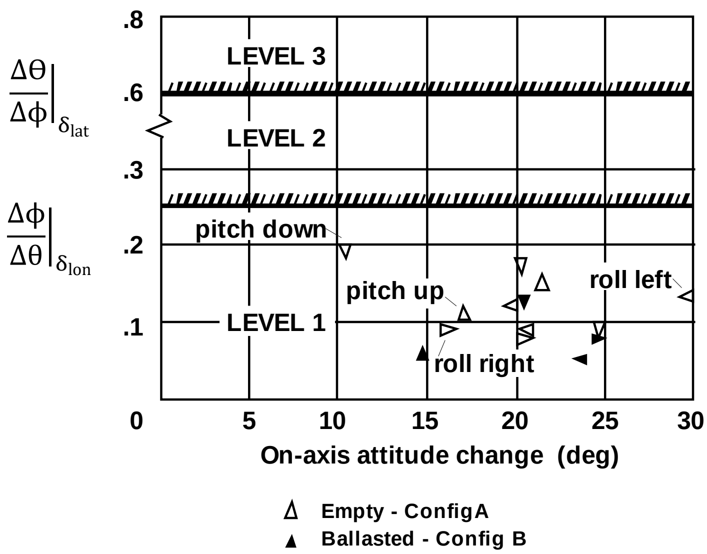


Figure 3.6 Pitch-Roll Coupling for the Empty and Ballasted Configurations at Hover

The data points are within the Level 1 region, but the confidence and repeatability in obtaining these data were less than ideal. One approach to dealing with the difficulties of off-axis inputs may be that proposed in reference 20. Compliance data are obtained from the control frequency sweeps used in the bandwidth analysis. Employing a multi-input, multi-output analysis removes the off-axis control input effects, thus requiring no additional compliance testing. Figure 3.7 shows the UH-60A pitch-roll coupling results at hover for the empty and internally ballasted configurations, on the reference 20 frequency-domain coupling boundaries. These boundaries were developed from a roll-axis tracking task. Although this task may not be applicable to the utility mission, the predicted Level 2 pitch-roll coupling may be related to the assigned Level 2 qualitative ratings for tasks like the Pirouette (see Section 4.2.3). These frequency-domain based criteria should be expanded to cover a broader range of MTEs.

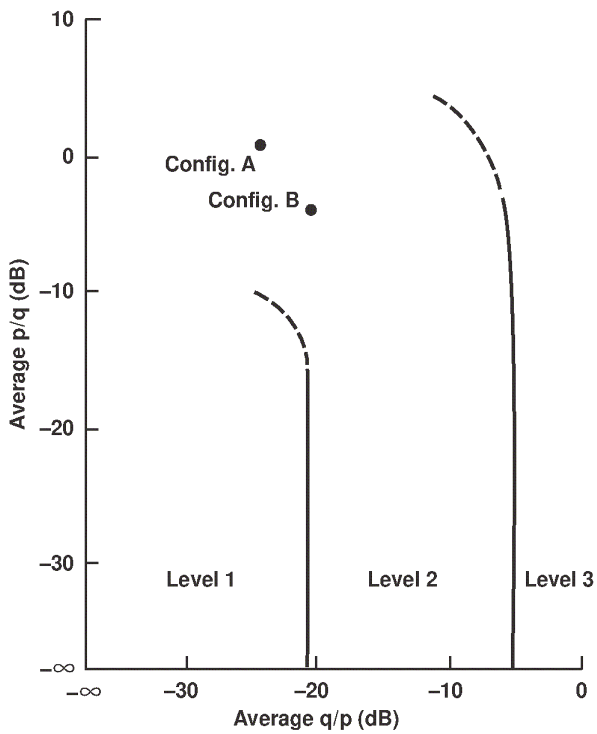


Figure 3.7 Pitch-due-to-Roll and Roll-due-to-Pitch Coupling

Height-Due-to-Yaw Control. Paragraph 3.3.9.3 of reference 11 specifies that the height response due to yaw control inputs shall not be objectionable. During the collection of the yaw Attitude Quickness data and the yaw large amplitude data, there were no comments from the pilots about objectionable coupling into the height axis.

3.3.9 Response to Collective Controller

Height Response Characteristics. Paragraph 3.3.10.1 of reference 11 states the vertical rate response to a collective step input shall have a qualitative first-order appearance for the first five seconds. In addition, it specifies limits on the parameters defined by the equivalent first-order transfer function of vertical-rate-to-collective input. For Level 1, these limits are 5.0 seconds for the dynamics time constant and 0.2 seconds for the delay. For Level 2, the limits are infinity and 0.3 seconds, respectively. In addition, the coefficient of determination (a "goodness of fit" indicator), must be between 0.97 and 1.03. Note, the delay term (τ_{hdot}) may be less than zero.

Collective step responses were performed with the aircraft in the empty and internally ballasted configurations and were performed in ground effect (IGE) and out of ground effect (OGE). Up and down collective steps were accomplished for the empty configuration (see Section 3.2 *Heave*). Only up-collective steps were accomplished for the internally ballasted configuration. The rate of climb response had to be synthesized from a combination of vertical acceleration and radar altitude. From the IGE data, the height response characteristics appear first-order in appearance and meet the Level 1 boundaries. From the OGE data, the height response characteristics appear acceleration-like, i.e., the dynamics time constant is greater than five seconds (Level 2). The upper illustration in Figure E-44 shows the IGE comparison between the synthesized rate of climb and the first-order curve fit for a collective step of approximately 19%. The first-order fit has the following first-order parameters: T_{hdot} = 2.35 seconds and

τ_{hdot} = 0.0048 seconds. The lower illustration in Figure E-44 shows the OGE comparison (T_{hdot} = 8.62 seconds and τ_{hdot} = −0.2664 seconds) for a collective step of approximately 8.6%. The coefficient of determination was within required values for all of the curve fits. Note that both of these example data runs were from the internally ballasted aircraft configuration and hence, only for an up-collective step.

Torque Response. Paragraph 3.3.10.2 of reference 11 specifies that torque, or any other parameter displayed to the pilot as a measure of the maximum allowable power that can be commanded without exceeding engine or transmission limits, shall have dynamic response characteristics that fall within prescribed boundaries (figure 9(3.3) in ref. 11). For this test, the recorded torque was the nominal Black Hawk torque signal, i.e., from the torque sensor mounted on the exhaust case that measures the twist of the power turbine shaft. On the aircraft, this signal is transmitted to a signal data converter and into the torque indicator on the display panel, presenting torque as a percent. It is not known if the data converter or the indicator has any added filtering dynamics. As the displayed torque was not recorded, there are no data to compare with the prescribed boundaries. It should be noted that during the assessment of ADS-33D using a CH-47D helicopter (refs. 8 and 9), the torque displayed to the pilot is on an analog gauge having a damped dynamic response. Hence, due to the damping of the torque gauge, the recorded data were not representative of the displayed torque and therefore the torque response requirements could not be determined.

Vertical Axis Control Power. Paragraph 3.3.10.3 of reference 11 specifies the vertical axis control power requirements. The requirements are stated in terms of producing a vertical rate of climb within 1.5 seconds after initiation of a rapid displacement of the vertical axis controller from trim while being in a hover with a wind up to 35 knots from the most critical direction. For Level 1, the vertical rate must be equal or greater than 160 ft/min (2.667 ft/sec). For Level 2, the rate must be equal or greater than 55 ft/min (0.917 ft/sec) and for Level 3, the rate must be equal or greater than 40 ft/min (0.667 ft/sec).

The data for this requirement can be obtained from time history data applicable to other paragraphs. For example, from the collective step responses used to quantify the height response characteristics (see *Height Response Characteristics* in the current Section), the vertical rate of climb was assessed 1.5 seconds after the collective input. Looking at Figure E-45, one can see that the vertical rate is greater than the Level 1 requirement (2.667 ft/sec) for both the IGE (upper) and OGE (lower) hover. This requirement is easily met in all but the smallest collective steps. It should be noted that the winds on the day of testing were approximately four knots.

Rotor RPM Governing. Paragraph 3.3.10.4 of reference 11 states that the rotor speed shall remain within the limits set by the Service Flight Envelopes during the execution of all specified Mission Task Elements conducted within the Operational Flight Envelopes. In addition, it shall be possible to meet all of the directional control requirements at the lowest sustained operating RPM limit.

As the UH-60A was built and procured before the concept of Operational and Service Flight Envelopes, there is not a defined Operational Flight Envelope for rotor speed. However, the operator’s manual for the aircraft (reference 13) states that the continuous rotor RPM limits are between 95 and 101 percent. The minimum rotor RPM, except for idle and transient, is 91 percent and the transient limits are between 101 and 107 percent. For this entire test, the rotor RPM was set at the nominal 100 percent. At no time during the execution of the MTEs did the evaluation pilots mention out-of-limits problems with the rotor RPM. The directional control requirements were assessed with the rotor RPM set at 100 percent.

Position Hold. The UH-60A does not have a Position Hold response and hence, this requirement was not assessed.

Translational Rate Response-Type. The UH-60A does not have a Translational Rate response and hence, this requirement was not assessed.

3.4 Forward Flight

3.4.1 General

Initially, the test plan called for the forward flight quantitative requirements to be evaluated at 60 and 120 knots. The 60-knot condition was chosen as it is about the same speed used in the Slalom MTE and is at the low end of the Forward Flight region. After an initial try at collecting data at 60 knots, it became obvious that this relatively low forward flight speed would make data collection difficult and may not be highly mission relevant. In addition, being on the backside of the power curve aggravated maintaining "on-condition" during the maneuvering stability tests. Hence, the two flight conditions (60 and 120 knot) were combined into a single 80-knot evaluation.

3.4.2 Pitch Attitude Response to Longitudinal Controller

Short-Term Response (Bandwidth). Paragraph 3.4.1.1 and figure 1(3.4) from reference 11 present the requirements for small-amplitude, short-term attitude changes to control inputs. The requirements are in terms of bandwidth and phase delay as defined in figure 2(3.3) of reference 11. The flight test technique to acquire the data consists of performing frequency sweeps on the primary pilot inceptors. The frequency sweep testing was performed according to techniques and guidelines outlined in reference 17. Three "good" sweeps per axis per flight condition were collected. The characterization of a "good" sweep is highlighted in the hover/low-speed section (Section 3.3.2) of this report. Before performing the frequency sweeps, the FPS and TRIM were turned off to eliminate correlated longitudinal and lateral cyclic inputs through the trim actuators due to roll-yaw and pitch-yaw coupling. Also, the horizontal stabilator control was set to: auto control ON.

Figure E-46 shows the time history from a typical longitudinal cyclic sweep. All the frequency sweep data were analyzed using CIFER® (ref. 18). Figure E-47 shows the resultant Bode plot for the pitch axis. Shown in Figure 3.8 is the short-term response to control (Bandwidth) results for the internally ballasted configuration in forward flight (80 knots). As can be seen, the UH-60A in this configuration just exceeds the 2 rad/sec boundary that prescribes the Level 1 region for "Air Combat" and "All Other MTEs – IMC and/or divided attention operations." Note, in ADS-33D-PRF the hover/low-speed aggressive agility requirements were under the category of Target Acquisition and Tracking, whereas the forward flight requirements were under Air Combat. In ADS-33E-PRF (ref. 21), the hover/low-speed and forward flight categories were unified under the Target Acquisition and Tracking name. When compared to the boundaries for "All other MTEs – VMC and fully attended operations," the aircraft has about a 1.0 rad/sec margin above the Level 1-2 boundary.

Mid-Term Response to Control Inputs. Paragraph 3.4.1.2 and figure 3(3.3) from reference 11 specify the requirements for the mid-term response characteristics for all frequencies below the bandwidth frequency. Use of an Attitude Hold response type constitutes compliance with this paragraph as long as any oscillatory modes following a pulse controller input have an effective damping ratio of at least 0.35. If Attitude Hold is not available, the applicable criterion depends on the degree of divided attention. For fully attended operations, the mid-term response requirements shall meet the requirements in figure 3(3.3) of reference 11. For divided attention operations, the limits of figure 3(3.3) shall be met, except that the Level 1 damping shall not be less than $\zeta = 0.35$ at any frequency.

Figure E-48 presents a time history plot for a longitudinal cyclic doublet from the internally ballasted aircraft configuration at 80 knots. As can be seen, after the doublet is removed the pitch rate response damps out very quickly with no oscillations and hence, meets the Level 1 requirements.

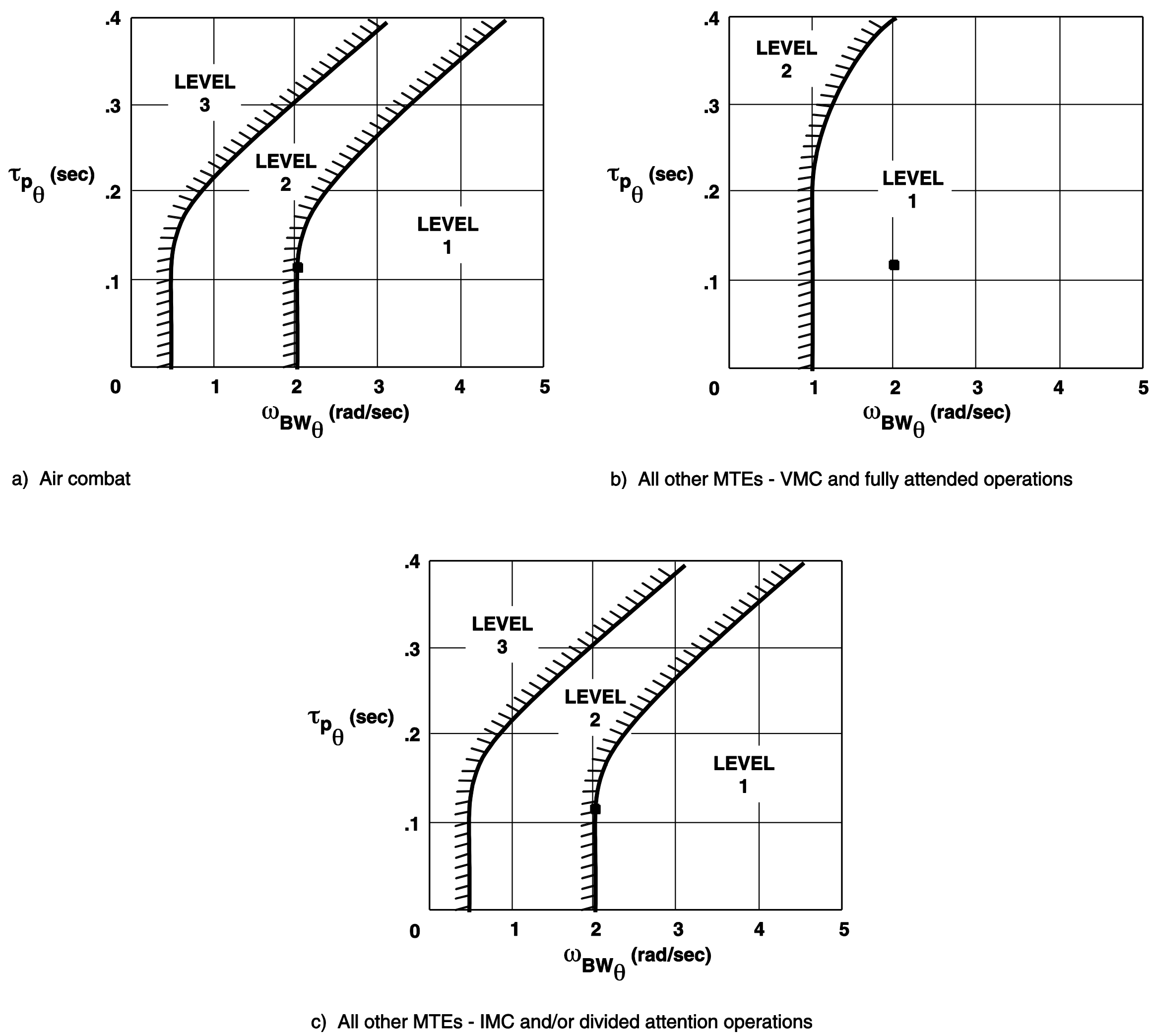


Figure 3.8 Small-Amplitude, Short-Term Response to Pitch Control Inputs (Bandwidth) in Forward Flight

3.4.3 Mid-Term Response – Maneuvering Stability

Paragraph 3.4.1.3 of reference 11 has two sub-paragraphs that define: (a) Control Feel and Stability in Maneuvering Flight at Constant Speed; and (b) Control Forces in Maneuvering Flight. Both of these will be discussed separately below.

Control Feel and Stability in Maneuvering Flight at Constant Speed. Reference 11 states that in steady turning flight at constant airspeed, and in pull-ups and pushovers, for Level 1 and Level 2 there shall be no tendency for the aircraft pitch attitude or angle of attack to diverge aperiodically. For the above conditions, the incremental control force required to maintain a change in normal load factor and pitch rate shall be in the same sense (aft – more positive; forward – more negative) as those required to initiate the change. These requirements apply for all local gradients throughout the range of operational and service load factors defined in paragraphs 2.9.1 and 2.9.2 of reference 11.

Data were collected in the internal ballast configuration at a nominal airspeed of 80 knots with the SAS/FPS and Trim ON. Data were collected in steady turns to the right and left and in pull-ups and pushovers, with examples shown in Figures E-49 through E-52. From the steady turn data, average longitudinal cyclic stick position and normal load factor were extracted over the duration of the maneuver. From the pull-ups and pushovers, the maximum and minimum values of stick position and load factor were extracted. Figure E-53 shows the longitudinal cyclic stick position versus load factor for the turns, pull-ups, and pushovers. Note, the figure shows control position and reference 11 stipulates control forces. However, since the Black Hawk has an irreversible servo and no feel augmentation or bobweight devices, the relationship between control position and forces is basically unique (except for friction and inertia effects). Figure E-53 shows a relatively linear relationship between control position and load factor. There was no tendency for the aircraft pitch attitude or angle of attack to diverge aperiodically and the incremental control required to maintain a change in normal load factor and pitch rate were in the same sense (i.e., aft – more positive; forward – more negative).

Control Forces in Maneuvering Flight. Reference 11 states that the variations in longitudinal control force with steady-state normal acceleration shall have no objectionable nonlinearities throughout the Operational Flight Envelope. At no time will a negative local gradient be permitted. In addition, deflection of the pilot's cockpit controller must not lead the control force at any frequency below 5 rad/sec. For Level 1 and centersticks, the local force gradient shall be no less than 3 lb/g and no greater than 15 lb/g. There are no criteria for Level 2 limits.

Although no Operational Flight Envelope is defined, there were no objectionable comments regarding nonlinearities in the longitudinal control forces with steady-state normal accelerations from any of the pilots while performing the MTEs. Since controller forces were not measured, there is no way to assess the requirement about deflection leading the control force at any frequency below 5 rad/sec. An estimation of the local force gradient was obtained by using Figure E-53 and the longitudinal controller force-displacement characteristics from reference 15. In reference 15, the force-displacement characteristics were measured on the ground (rotor static), hydraulic and electrical power ON, SAS/FPS and Trim ON, directional control centered, and with the collective in the full UP and DOWN positions. Combining these plots, Figures E-54 and E-55 show the longitudinal controller forces versus load factor for approximately 80 knots with the collective full-UP and full-DOWN, respectively. Also shown on these plots are the 3 and 15 lb/g local force gradient limits for Level 1. Note, the UH-60A is less than the 15 lb/g, but is marginal at being above 3 lb/g. Careful inspection reveals instances of local gradients below 3 lb/g.

3.4.4 Pitch Control Power

Paragraph 3.4.2 of reference 11 specifies that for Level 1, it shall be possible, from trimmed unaccelerated flight, to achieve the steady load factor specified in the Operational Flight Envelopes. For Level 2, there shall be sufficient pitch control authority to accelerate from 45 knots to the maximum level flight airspeed, and to decelerate back to 45 knots at constant altitude. As there is no Operational Flight Envelope defined, flight tests to demonstrate Level 1 were not performed. However, the Level 2 requirement was easily tested and met.

Figure E-56 presents a time history from the acceleration/deceleration from 45 knots to maximum level flight speed (V_h), and back to 45 knots. V_h (152 knots) was defined by 100% torque. This maneuver was performed with the FPS OFF.

3.4.5 Flight Path Control

Paragraph 3.4.3 of reference 11 specifies the requirements for flight path control. It states that the flight path response to collective or longitudinal cyclic control inputs shall not be objectionable to the pilot.

During the execution of the MTEs, no complaints were received from the pilots about objectionable coupling into flight path control from collective or longitudinal cyclic control inputs.

ADS-33E-PRF (ref. 21) was published after the flight test discussed herein. In this version, the flight path control requirements are subdivided into two criteria: one for flight path response to pitch attitude (front side of the power required curve), and one for the flight path response to collective controller (back side of the power required curve). The 80-knot flight condition was determined to be on the "front side." The front side requirements in reference 21 are as follows: the vertical rate response shall not lag the pitch attitude response, with collective controller held fixed, by more than 45 degrees at all frequencies below 0.40 rad/sec for Level 1 and 0.25 rad/sec for Level 2.

Figures E-57 and E-58 show the frequency responses generated using CIFER® from the longitudinal frequency sweeps. The low frequency coherence is good for both $\dot{h}$ and θ; however, there are no data below ~0.35 rad/sec. At 0.4 rad/sec, the Level 1 criteria are met with $\dot{h}$ lagging θ by 42.1 deg (−152.7 to −110.6 deg). It can be assumed that the phase lag is smaller at lower frequencies and thus, have satisfied the Level 1 requirement.

3.4.6 Interaxis Coupling

Paragraph 3.4.4 of reference 11 specifies that control inputs to achieve a response in one axis shall not result in objectionable responses in one or more of the other axes while performing any of the (forward flight) Mission Task Elements (MTEs). This shall hold for control inputs up to and including those required to perform any of the specified (forward flight) MTEs. Specific limits on interaxis coupling are given for collective-to-attitude and pitch-to-roll (and roll-to-pitch) for aggressive maneuvering. During the evaluation of the forward flight Slalom MTE, no objectionable comments were received from the pilots regarding off-axis responses.

Collective-to-Attitude Coupling. Requirements on collective-to-attitude coupling are established for small collective inputs (<20% of full travel) and for large collective inputs (≥20% of full travel). For the small collective inputs, paragraph 3.4.4.1.1 of reference 11 specifies that the peak change in pitch attitude occurring within the first three seconds following an abrupt change in collective shall be such that the absolute value of the ratio of peak attitude over peak normal acceleration shall be no greater than 3 $deg/m/sec^2$ ($1.0\ deg/ft/sec^2$). For the large collective inputs, paragraph 3.4.4.1.2 of reference 11 specifies the requirements in the same format except the limits are different: the ratio of peak attitude over peak normal acceleration shall be no greater than 1.5 $deg/m/sec^2$ ($0.5\ deg/ft/sec^2$) for up-collective and 0.76 $deg/m/sec^2$ ($0.25\ deg/ft/sec^2$) for down-collective. Additionally, the large collective input paragraph has requirements on autorotations to touchdown. However, autorotations were not performed as part of this test.

Figures E-59 through E-62 show example time histories from a small up- and down-collective input and from a large up- and down-collective input, respectively. The ratios of the peak attitude change over the peak normal acceleration are shown in Table 3.6. The UH-60A helicopter is well within the Level 1 limits.

Pitch-to-Roll and Roll-to-Pitch Coupling During Aggressive Maneuvering. Paragraph 3.4.4.2 of reference 11 specifies the coupling requirements between pitch and roll during aggressive maneuvering. These requirements apply for Ground Attack, Slalom, Pull-up/Push-over, Assault Landing, and Air Combat Mission Task Elements. The ratio of peak off-axis attitude response from trim within 4 seconds to the desired (on-axis) attitude response following an abrupt control step shall not exceed 25% for Level 1 and 60% for Level 2. Heading excursions shall be limited by use of the heading controller. These requirements shall hold for control inputs up to and including those required to perform the specified Mission Task Elements.

Table 3.6 Peak Normal Accelerations

run#	direction	size	Δ_theta (degrees)	Δ_nz (ft/sec^2)	Δ_theta /Δ_nz (deg-sec^2/ft)	L1 limit (deg-sec^2/ft)
21357	up	sm	1.0446	11.54	0.0905	1.00
21358	up	sm	0.3122	4.5466	0.0687	1.00
21359	up	sm	0.0747	3.05	0.0245	1.00
21360	down	sm	0.3452	1.3	0.2655	1.00
21361	down	sm	--	--	--	--
21362	down	sm	0.7702	6.31	0.1221	1.00
21363	down	sm	0.6377	7.82	0.0815	1.00
21364	up	lg	0.7276	12.52	0.0581	0.50
21365	up	lg	0.973	16.04	0.0607	0.50
21366	down	lg	1.1279	11.53	0.0978	0.25
21367	down	lg	1.5141	15.55	0.0974	0.25
21368	down	lg	2.4434	23.64	0.1034	0.25

As the Black Hawk performs Slaloms and Assault Landings, these pitch-roll requirements were considered applicable. Figures E-63 and E-64 show example time histories from longitudinal cyclic steps forward and aft, respectively. Figure 3.9 shows the resultant ratios of peak off-axis attitude response to the on-axis response for pitch up and down inputs for a range of attitude changes. The UH-60A is within the Level 1 limits for the data taken. Note that it was somewhat difficult to collect these data. The difficulty stems from two issues: holding the on-axis input for 4 seconds dictates a rather small input to avoid excessively large attitude changes (as the aircraft response is a rate command). The other issue is the need for a "precise" trim in the off-axis and no off-axis inputs during the on-axis step input. These difficulties necessitated multiple repetitions of the test points on the flight test card to collect adequate data.

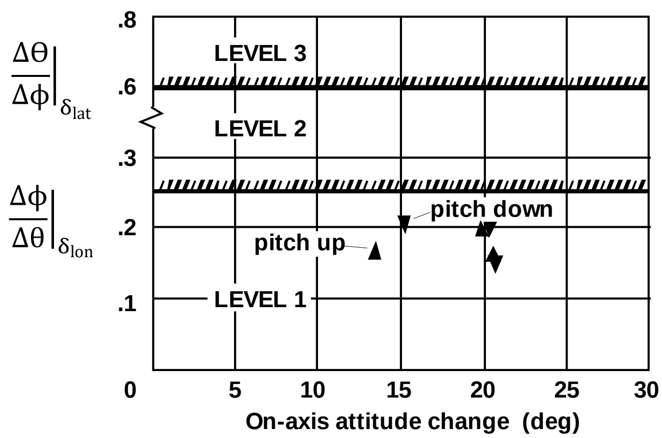


Figure 3.9 Pitch-Roll Coupling for the Internally Ballasted Configuration in Forward Flight (80 knots)

3.4.7 Roll Attitude Response to Lateral Controller

Small-Amplitude Roll Attitude Response to Control Inputs. Paragraph 3.4.5.1 and figure 2 (3.4) from reference 11 specifies roll-axis requirements for small-amplitude, short-term attitude changes to control inputs. The requirements are in terms of bandwidth and phase delay as defined in figure 2(3.3) of reference 11. The flight test technique to acquire the data consists of performing frequency sweeps on the primary pilot inceptors. The frequency sweep testing was performed according to techniques and guidelines outlined in reference 17. Three “good” sweeps per axis per flight condition were collected. The characterization of a “good” sweep is highlighted in the hover/low-speed section (Section 3.3.2 of this report). Before performing the frequency sweeps, the FPS and TRIM were turned off to eliminate correlated longitudinal and lateral cyclic inputs through the trim actuators due to roll-yaw and pitch-yaw coupling. Also, the horizontal stabilator control was set to: auto control ON.

Figure E-65 shows an example time history from a typical lateral cyclic frequency sweep. All the frequency sweep data were analyzed using CIFER® (ref. 18). Figure E-66 shows the resultant Bode plot. Shown in Figure 3.10 is the roll-axis short-term response to control (Bandwidth) results for the internally ballasted configuration in forward flight (80 knots). As can be seen, the UH-60A in this configuration exceeds the boundary that prescribes the Level 1 region for all categories. When compared to the boundaries for “All other MTEs – VMC and fully attended operations,” the aircraft has about a 2 rad/sec margin above the Level 1-2 boundary.

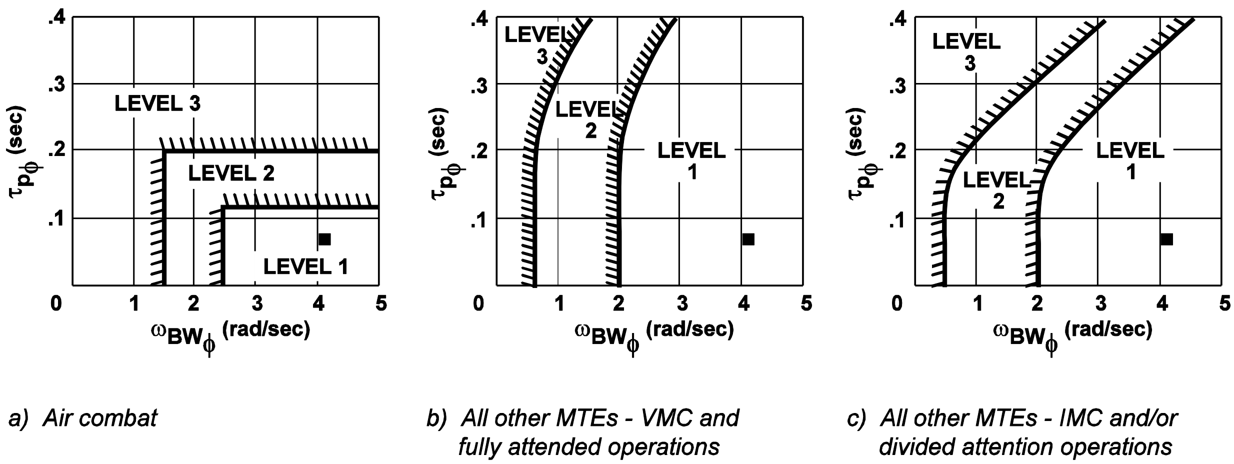


Figure 3.10 Small-Amplitude, Short-Term Response to Roll Control Inputs (Bandwidth) in Forward Flight

Moderate-Amplitude Attitude Changes. Paragraph 3.4.5.2 of reference 11 specifies the moderate-amplitude attitude changes (or Attitude Quickness) requirements for roll. This criterion is expressed as the ratio of peak angular rate to the change in angular attitude for rapid attitude changes from one steady attitude to another. The required attitude changes shall be made as rapidly as possible. It is not allowed to have significant control reversals in the sign of the cockpit controller input relative to the trim position. The initial attitudes and attitude changes required for compliance shall be representative of those encountered while performing the required MTEs.

Figures E-67 through E-69 show example time histories of the data collection for the Attitude Quickness specification for the internally ballasted configuration. Figure 3.11 presents the roll Attitude Quickness results at 80 knots. Data are shown for roll-left and roll-right inputs. The data are plotted on the “All Other MTEs” boundaries and shows that the UH-60A roll Attitude Quickness data are in the predicted Level 1 regions.

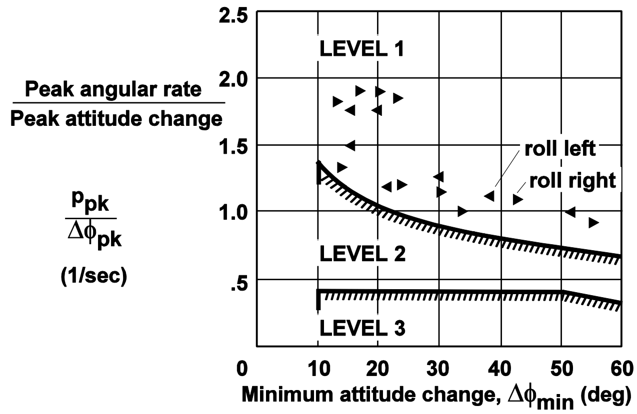


Figure 3.11 Roll Attitude Quickness, 80 knots

Large-Amplitude Roll Attitude Changes. Paragraph 3.4.5.3 of reference 11 specifies that the minimum achievable roll rate (for Rate Response-types) shall be no less than the limits specified in Table 2 (3.4) from reference 11. Yaw control may be used to reduce sideslip that retards roll rate (not to produce sideslip that augments roll rate).

Compliance testing for demonstrating a minimum achievable roll rate was performed in a build-up fashion. Initially, one-inch lateral cyclic steps were used. These were increased in half-inch increments up to a 3.5-inch right step and a 4.0-inch left step. Once the control inputs reached 2.5 inches in magnitude, the pilots trimmed the aircraft in a 20-degree bank in the opposite direction before making the control input. The test plan had a 60-degree limit on roll attitude, and trimming 20-degrees in the opposite direction allowed the roll rate to be achieved before the roll attitude limit was reached. Figures E-70 and E-71 show representative time histories from a right- and left-cyclic step input, respectively. At 80 knots, the UH-60A demonstrated the Level 1 minimum achievable roll rate of ±50 deg/sec for aggressive maneuvering in the internally ballasted configuration.

Linearity of Roll Response. Paragraph 3.4.5.4 of reference 11 specifies that there shall be no objectionable nonlinearities in the variation of rolling response with roll control deflection or force. During the conduct of data collection for the moderate- and large-amplitude roll attitude changes paragraphs, and during the MTE assessments, there were no pilot complaints about objectionable nonlinearities of the roll response.

3.4.8 Roll-Sideslip Coupling

The requirements on roll-sideslip coupling are contained in the *Bank Angle Oscillations* and the *Turn Coordination* paragraphs below. These requirements apply for both right and left lateral control inputs. The yaw controller shall remain free. The parameters used are defined in figure 4 (3.4) of reference 11.

Bank Angle Oscillations. Paragraph 3.4.6.1 of reference 11 specifies the value of the parameter $\varphi_{OSC}/\varphi_{AV}$ following a pulse lateral control command for Rate Response-Type shall be within the limits specified in figure 5 (3.4) (ref. 11) for Levels 1 and 2. The input shall be as abrupt as practical. For Levels 1 and 2, φ_{AV} shall always be in the direction of the lateral control command.

Time history data from the 80-knot roll-axis moderate-amplitude attitude changes (Attitude Quickness) were used as compliance data for this requirement. The roll Attitude Quickness control pulses were used because a standard control pulse input does not result in a steady state change in roll attitude for this aircraft. A standard control pulse input starts and ends at the trim value. For this aircraft, the Attitude

Quickness control pulses did not return to the initial trim value, but held an offset allowing the aircraft to achieve a steady-state roll attitude change from trim. Figure E-72 shows an example time history from the internally ballasted aircraft configuration at 80 knots. Using the Attitude Quickness control pulses, the parameter $\varphi_{OSC}/\varphi_{AV}$ was approximately 0.02 to 0.04; this is well within the Level 1 limits. Also, because the value is less than 0.05, it makes no difference by how much roll rate leads or lags the sideslip.

Turn Coordination. Paragraph 3.4.6.2 of reference 11 specifies that the amount of sideslip resulting from abrupt lateral control commands shall not be excessive or require complicated or objectionable directional control coordination. Also, the ratio of the maximum change in sideslip angle to the initial peak magnitude in roll response, $|\Delta\beta/\varphi_1|$, for an abrupt lateral control pulse command for Rate Response-Types shall not exceed the limit specified on figure 6(3.4). In addition, $|\Delta\beta/\varphi_1|$ x $|\varphi/\beta|_d$ shall not exceed the limit specified on figure 7(3.4) in reference 11.

During the testing, no pilot complained of excessive sideslip or complicated/objectionable directional control inputs. Although during the Slalom MTE, some pilots complained of sloppy turn coordination and the need to use pedals. Using the same Attitude Quickness time histories used for the Bank Angle Oscillations requirements above, the Level 1 turn coordination requirement was satisfied at all times, with $|\Delta\beta/\varphi_1|$ equal to approximately 0.3.

3.4.9 Yaw Response to Yaw Controller

Small-Amplitude (Bandwidth) Yaw Response for Air Combat. Paragraph 3.4.7.1 of reference 11 specifies the heading response to cockpit yaw control force or position inputs shall meet the limits specified in figure 8 (3.4). The bandwidth and phase delay parameters are obtained from frequency responses as defined in figure 2(3.3) in reference 11. A discussion of frequency sweep techniques and data analysis is discussed in Section 3.3.2 of this document.

Even though the UH-60A was not designed for air combat, yaw controller sweeps were easily performed to characterize the response. Data were collected on a very calm day with the internally ballasted configuration at 80 knots. For these yaw-axis sweeps, the FPS was turned OFF and the stabilator was left in the AUTO position. The yaw controller sweeps were performed from the left-seated pilot, while the right-seated pilot tried to maintain the aircraft about trim using the cyclic controls.

Figure E-73 shows an example time history from a yaw controller frequency sweep. Figure E-74 shows the Bode plot from the yaw controller sweeps and Figure 3.12 shows the resultant response characteristics on the specified limits of figure 8(3.4) (ref. 11). As can be seen, the aircraft yaw response almost meets the Level 1 requirements for air combat.

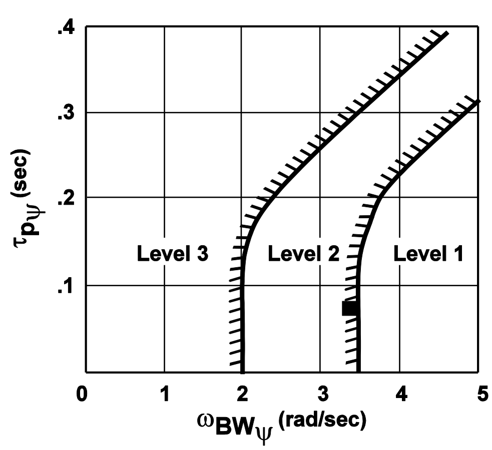


Figure 3.12 Small-Amplitude, Short-Term Yaw Response (Bandwidth) for Air Combat

Large-Amplitude Heading Changes. Paragraph 3.4.7.2 of reference 11 specifies that the heading change following an abrupt step displacement of the yaw control, with all other cockpit controls fixed, shall not be less than: (for Level 1) the lesser of 16 degrees or the sideslip limit; (for Level 2) the lesser of 8 degrees or one-half of the sideslip limit; and (for Level 3) the lesser of 4 degrees or one-quarter of the sideslip limit. The sideslip limit is typically defined by the Operational Flight Envelope; however, as an OFE is not defined for the UH-60A, the steady state sideslip limit was obtained from reference 23: approximately 28 degrees at 80 knots.

Figure E-75 and E-76 show example time histories from abrupt step displacement of the yaw controller at 80 knots with the internal ballast configuration. The other cockpit controls appear to remain nearly constant during the pedal step. From the nose-left yaw-controller step input, the sideslip angle reaches approximately 21 degrees before recovery. For the nose-right yaw-controller input, the initial trim sideslip was non-zero (4–6 deg). Following the nose-right step input, the sideslip reaches approximately 25 degrees. These sideslip excursions exceed the Level 1 minimum of 16 degrees.

In reference 21, the Large-Amplitude Heading Changes requirement was modified to demand the above mentioned sideslip changes be achieved in one second following the step displacement of the yaw controller. This was the original intent of the requirement. In addition, this requirement has been made applicable to only the Aggressive agility rather than all degrees of agility. In reference 21, the utility rotorcraft category specifies Aggressive agility for four utility maneuvers: Deceleration to Dash; Transient Turn; Pull-up/Push-over; and Roll Reversal. For the nose-left input in figure 1 (3.4.7.2), the approximately 18% pedal step results in a one-second later sideslip of about 8 degrees. For the nose-right input in figure 2 (3.4.7.2), the approximately 18% pedal step results in a one-second later sideslip of about 7 degrees. It is not known whether a larger input would have produced a correspondingly larger sideslip angle within one second.

Linearity of Response. Paragraph 3.4.7.3 of reference 11 states that there shall be no objectionable nonlinearities in the variation of directional response with yaw control deflection or force. During the conduct of the test, no objectionable comments were made regarding nonlinearities in the variation in directional response.

Yaw Control with Speed Changes. Paragraph 3.4.7.4 of reference 11 states that with the rotorcraft initially trimmed directionally, it shall be possible to maintain heading constant with the yaw controller, with no perceptible change in bank angle, over a speed range of ±30 percent of the trim speed or ±20 knots, whichever is less. For pedal controller, the yaw control forces shall not be greater than one-half those of table 4(3.6) in reference 11. These requirements must be satisfied without re-trimming, and should be accomplished at constant power (altitude varies), and at constant altitude (power varies).

Figures E-77 and E-78 show example time history plots for the internal ballast configuration with an initial trim speed of about 80 knots. Figure E-77 shows a deceleration from 83 knots to 68 knots for a constant power setting. Figure E-78 shows an acceleration from 85 knots to 112 knots for a constant altitude. Table 3.7 presents the data for the six data runs performed. The pedal displacement changes for all of these speed-change data runs varied between 0.09 and 0.33 inches. Based on the pedal force-feel characteristics (ref. 15), these displacement changes should result in pedal force changes of approximately two to three pounds, which is an order of magnitude less than one-half those of Table 4(3.6). The UH-60A easily meets the Level 1 requirement.

Table 3.7 Acceleration Data

run#		const	V_start (kts)	V_end (kts)	V_final (kts)	t_80 (sec)	pedal_diff (in)	%pedal_diff
21428	decel	pwr	80.88	65.99	x	5	0.32	5.64
21429	decel	pwr	83.06	68.21	x	8	0.22	3.84
21430	decel	alt	83.30	64.92	x	7	0.12	2.10
21431	accel	pwr	81.64	122.61	101.64	8	0.33	5.89
21432	accel	alt	81.75	114.67	101.75	4	0.09	1.66
21433	accel	alt	85.23	111.94	105.23	8	0.05	0.80

3.4.10 Lateral-Directional Stability

Lateral-Directional Oscillations. Paragraph 3.4.8.1 of reference 11 specifies that the frequency, ω_n, and damping ratio, ζ, of the lateral-directional oscillations following a yaw control doublet shall exceed the minimums specified on figure 9(3.4) in reference 11. The requirements shall be met with the controls fixed and with them free for oscillations of any magnitude that might be experienced in operational use. If the oscillation is nonlinear with amplitude, the requirements shall apply to each cycle of the oscillation.

Figure E-79 shows an example time history for a yaw control doublet at 80 knots in the internally ballasted aircraft configuration. Lateral-directional oscillations are essentially non-existent, and therefore the UH-60A meets the Level 1 requirements.

However, when a lateral control pulse was applied during the same flight, a small, very lightly damped oscillation occurred. Figures E-80 and E-81 show these results for a 12% and 24% magnitude lateral control pulse, respectively. Both input magnitudes generated the same oscillations. Using the methods described in appendix B of reference 22, these high-frequency oscillations were calculated to have a natural frequency, ω_n, of about 6.5 rad/sec, and a damping ratio, ζ, of about 0.04. These high-frequency, low-amplitude oscillations are not the target of the Lateral-Directional Oscillation requirements, but fall into the Residual Oscillations requirements from reference 11. These were also observed in the Hover data (see Mid-Term Response to Control Inputs, 3.3.2). The pilots were specifically questioned about this oscillation, and they responded by saying that it was not noticed. However, there was a comment about roll oscillations while performing the Slalom MTE, but the pilot stated he was not compensating for this oscillation. Hence, this Residual Oscillation in forward flight did not appear to interfere with pilot's ability to perform the Slalom MTE. This small, relatively high-frequency oscillation appeared occasionally throughout this flight test campaign.

Spiral Stability. Paragraph 3.4.8.2 of reference 11 specifies that following a lateral pulse control input, the time for the bank angle to double amplitude shall be greater than: 20 seconds for Level 1; 12 seconds for Level 2; and 4 seconds for Level 3. These requirements shall be met with the cockpit controls free and the aircraft trimmed for straight and level flight. The values specified apply to an exponential divergence and should not depend on the size of the control input. If the variation in roll angle with time is linear following the pulse control input, this requirement is satisfied.

Using the lateral pulse control input data in Figures E-80 and E-81, the bank angle returns to the trim value and does not diverge within 20 seconds. Therefore, the UH-60A meets the Level 1 requirement for spiral stability.

3.4.11 Lateral-Directional Characteristics in Steady Sideslips

The following sideslip requirements are expressed in terms of characteristics in yaw-control-induced, steady zero-yaw-rate sideslips with the aircraft trimmed for straight and level flight. Sideslip angles to be demonstrated shall be to the limits of the Operational Flight Envelope (OFE).

Yaw Control in Steady Sideslips. Paragraph 3.4.9.1 of reference 11 states that for the sideslips specified above, right yaw control deflection and force shall be required in left sideslips and left yaw control deflection and force shall be required in right sideslips. For Levels 1 and 2, the following requirements apply: between sideslip angles of ±15 degrees, or the sideslip limit of the OFE, whichever is less, the variation of yaw controller deflection and force shall be essentially linear with sideslip.

For larger sideslip angles, an increase in yaw control deflection shall be required for an increase in sideslip, and the following requirements shall apply: (Level 1) The gradient of sideslip angle with yaw control force shall not reverse slope; (Level 2) The gradient of sideslip angle with yaw control force is permitted to reverse slope provided the sign of the yaw control force does not reverse. The term gradient does not include that portion of the yaw control force versus sideslip-angle curve within the preloaded breakout force or friction band.

Steady sideslips were performed over a range of about ±15 degrees. Figure E-82 presents the trim control positions and sideslip/bank angles for the internally ballasted aircraft configuration at 80 knots. The force-feel characteristics were not measured; however, the yaw control deflection is linear with sideslip angle for the angles achieved. The aircraft meets the Level 1 requirements for the sideslip angles evaluated.

Bank Angle in Steady Sideslips. Paragraph 3.4.9.2 of reference 11 states that for the sideslips specified above, an increase in right bank angle shall accompany an increase in right sideslip, and an increase in left bank angle shall accompany an increase in left sideslip. As presented in Figure E-82, the aircraft meets the stated requirement.

Lateral Control in Steady Sideslips. Paragraph 3.4.9.3 of reference 11 states that for the sideslips specified above, left lateral control deflection and force shall be required in left sideslips and right control deflection and force shall be required in right sideslips. For Level 1 and 2, the variation of lateral control deflection and force with sideslip angle shall be essentially linear. Again, from Figure E-82, the aircraft meets the stated requirement for lateral control in steady sideslips and is very linear.

Positive Effective Dihedral Limit. Paragraph 3.4.9.3.1 of reference 11 states that for Level 1, positive effective dihedral (right roll control for right sideslip and left roll control for left sideslip) shall never be so great that more than 75% of the roll control power available to the pilot and no more than 11 pounds of roll control force are required for sideslip angles which might be experienced in performing the required Mission Task Elements. The corresponding limits for Level 2 shall be 90% and 13.5 pounds.

From Figure E-82, the total variation in roll control (lateral cyclic) is approximately ±5% for the range of sideslip angles investigated (~ ±15 deg). This is well within the 75% roll control power limit. Also, from the lateral cyclic force-feel characteristics in reference 15, it appears that this ±5% of lateral control movement would translate into approximately ±0.5 pounds of force (not accounting for preloaded breakout force or friction band). Even if the breakout force were included (on the order of ±0.7 pounds), the total roll control force would be well below the 11-pound limit. The UH-60A helicopter meets the Level 1 limits for positive effective dihedral.

Pitch, Roll, and Yaw Responses to Disturbance Inputs. During this test, it was not possible to insert an input directly into the control surface actuator. Hence, this requirement was not assessed.

The remaining quantitative requirements in Section 3 of ADS-33 include Controller Characteristics, Specific Failures, Transfer Between Response Types, and Ground Handling and Ditching Characteristics. The Controller Characteristics may be found in reference 15. For the UH-60A, there is only one control response type, and so the Transfer Between Response Types was not applicable. The Specific Failures (3.7) and Ground Handling and Ditching Characteristics (3.9) were not assessed during this test campaign.

4 Flight Test Maneuvers

4.1 General

The flight test maneuvers are to provide an overall assessment of the rotorcraft's handling qualities for specific critical maneuvers. These maneuvers correspond to Mission Task Elements (MTEs) specified in the required response-type tables of reference 11 for hover and low speed (table 1(3.2) from ref. 11) and forward flight (table 2(3.2) from ref. 11). The purpose of these flight test maneuvers is to confirm that an aircraft whose handling qualities are predicted to be Level 1 from the assigned quantitative data (Section 3 of ref. 11) would demonstrate Level 1 handling qualities from the qualitative data (Section 4 of ref. 11). The qualitative data do not take precedence over the quantitative data from Section 3. For example, predicted Level 2 yaw response should not be discounted just because assigned Level 1 ratings were provided for the Hover MTE (the Hover MTE may not expose yaw axis issues). Additionally, the qualitative flight test maneuvers can highlight problem areas that may appear only while maneuvering of the aircraft from trim, or may highlight insufficient quantitative criteria.

The flight test maneuvers in reference 11 are divided into five categories: precision tasks in the good visual environment; aggressive tasks in the good visual environment; decelerating approach in instrument meteorological conditions (IMC); precision tasks in the Degraded Visual Environment (DVE); and moderately aggressive tasks in the Degraded Visual Environment. For the ADS-33 assessment using the UH-60A helicopter, only a subset of the Good Visual Environment maneuvers was evaluated. It was not possible to assess the IMC tasks or the DVE tasks. For example, Moffett Federal Airfield is at the southern end of the San Francisco bay and is surrounded with urban "sprawl." This provides an abundance of ambient light, and most notably, an excellent horizon reference line, which is not representative of the DVE.

The development of the Section 4 maneuvers specific to the utility rotorcraft occurred in two phases of the test campaign. Initially, the ADS-33D-PRF (ref. 11) flight test maneuvers were flown with the aircraft empty to assess applicability. Subsequently, these maneuvers were evaluated with the aircraft in a representative mission weight to assess the maneuver performance standards. In addition, some of the maneuvers were evaluated with an external slung load. From the initial flight testing, the following maneuvers were considered either inappropriate or too aggressive for utility helicopters: Vertical Remask, Acceleration and Deceleration, Sidestep, Turn-to-Target, and the High and Low Yo-Yo maneuvers. Two new maneuvers from the Cargo helicopter evaluation (refs. 8 and 9), the Depart/Abort and Lateral Reposition maneuvers were evaluated and found to be appropriate for the Utility class of helicopters. A third new maneuver from Cargo helicopter evaluation, the Forward Flight Maneuvering MTE, was evaluated and found to be too long duration and not very enlightening of handling quality issues or problems. The following maneuvers were not evaluated: Landing, Deceleration to Dash, Transient Turn, Pull-up/Push-over, and Roll Reversal at Reduced and Elevated Load Factors.

As a starting point, the maneuver performance standards for these Utility-class maneuvers were taken from the Cargo-class maneuvers developed during the CH-47D flight tests (refs. 8 and 9). Guidance on setting task performance standards was provided by Mr. David Key and is contained in Appendix D. The evaluation pilots were highly qualified U.S. Army and Navy test pilots with extensive experience flying the H-60. In addition, several of these test pilots were instructors at the U.S. Navy Test Pilot School. Hence, the pilots were highly qualified and had an excellent basis to correlate the achieved maneuver performance with the aircraft's mission effectiveness. During the maneuver assessment phase, a few of the CH-47D recommended maneuver performance standards were changed. These will be discussed below for the applicable maneuvers.

ADS-33D-PRF states that all of the ground-referenced MTEs shall be performed in calm wind conditions (steady component less than 5 knots). In addition, it specifies the Hover, Hovering Turn, Pirouette, and the Vertical Maneuver shall also be performed in a moderate wind (steady wind component between 20 and 35 knots) from the most critical direction. If the critical wind direction has not been defined, then the maneuver shall be accomplished with the wind blowing from the rear of the aircraft. For the maneuver development and assessments in the UH-60A, the winds were either calm or light (steady wind component between 10 and 15 knots). The courses for the MTEs were set up on the best available airfield space; this allowed the courses to be set up for the entire duration of the test program. However, the courses were not arranged specifically to align with the wind to be from the most critical direction. In reality, with the visiting evaluation pilots, the maneuvers were assessed in whatever wind conditions (≤ 15 knots) were present on that day.

During the maneuver development, the UH-60A handling qualities were concurrently evaluated. During the performance of the maneuvers, the laser tracker system provided task performance data in real time. This task performance data was provided to the pilot after each evaluation run and prior to the HQR. The procedures for the conduct of the assessment included practice runs on the courses until the pilot's control strategy and task performance were consistent. Then, at least three formal data runs were collected prior to the comments and HQR. The formal questionnaire used to elicit pilot comments is contained in Appendix F. The pilot questionnaire was a valuable guide toward obtaining comprehensive and systematic commentary to accompany the HQRs.

4.2 Precision Tasks in the Good Visual Environment

4.2.1 Hover

The objectives of the Hover maneuver are to check the ability to transition from translating flight to a stabilized hover with precision and an acceptable level of aggressiveness. In addition, the maneuver checks the ability to maintain a precise hover position, heading, and altitude in the presence of winds. The maneuver description for the UH-60A flight assessment of ADS-33 was as follows: from a hover, the pilot initiates a translation between 6–10 knots, at a (radar) altitude of 17 ft toward a precision hover point. This precision hover point was about 40 degrees relative to the aircraft heading. (The ADS-33 calls for this to be approximately 45 degrees; however, the UH-60A has a "door post" that blocks the pilot's view between 48 and 68 degrees (zero degrees being straight ahead). Since the recommended heading tolerance for the maneuver was ±5 degrees, it was considered acceptable to rotate the 45-degree lead-in angle to 40 degrees in order to get the ground course cues for the lead-in to the precision hover point visible to the pilot through the front window.) The maneuver terminates in a precision hover after the translation. The deceleration from 6–10 knots to a stable precision hover shall be accomplished within a short time. Then the pilot shall maintain this precision hover for 30 seconds. The maneuver is performed with and without an external slung load. During the maneuver applicability assessment, the evaluation pilots felt the CH-47D recommended heading tolerances (±5 deg for Desired, and ±10 deg for Adequate performance) were a bit too lenient. Consequently, they recommended that the heading tolerances for utility-class rotorcraft should be ±3 degrees for Desired and ±7 degrees for Adequate. The performance standards for this maneuver are summarized in Table 4.1.

Table 4.1 Hover – Performance

Desired Performance	Cargo/Utility	External Slung Load
• Attain a stabilized hover with X seconds of initiation of the deceleration:	5 sec	10 sec
• Maintain a stabilized hover for at least:	30 sec	30 sec
• Maintain the longitudinal and lateral position within ±X ft of a point on the ground:	3 ft	3 ft
• Maintain altitude within ±X ft:	2 ft	2 ft
• Maintain heading within ±X degrees:	3 deg	3 deg
• There shall be no objectionable oscillations in any axis either during the stabilized hover, or the transition to hover	✓	✓
Adequate Performance		
• Attain a stabilized hover with X seconds of initiation of the deceleration:	8 sec	15 sec
• Maintain a stabilized hover for at least:	30 sec	30 sec
• Maintain the longitudinal and lateral position within ±X ft of a point on the ground:	6 ft	6 ft
• Maintain altitude within ±X ft:	4 ft	4 ft
• Maintain heading within ±X degrees:	7 deg	7 deg

The course for the Hover MTE is shown in Appendix D. Compared to the suggested course layout in ADS-33, the hover board and target were quite far away from the precision hover point. This increase in distance was to take advantage of an existing support structure on which to hang the hover boards at an altitude closer to the pilot's eye height, as opposed to placing the hover board on the ground. It has been noted from other tests that by having the hover board on the ground, the pilot is only able to obtain altitude cue information from the board when the precision hover point is reached. By having the hover board elevated, the pilot can obtain altitude information during the 6–10 knot translation to the precision hover point. That is, the pilot is able to monitor and control altitude during the translation so the aircraft altitude is within the desired tolerance at arrival to the precision hover point, then the entire time-to-stabilize the aircraft to a hover can be used to get the horizontal axes "stable" and the aircraft over the hover point. If the aircraft arrives at the precision hover point not at the desired altitude, the pilot, in addition to getting the horizontal axes stable, must also monitor/adjust the heave axis and then the 5-second time to stabilize may be insufficient, and thus the HQRs may be degraded. The 6–10 knot translation speed was called out by the copilot using the aircraft's inertial navigation system.

The Hover MTE was performed in three aircraft configurations: empty, with an internal load, and with an external slung load. The empty and external load configurations were flown in calm and light wind conditions, whereas the internally ballasted configuration was evaluated only in calm wind conditions. Complete pilot comments for the Hover MTE in all configurations and applicable wind conditions are contained in Appendix F. In general, the pilots were able to achieve desired performance on all the maneuver performance standards. The exception was the external slung load configuration in light winds. The combination of the external slung load and winds caused many "small oscillations that were relatively difficult to counter in a precise manner," and hence only adequate performance could be achieved. Comments from the pilots on the aggressiveness and precision with which the maneuver could be performed varied from "fairly aggressive" to "it's not a very aggressive maneuver." The exception was the external slung load configuration evaluated in light winds: the pilot had difficulty controlling speed on the translation to the precision hover point and precision was difficult to maintain because of the slow development of rates. Describing the aircraft characteristics, in general, the pilots did not have issues with the controller force characteristics, the predictability of the initial response, any mid- to long-term response problems, or any non-linearity of response issues. However, some pilots did complain of roll oscillations and disharmony between the pitch and roll responses. The roll oscillations were likely amplified by the external slung load. One pilot, when discussing the roll oscillations, mentioned small lateral cyclic inputs (quarter to a half-inch) at 1-2 hertz for about 5-seconds until the oscillations subsided. As far as pilot control strategies, some pilots kept their feet OFF of the pedals, thus letting the heading hold system keep the heading within desired constraints. Other pilots kept their feet ON the pedals claiming it was "like I fly for a real mission" and therefore, they had to monitor/control heading during the maneuver. The latter technique would seem to potentially increase pilot workload. For example, one pilot commented, "…I had my feet off the pedals … and that eliminated any heading oscillation."

The HQRs for the Hover MTE are presented in Figure 4.1. In general, the HQRs were degraded by one rating point in the light wind conditions compared to the calm conditions. Even though the task performance standards are somewhat relaxed for the external slung load configurations, the HQRs are slightly degraded compared to the non-external-load configurations. For the calm wind conditions, the HQRs mainly fall into the Level 1 region of the Cooper-Harper Handling Quality Rating scale (HQR≤3.5). Figure E-83 presents a sample time history from a data collection run for the Hover MTE in the internally ballasted configuration in calm winds. Most of the pilots commented that the critical sub phase, in terms of the HQR, for this MTE was the deceleration to hover. That is, getting all the cues lined up at the end of the deceleration and being able to call "stable" within 5 seconds was the highest workload. A few other pilots complained the highest workload came in monitoring and controlling the vertical axis. For the cases with an external slung load, the pilots agreed that the external slung load had a significant effect on the HQR, with the main effects being the load oscillations. One pilot commented that the external load oscillations were the cause of aircraft translations without attitude changes, making it somewhat difficult to sense/predict position errors.

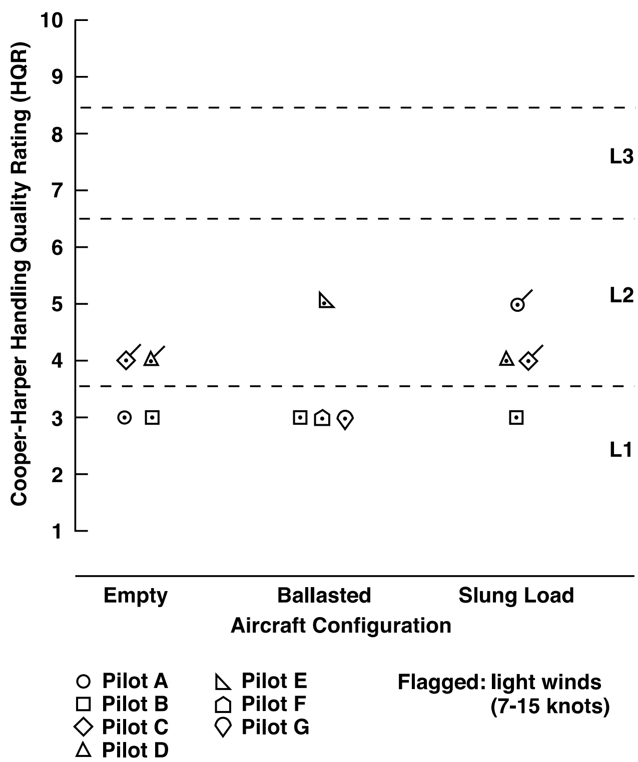


Figure 4.1 Hover MTE Handling Quality Ratings

4.2.2 Hovering Turn

The objectives of the Hovering Turn maneuver are to check for undesirable handling qualities in a moderately aggressive hovering turn, to check the ability to recover from a moderate rate hovering turn with reasonable precision, and to check for undesirable interaxis coupling. The maneuver description for the UH-60 flight assessment of ADS-33D-PRF was as follows: from a stabilized hover at an altitude (radar) of 17 feet, complete a 180-degree turn about the mast of the aircraft. The final position is the target point for the Hover MTE. Perform the maneuver in both directions and in calm and light winds. The Hovering Turn MTE used the Hover MTE course with extra markers placed in the 12 and 3 o'clock position relative to the initial heading of the aircraft. These extra markers were aligned with the pilot's seat. The maneuver began with the aircraft lined-up on these extra markers, one set in front of the pilot to provide lateral drift information and other set to the pilot's immediate right, providing fore-aft drift information. In this initial position, the hover target and board were located at the aircraft's 6 o'clock position.

During the ADS-33D flight assessment with a CH-47D, the aircraft rotation point for the Hovering Turn was varied between the aircraft center, the aircraft tail, and the pilot station. After several iterations, the CH-47D test team "felt turning about the pilot station would be most mission representative if done at a moderately aggressive rate." During the ADS-33D-PRF flight assessment with a UH-60A, the test team quickly agreed that the turn should be performed about the aircraft center, or rotor mast. Choosing the aircraft center should minimize cross-control inputs and allow evaluation of the aircraft's single-axis yaw response.

The course for the Hovering Turn MTE is shown in Appendix D. The performance standards for this maneuver are provided in Table 4.2. Note, the performance standards were the same with and without an external slung load.

Table 4.2 Hovering Turn – Performance

Desired Performance	**Cargo/Utility**	**External Slung Load**
• Maintain the longitudinal and lateral position within ±X ft of a point on the ground:	3 ft	3 ft
• Maintain altitude within ±X ft:	3 ft	3 ft
• Perform a 180-degree heading change within ±X deg.:	5 deg	5 deg
• Complete the turn to a stabilized hover (within the ±5 deg. window) within X seconds from initiation of the maneuver:	15 sec	15 sec
Adequate Performance		
• Maintain the longitudinal and lateral position within ±X ft of a point on the ground:	6 ft	6 ft
• Maintain altitude within ±X ft:	6 ft	6 ft
• Perform a 180-degree heading change within ±X deg.:	10 deg	10 deg
• Complete the turn to a stabilized hover (within the ±5 deg. window) within X seconds from initiation of the maneuver:	20 sec	20 sec

The Hovering Turn MTE was performed in the empty and external slung load configurations in calm and light wind conditions, and in the internally loaded configuration in calm winds only. Complete pilot comments for the Hovering Turn MTE in all the configurations and wind conditions evaluated are contained in Appendix F. For all the configurations, the pilots, in general, were able to achieve desired performance on all the maneuver performance standards.

Figure E-84 presents a sample time history from a data collection run to the right for the Hovering Turn MTE in the internally loaded configuration in calm winds. Some pilots commented that the longitudinal desired tolerances were difficult to achieve due to poor cueing during the turn. Also, some pilots mentioned that capturing the final heading was a driving factor in terms of maneuver performance with a tendency to overshoot approximately 6–10 deg on the final heading. The pilots commented that the task is not an aggressive task. In fact, some pilots thought it was more important to "enter" and "exit" the turn in a smooth manner. This minimizes position excursions and heading overshoot at the end of the maneuver. One pilot, evaluating the internal ballast configuration, summarized these impressions as follows: "it's not an unusually aggressive maneuver to stay within the time standards, but the precision with which to capture the final heading and maintain other parameters is difficult because of the predictability of the yaw response to a given pedal input. There appears to be some other coupling that's involved as you have to make a large pedal input to get stopped in time, there appears to be some pitch-to-roll or some yaw-to-roll coupling that gets you in trouble in terms of roll oscillations to meet your lateral standards."

The HQRs for the Hovering Turn MTE are presented in Figure 4.2. The HQRs mainly fall into the Level 2 region. The effects of a light wind tend to degrade the handling qualities by about one rating point. The effect of the external slung load configuration, compared to the internally loaded configuration, also tends to degrade the handling qualities by a little less than one rating. The majority of the pilots considered the level of difficulty of turning to the right or left to be about the same. However, two pilots thought going to the right was more difficult than going to the left. Initially, this was somewhat surprising since turning to the right allows the pilot to see the final hover point out the right window as the turn is in progress, whereas, turning to the left, the pilot must look "cross-cockpit" to pick up the final hover point. Upon further questioning, the pilots commented that in turning to the right, the pilot was "blind" to the longitudinal position cues until the turn was almost complete. Whereas, turning to the left, the pilot was able to pick out longitudinal position cues 90 degrees into the turn, and these remained within his peripheral vision through the rest of the turn.

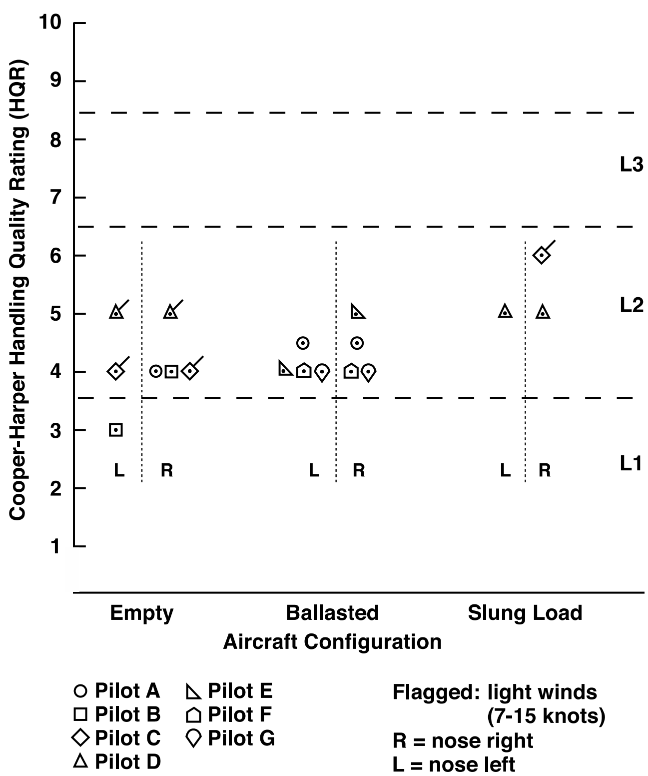


Figure 4.2 Hovering Turn MTE Handling Quality Ratings

4.2.3 Pirouette

The objectives for the Pirouette maneuver are to check the ability to: accomplish precision control of the rotorcraft simultaneously in pitch, roll, yaw, and heave axes; and control the rotorcraft precisely in a moderate wind that is continuously varying in direction relative to the rotorcraft heading. The maneuver is initiated from a stable hover over a point on the circumference of 100-ft radius circle with the nose of the aircraft pointed at the center reference point, and at a hover altitude of approximately 14 ft. Accomplish a lateral translation around the circle, keeping the nose of the aircraft pointed at the center of the circle, and the circumference of circle under a selected point on the helicopter. Maintain essentially constant lateral groundspeed throughout the lateral translation. Terminate the maneuver with a stabilized hover over the starting point. Perform the maneuver in both directions and in calm and in light winds.

Based upon lessons learned from the CH-47D tests, four concentric circles were painted on the taxiway to denote the "Desired-Adequate" boundaries for traveling around the circle. Also, a pole with an orange bucket on top was placed in the center of the Pirouette circle at half the "Desired" altitude to provide altitude cuing for the pilot by aligning this bucket with the painted taxiway circles. The course for the Pirouette MTE is shown in Appendix D. The performance standards for this maneuver are given in Table 4.3. Note, the performance standards were the same with and without an external slung load.

Table 4.3 Pirouette – Performance

Desired Performance	**Cargo/Utility**	**External Slung Load**
• Maintain a selected reference point on the rotorcraft within ±X ft of the circumference of the circle:	10 ft	10 ft
• Maintain altitude within ±X ft:	3 ft	3 ft
• Maintain heading so that the nose of the rotorcraft points at the center of the circle within ±X deg:	10 deg	10 deg
• Complete the circle and arrive back over the starting point within:	45 sec	45 sec
• Achieve a stabilized hover (within ±10 ft) within X seconds after returning to the starting point:	5 sec	5 sec
• Maintain the stabilized hover for X seconds:	5 sec	5 sec
Adequate Performance		
• Maintain a selected reference point on the rotorcraft within ±X ft of the circumference of the circle:	15 ft	15 ft
• Maintain altitude within ±X ft:	10 ft	10 ft
• Maintain heading so that the nose of the rotorcraft points at the center of the circle within ±X deg:	15 deg	15 deg
• Complete the circle and arrive back over the starting point within:	60 sec	60 sec
• Achieve a stabilized hover (within ±10 ft) within X seconds after returning to the starting point:	10 sec	10 sec
• Maintain the stabilized hover for X seconds:	5 sec	5 sec

During the initial maneuver assessment phase, several recommendations were made. One pilot recommended that directional cueing lines be added to the center of the circle, like spokes emanating from the center of wheel. Other pilots felt the center pole was sufficient for directional cueing, and so these lines were not added. Another recommendation was to require the pilots to use the cues from the direction in which they are traveling. That is, when in the right seat and flying the Pirouette to the left, the pilot should use the circle-cues to his left and not look to the right (behind his direction of travel) as this technique is totally unrealistic due to normal safety considerations. One problem with this latter recommendation is the reduction in cueing by having to look cross-cockpit. Perhaps for a cockpit with side-by-side seating, the evaluation pilot should be allowed to sit in the left seat when performing maneuvers to the left so as to reduce detrimental cueing effects on the handling qualities rating.

The Pirouette MTE was performed in the empty and internal load configurations in calm and light wind conditions, and in the external load configuration in calm winds only. Complete pilot comments for the Pirouette MTE in all the configurations and wind conditions evaluated are contained in Appendix F. For nearly all the configurations, the pilots, in general, were not able to achieve desired performance on all the maneuver performance standards. Of course there were a few exceptions, but generally, the pilots were into adequate performance on one or more of the performance parameters. This is exacerbated with winds and going to the left. Figure E-85 presents a sample time history from a data collection run to the right for the Pirouette MTE in the internally loaded configuration in calm winds.

From the pilot comments, the pilots felt the Pirouette maneuver was an aggressive task. One pilot thought increasing the aggressiveness tended to push one or more of the maneuver performance standards out of the desired range. On the other hand, a couple pilots observed that it was a bit easier, in terms of the aircraft "wanting" to stay on speed, to go around the circle a little faster, i.e., in the 37–40 second time range as opposed to the 45-second maximum. The effect of winds, even light winds, can have an impact on this maneuver, dramatically changing the trim bank angle needed to maintain a constant speed around the circle. This, in turn, influences the longitudinal position as the wind azimuth changes from a head wind to a tail wind as the aircraft proceeds around the circle. In general, the pilots felt there were no unacceptable oscillations that resulted from trying to achieve desired performance. No objectionable controller force characteristics were noted, although one pilot stated the task was very difficult if performed with the trim release not depressed. No problems were noted with the predictability of the initial response or the mid- to long-term response. In terms of oscillations or tendency to overshoot during the recovery to a stable hover, a majority of the pilots mentioned roll oscillations (see Sections 3.3.2 and 3.4.10) and a tendency to overshoot the heading (see Section 3.3.6). No non-linearity in the response was noticed. No specific problems were noted in the harmony of the pitch or roll axes, speed control, or with heading hold/turn coordination. A couple pilots commented on harmony issues with the collective axis. The control compensation required to account for deficiencies in the aircraft were mainly centered on the longitudinal and heave axes. One pilot mentioned collective pumping. The pilots didn't mention any specific modifications to their "normal" control strategy in order to get the aircraft to behave like they wanted it.

The HQRs for the Pirouette MTE are presented in Figure 4.3. All but one of the HQRs fall into the Level 2 region. There were no Level 1 ratings and there was one Level 3 rating (HQR=8) for the empty configuration going to the left in light wind. Although the pilots mention the detrimental effects of the winds on control strategy/workload and task performance, the HQRs do not reflect this aspect. For example, the best HQRs for the internal load configurations were with a light wind. The critical sub phase of the maneuver was mainly split between the deceleration-to-hover phase and the compensation required when performing the maneuver with winds. For the case with the external slung load, the pilot noted that the external slung load did have a significant impact, mainly in the deceleration phase where the external load contributed to roll oscillations. This was likely exacerbated by having the same performance standards with and without an external slung load.

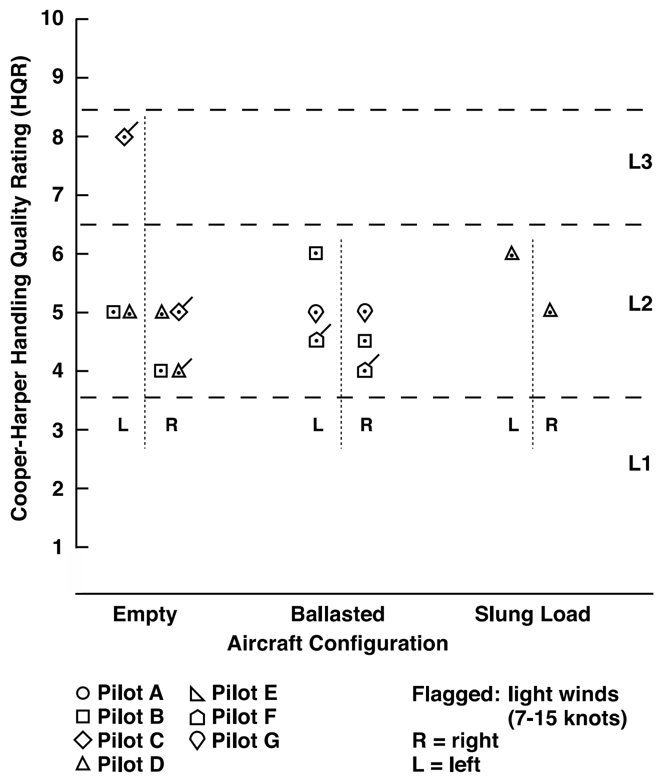


Figure 4.3 Pirouette MTE Handling Quality Ratings

4.2.4 Slope Landing

The objectives of the Slope Landing maneuver are to check the ability to: precisely coordinate control of the heave and lateral axes with either the left or right part of the landing gear in contact with the ground; and to precisely coordinate control of the heave and longitudinal axes with either the aft or forward part of the landing gear in contact with the ground. The ADS-33D-PRF maneuver description states the pilot shall perform a vertical landing to a sloped surface with the aircraft's longitudinal axis oriented perpendicular and parallel to the fall line. That is, the landing shall be made with the nose pointed uphill and downhill, and with the upslope to the right and to the left. Once the upslope landing gear is in contact with the ground, maintain a level rotorcraft attitude for a short period of time, and then gently lower the downslope landing gear to the ground. When taking off, raise the downslope landing gear, keeping the upslope gear in contact with the ground, and maintain a level rotorcraft attitude for a short time before liftoff. The test area should consist of sloped terrain that is at least 75% of the rotorcraft slope landing performance limits. The landing area shall be clearly marked on the ground.

For the ADS-33D-PRF flight assessment with the UH-60A, the Slope Landing MTE was performed at Black Mountain, an unimproved site in the foothills east of Moffett Field. The Slope Landing MTE was performed with the aircraft in the empty configuration, by only two pilots, and only evaluated the aircraft-slope orientation with the right landing gear on the uphill slope. With the aircraft's maximum slope landing limit of 15 degrees, the slope for the ADS-33D-PRF assessment was set at 12 degrees. To be more in-line with the Aircrew Training Manual (ATM) (ref. 24) slope landing maneuver, the maneuver description was modified to say the landing shall be completed by lowering the collective to the full down position and neutralizing the other controls.

The ADS-33D-PRF maneuver performance standards for the touchdown area are related to the size of the rotorcraft landing gear footprint. That is, for desired performance, the touchdown area is 6 ft longer and 4 ft wider than the landing gear footprint. For adequate performance, the touchdown area is 12 ft longer and 8 ft wider than the landing gear footprint. Since the landing gear of the UH-60A are not visible to the pilot, two concentric rectangular boxes (4x6 ft and 8x12 ft) were painted on the ground to represent the touchdown area. Traffic cones were aligned with the pilot's 12 and 3 o'clock positions to help position the upslope landing gear over the touchdown area. These traffic cones were acceptable for getting the pilot generally on top of the touchdown rectangle, but the final guidance was provided by the crew chief onboard the aircraft looking down through the gunner's window. This was considered mission realistic, but adds an added dimension of crew coordination that might affect the HQR. The slope landing area with the aircraft in place is shown in Appendix D. Performance standards for the Slope Landing MTE are shown in Table 4.4.

Table 4.4 Slope Landing – Performance

Desired Performance	**Cargo/Utility**
• Touch down and maintain a final position within an area that is X ft longer than the rotorcraft landing gear:	6 ft
• Touch down and maintain a final position within an area that is X ft wider than the rotorcraft landing gear:	4 ft
• Maintain heading within ±X deg:	5 deg
• Maintain a level rotorcraft attitude with one part of the landing gear in contact with the ground and rest in the air for at least X seconds before lowering and raising the downhill part of the landing gear:	5 sec
• No perceptible horizontal drift at touchdown:	✓
• Any limitations such as mast bending shall remain within the OFE:	✓
Adequate Performance	
• Touch down and maintain a final position within an area that is X ft longer than the rotorcraft landing gear:	12 ft
• Touch down and maintain a final position within an area that is X ft wider than the rotorcraft landing gear:	6 ft
• Maintain heading within ±X deg:	10 deg
• Maintain a level rotorcraft attitude with one part of the landing gear in contact with the ground and rest in the air for at least X seconds before lowering and raising the downhill part of the landing gear:	1 sec
• No perceptible horizontal drift at touchdown:	✓
• Any limitations such as mast bending shall remain within the OFE:	✓

During the practice landings, the pilots initiated the maneuver with a short translation to the touchdown area. For one pilot, this translation was on the order of 10 ft, while the other pilot used 30–40 ft. After some discussion, it was decided that the 30–40 ft translation was not particularly useful as the prime ingredient of the task is to perform a slope landing to a spot from a stable hover. A couple of other observations were noted: after landing on the slope, there's a tendency for the aircraft attitude to increase in the direction of the slope as the downhill landing gear strut collapses more than the uphill strut. Also, for the UH-60A, the pilot and co-pilot's attitude indicator need to both be set to zero on the ramp prior to takeoff.

The Slope Landing MTE was performed in the empty configuration only. Complete pilot comments for the Slope Landing MTE are contained in Appendix F. The evaluation pilots commented that desired performance was achieved on all data runs. Figure E-86 presents a sample time history from a data run. One pilot commented that the 12 o'clock-positioned traffic cones were somewhat useful for initial positioning but they became obscured slightly as the aircraft reached the touchdown point. The same pilot commented that the 3 o'clock-positioned traffic cones were unusable.

From the pilot comments, the pilots felt the Slope Landing maneuver was not an aggressive task. In fact, this task does not support being aggressive, and actually mitigates against being aggressive. During the maneuver evaluation, the pilots did not note any: objectionable controller force characteristics, predictability problems of initial aircraft response, objectionable oscillations, non-linearity of response, nor any problems with harmony. One piloted commented that he did not like leveling the tip path plane (with respect to the aircraft) as part of the task. This was considered inappropriate for a slope landing if the crew is really concerned about the ability to keep the aircraft on the slope, "there is no reason to give yourself a downslope vector." The Slope Landing MTE was rated as an HQR=3 and HQR=4. The critical sub-phase of the task is getting the downhill landing gear on the ground after the uphill gear is in contact with the ground. Additionally, getting the cyclic centered after all landing gear were on the deck was considered critical. Holding the aircraft level with one gear in contact with the ground was not considered difficult.

4.3 Aggressive Tasks in the Good Visual Environment

4.3.1 Vertical Maneuver

The objectives of this maneuver are to check for adequate heave damping and vertical control power, to assess the characteristics of the heave axis controller, and to check for undesirable coupling between the collective and the other axes. This maneuver has undergone modification and refinement over the years from ADS-33C to ADS-33D and ADS-33E. In ADS-33C, this maneuver was entitled "Rapid Bob-up and Bob-down" and was initiated from a stabilized 10 ft hover followed by a bob-up to 25 ft to achieve a line-of-sight on a simulated threat. Once the simulated threat is stabilized in a fictitious fixed gun-sight, perform the descent to the initial hover position. In ADS-33D (ref. 5), the maneuver was renamed "Bob-up and Bob-down" and the maneuver description was modified. It was also initiated from a stabilized 10 ft hover followed by a bob-up to 40–50 ft. At the top of the maneuver, the pilot was to stabilize on the reference altitude for 2 seconds before descending back to the initial altitude. During the ADS-33 assessment with the CH-47D, this maneuver was further refined and re-named the "Vertical Maneuver." The Vertical Maneuver started from a stabilized 15 ft hover. The pilot initiated a vertical ascent to 40 ft, stabilized for 2 seconds, and then descended back to the 15 ft hover. Emphasis was placed more on precision rather than the aggressiveness of the maneuver. During the initial phase of the CH-47D tests, the aircraft was flown unloaded resulting in a larger power margin and the selection of 10 seconds for the maneuver time tolerance. Once the CH-47D was loaded up to a representative mission weight, the 10-second time tolerance was too stringent and had to be relaxed to 13 seconds for desired and 18 seconds for adequate performance. These relaxed times still required moderately aggressive thrust applications, which would still single out problems in the heave axis and be representative of cargo aircraft applications. For the ADS-33D-PRF assessment with a UH-60A, this latter maneuver description and performance requirements were used with one minor change toward more precision: the 2-second stabilization at the top of the maneuver was increased to four seconds and 2 seconds were added to the total maneuver time. Performance standards for the Vertical Maneuver MTE are given in Table 4.5. Note, the performance standards were the same with and without an external slung load.

Table 4.5 Vertical Maneuver – Performance

Desired Performance	**Cargo/Utility**	**External Slung Load**
• Maintain the longitudinal and lateral position within ±X ft of a point on the ground:	3 ft	3 ft
• Maintain start/finish altitude within ±X ft:	4 ft	4 ft
• Maintain heading within ±X deg:	5 deg	5 deg
• Complete the maneuver within:	15 sec	15 sec
Adequate Performance		
• Maintain the longitudinal and lateral position within ±X ft of a point on the ground:	6 ft	6 ft
• Maintain start/finish altitude within ±X ft:	6 ft	6 ft
• Maintain heading within ±X deg:	10 deg	10 deg
• Complete the maneuver within:	20 sec	20 sec

For Vertical Maneuver MTE, the Hover MTE course was used along with an additional hover board and target for cueing at the top of the maneuver. A sketch of the hover boards and targets used for multiple maneuvers is shown is Appendix D. The Vertical Maneuver MTE was performed in the empty and external load configurations in calm and light wind conditions, and in the internally loaded configuration in calm winds only. For nearly all the configurations, the pilots, in general, were able to achieve desired performance on all the maneuver performance standards; of course there were a few exceptions. For example, two pilots evaluating the internal ballast configuration were bumping into the adequate standards on one or more of the maneuver performance standards. The longitudinal position requirement was the most troublesome, mainly due to reduced effectiveness of the existing fore-aft cues while at the top of the maneuver. For the external slung load configuration, one pilot fell into the adequate range on two of the three data runs, once for not making the desired time and once for fore-aft drifts into adequate. A sample time-history of a data run for the Vertical Maneuver MTE is shown in Figure E-87.

Pilot comments for the Vertical Maneuver MTE are contained in Appendix F. In describing the aggressiveness and precision with which the maneuver was performed, the pilots didn't feel the maneuver required an overly aggressive technique to be within the desired performance boundaries. However, the pilots could be aggressive if needed, but there's a penalty in terms of precision and capturing the hover board/target at the top of the maneuver. One pilot mentioned the rapid application of the collective and subsequent torque response to be the most difficult or complicated aspect of this maneuver. That is, the maneuver is relatively small in vertical displacement and there is insufficient time to make a rapid collective input and still look into the cockpit to assess the torque response before arriving at the top of the maneuver. This really complicates the vertical deceleration and stabilization at the top of the maneuver. The pilots did not note any: unacceptable oscillations; objectionable controller force characteristics; problems with predictability of the initial and mid- to long-term response; issues with non-linearity of the response; problems with harmony of pitch and roll; or height control. One pilot mentioned a tendency to overshoot the altitude at the top of the maneuver and the final altitude at the hover point. In terms of pilot control strategy for performing the maneuver, a key ingredient was to have a very good stable hover prior to pulling in collective and then leave your feet on the floor letting the aircraft heading-hold feature keep the heading within the desired tolerance. One pilot mentioned that he got better task performance and lower workload by keeping his feet on the floor, but added "it's not the way I'd actually fly the aircraft."

Figure 4.4 presents the pilot HQRs for the Vertical Maneuver. For the empty configuration, the ratings are all within the Level 1 region, even with a light wind. For the internally ballasted configuration and external slung configuration, a few ratings fell into the Level 2 region. These Level 2 ratings were primarily driven by poor heading control (pilot did not use the aircraft's heading-hold feature) and poor longitudinal cueing for determining and controlling fore and aft drift. The critical sub-phase or major determining factor in the overall handling quality rating varied between the pilots. Some considered the middle of the ascent and descent to be the critical phase, that is, this is the only time the pilot had to monitor and adjust the fore-aft position. Others considered altitude maintenance at the top and bottom of the maneuver as the critical phase. The external sling load, in and of itself, did not have an impact on the HQRs for this maneuver.

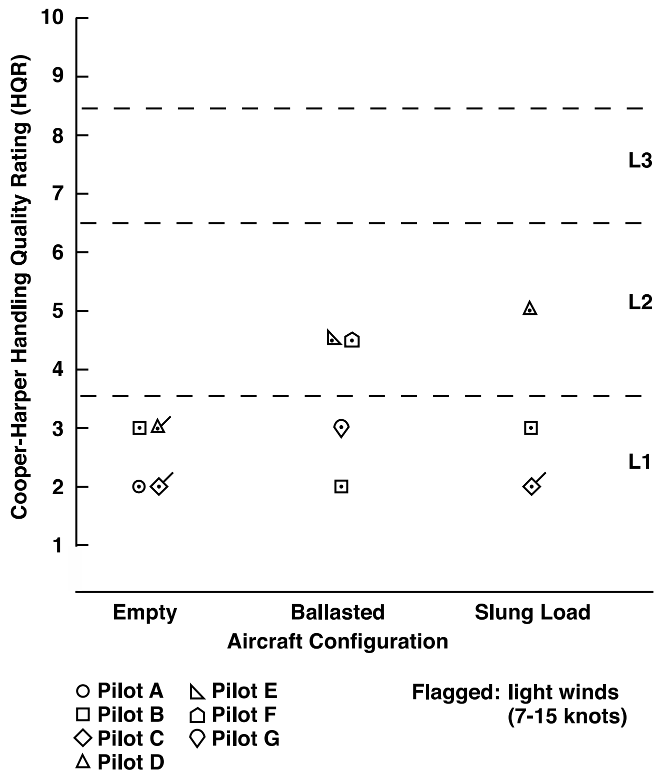


Figure 4.4 Vertical Maneuver MTE Handling Quality Ratings

4.3.2 Normal Departure/Abort to a Landing Zone

The Normal Departure/Abort to a Landing Zone MTE, or Depart/Abort for short, was developed during the ADS-33D flight assessment with a CH-47D. The Acceleration/Deceleration MTE was considered too aggressive for the CH-47D and so the Depart/Abort was developed (refs. 8 & 9). Likewise, for the ADS-33D-PRF flight assessment with the UH-60, the Acceleration/Deceleration MTE was considered too aggressive for the utility class rotorcraft. The primary objective for the Depart/Abort MTE is to check pitch axis and heave axis handling qualities during moderately aggressive maneuvering. Additional objectives include checking for: undesirable coupling between the longitudinal and lateral-directional axes; harmony issues between the pitch axis and heave axis; overly complex power management requirements; the ability to re-establish a hover after changing trim; and with an external slung load, checking for dynamic problems resulting from the slung load configuration.

For the ADS-33D-PRF assessment with the UH-60, the description of the maneuver is as follows: from a stabilized hover at a 30 ft wheel height and 800 ft from the intended endpoint, initiate a longitudinal acceleration to perform a normal departure. At approximately 40 knots groundspeed, abort the departure and decelerate to a hover such that at the termination of the maneuver, the cockpit shall be within 20 ft of the intended endpoint. It is not permissible to overshoot the intended endpoint and move back. If the rotorcraft stopped short, the maneuver is not complete until it is within 20 ft of the intended endpoint. The acceleration and deceleration phases shall be accomplished in a single smooth maneuver. A target of approximately 20 degrees of pitch attitude change from trim shall be used for the acceleration and deceleration. The maneuver is complete when control motions have subsided to those necessary to maintain a stable hover. The performance standards for the maneuver are given in Table 4.6.

Table 4.6 Depart/Abort Maneuver – Performance

Desired Performance	**Cargo/Utility**	**External Slung Load**
• Maintain lateral track within ±X ft:	10 ft	10 ft
• Maintain radar altitude below X ft:	50 ft	50 ft
• Maintain heading within ±X deg:	10 deg	10 deg
• Complete the maneuver within:	25 sec	30 sec
Adequate Performance		
• Maintain lateral track within ±X ft:	20 ft	20 ft
• Maintain radar altitude below X ft:	75 ft	75 ft
• Maintain heading within ±X deg:	15 deg	15 deg
• Complete the maneuver within:	30 sec	35 sec

The course cueing for the Depart/Abort MTE is illustrated in Appendix D. Lessons learned from prior tests were incorporated into the course cues. Specifically, the four columns of traffic cones laid out along the taxiway centerline to provide lateral track information were extended past the endpoint. This was found to be very helpful during the deceleration phase, where a high-nose attitude obscures the pilot's view of these cues. In addition, the two rows of traffic cones indicating the endpoint and the 20 ft-short line were extended into the in-field on the right side to improve the evaluation pilot's detection of these lines during the nose-high attitude in the deceleration phase.

The Depart/Abort MTE was performed in the empty and external load configurations in calm and light wind conditions, and in the internal load configuration in calm winds only. For nearly all the configurations, the pilots, in general, were able to achieve desired performance on all the maneuver performance standards. A sample time-history of a data run for the Depart/Abort MTE is shown in Figure E-88. Comments from one pilot implied that the external slung load configuration was somewhat easier to perform compared to the unloaded configuration. That is, there was a perception that the aircraft more quickly accelerated to the target airspeed and with the 5-second increase in maneuver completion time, this allowed for a less aggressive deceleration (20 deg pitch-up instead of a 30–35 deg pitch-up for the unloaded configuration). The lower pitch attitude deceleration allowed the pilot to better observe the course cueing, made the maneuver seem somewhat less aggressive, and therefore reduced the pilot workload. Several pilots explored the aggressiveness with which the maneuver was performed. For example, a couple of the pilots performed this maneuver more aggressively, i.e., accelerating to 50 knots before performing an aggressive 30–35 degree nose-high deceleration. They were able to perform the maneuver within the "Desired" performance standards with no detrimental characteristics. Although this level of aggressiveness is not required by ADS-33D-PRF, it is sometimes insightful to try to expose potential handling quality cliffs. Other pilots explored the less aggressive aspects of performing the maneuver, while still achieving "Desired" performance. They were able to perform the maneuver within "Desired" performance while only achieving a maximum speed of 30–35 knots. It should be noted that if the pilot is having trouble meeting the maneuver time constraints, it is suggested the time be made-up during the acceleration phase, not during the deceleration phase. If the aggressiveness is increased during the deceleration phase, there can be a "larger" increase in the pilot workload during the deceleration phase. This suggestion also applies to the Lateral Reposition MTE.

Detailed pilot comments for the Depart/Abort MTE are contained in Appendix F. Describing the aircraft characteristics, the pilots did not have issues with unacceptable oscillations, controller force characteristics, the predictability of the initial response, any mid- to long-term response problems, or any non-linearity of response issues. However, one pilot, during the evaluation of the external slung load configuration, did complain of a "tremendous roll oscillation" at the end of the maneuver. A couple of the pilots noted predictability problems, i.e., the tendency to undershoot the desired stopping point.

Figure 4.5 presents the HQRs for the Depart/Abort MTE. The ratings are equally split between HQR=3 and HQR=4, with one HQR=2. The light winds did not appear to affect the results. With "Desired" performance achieved, pilot compensation was the driving factor. Interestingly, the loss of the lateral visual cues during the nose-high deceleration phase forced the pilots to alter their typical visual scan and thus was the main contributor to increased pilot compensation. However, for the external slung load configuration, one pilot complained of minor but annoying deficiencies due to roll axis oscillations (see Section 3.3.2); "the roll oscillations are pretty annoying at the end with the sudden increases in power…" Also for the external slung load configuration, another pilot excited the longitudinal pendulum mode during the deceleration, leading to some load oscillations and "two to three overshoots in pitch, maybe three to four, and small longitudinal cyclic inputs to follow those and try to get them damped out." The critical sub phase of this task is the nose-high attitude and leveling-off during the deceleration phase. For the external slung load configuration, two of the four pilots thought the slung load negatively impacted the rating; one pilot thought the slung load made the task easier ("…aircraft is more stable, accelerates and decelerates a little quicker…"); and the fourth pilot thought the slung load had no impact.

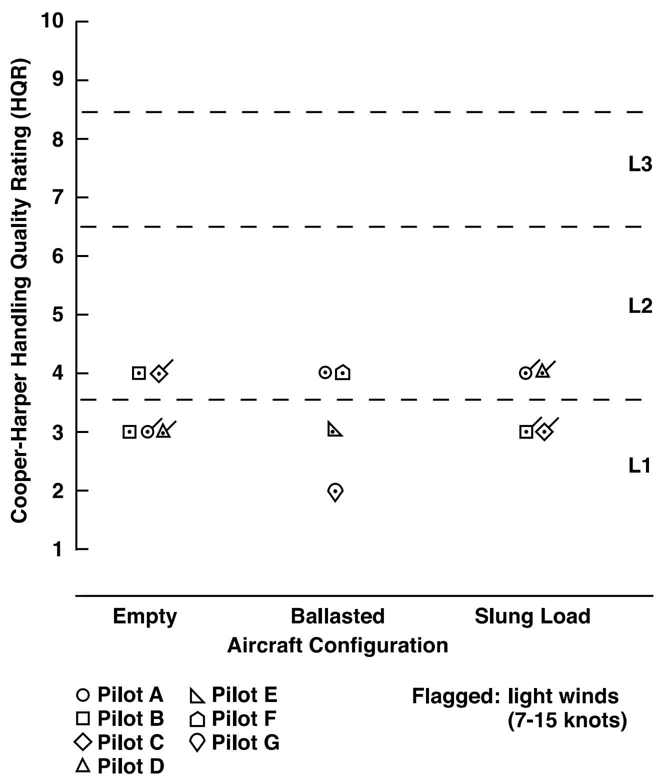


Figure 4.5 Depart/Abort MTE Handling Quality Ratings

4.3.3 Lateral Reposition

The Lateral Reposition MTE was developed also during the ADS-33D flight assessment with a CH-47D. The Sidestep MTE was considered too aggressive for the CH-47D and so the Lateral Reposition was developed. Likewise, for the ADS-33 flight assessment with the UH-60, the Sidestep MTE was considered too aggressive for the utility class rotorcraft. The primary objectives for the Lateral Reposition MTE are: to check roll axis and heave axis handling qualities during moderately aggressive maneuvering; to check for undesirable coupling between the roll controller and the other axes; and for configurations with an external slung load, to check for dynamics problems resulting from the external load.

For the ADS-33D-PRF assessment with the UH-60, the description of the maneuver is as follows: start in a stabilized hover at 25 ft wheel height with the longitudinal axis of the rotorcraft oriented 90 degrees to the taxiway centerline. Initiate a lateral acceleration to approximately 25 knots groundspeed followed by a deceleration to laterally reposition the aircraft in a stabilized hover 400 ft down the course within a specified time. The acceleration and deceleration phases shall be accomplished as single smooth maneuvers. The rotorcraft must be brought to within ±10 ft of the endpoint during the deceleration, terminating in a stable hover within this band. Overshooting is permitted during the deceleration, but will show up as a time penalty when the pilot moves back within the ±10 ft of the endpoint. The maneuver is complete when a stabilized hover is achieved. The performance standards for the maneuver are presented in Table 4.7. Note, the performance standards were the same with and without an external slung load. For the CH-47D flight tests with the external slung load, the "Desired" time to complete the maneuver was 25 seconds, and the "Adequate" time to complete the maneuver was 30 seconds.

Table 4.7 Lateral Reposition Maneuver – Performance

Desired Performance	**Cargo/Utility**	**External Slung Load**
• Maintain longitudinal track within ±X ft:	10 ft	10 ft
• Maintain radar altitude within ±X ft:	10 ft	10 ft
• Maintain heading within ±X deg:	10 deg	10 deg
• Complete the maneuver within:	18 sec	18 sec
Adequate Performance		
• Maintain longitudinal track within ±X ft:	20 ft	20 ft
• Maintain radar altitude within ±X ft:	15 ft	15 ft
• Maintain heading within ±X deg:	15 deg	15 deg
• Complete the maneuver within:	23 sec	23 sec

The course cueing for the Lateral Reposition MTE is illustrated in Appendix D. The maneuver was evaluated both to the right and to the left. With the evaluation pilot sitting in the right seat, performing the maneuver to the left forced the pilot's visual scan across the cockpit and for nearly all of the pilots there did not appear to be a detrimental effect on ratings. Two pilots noticed a difference; one pilot thought it was more difficult going to the left (ΔHQR=2) and another pilot thought it was somewhat more difficult going to the right (ΔHQR=1).

The Lateral Reposition MTE was performed in three aircraft configurations: empty, internally loaded, and with external slung load. A sample time-history of a data run for the Lateral Reposition in the internally loaded configuration is shown in Figure E-89. The empty and external load configurations were flown in calm and light wind conditions, whereas the internally loaded configuration was evaluated only in calm wind conditions. In general, the pilots were able to achieve desired performance on almost all of the maneuver performance standards for the empty and internal load configurations. A few pilots noted occasional problems keeping the heading within desired standards and occasional fore-aft drift problems during the deceleration phase, depending on direction of travel. The external slung load configuration in light winds was worse. The combination of the external slung load and winds caused many "small oscillations that were relatively difficult to counter in a precise manner," and hence only adequate performance could be achieved. Comments from the pilots on the aggressiveness and precision with which the maneuver could be performed varied from "fairly aggressive" to "the maneuver is more aggressive than what a normal pilot would fly." For the external slung load configuration evaluated in light winds, the pilot had difficulty controlling speed on the translation to the precision hover point and precision was difficult to maintain because of the slow development of rates.

Complete pilot comments for the Lateral Reposition MTE in all configurations and wind conditions that were evaluated are contained in Appendix F. Describing the aircraft characteristics, in general, the pilots did not have issues with the controller force characteristics, the predictability of the initial response, any mid- to long-term response problems, or any non-linearity of response issues. However, some pilots did complain of roll oscillations and disharmony between the pitch and roll responses. As far as pilot control strategies, some pilots kept their feet OFF of the pedals, thus letting the heading hold keep the heading within desired constraints. Other pilots kept their feet ON the pedals claiming it was "like I fly for a real mission" and therefore, they had to monitor/control heading during the maneuver. The latter technique would seem to potentially increase pilot workload. For example, one pilot commented, "…I had my feet off the pedals … and that eliminated any heading oscillation."

Figure 4.6 presents the HQRs for the Lateral Reposition MTE. For the empty configuration in calm atmospheric conditions, the ratings were generally HQR=4, with one HQR=4.5 and one HQR=3. The average was Level 2 (HQR=3.9). The empty configuration in light winds resulted in a degradation of about one rating, i.e., one HQR=6, two HQR=5s, and one HQR=4, for an average of HQR=5. Pilots complained of roll oscillations coupling into the heading control during the position capture at the end of the maneuver, requiring considerable-to-extensive compensation. Even though desired performance was generally obtained, the pilot workload was more than minimal, and hence, the handling quality ratings were Level 2. The ballasted configuration was only evaluated in calm atmospheric conditions, was rated the same whether going to the right or the left, and received an average HQR=3.75. Some pilots declared "minimum compensation required for desired performance" while another pilot stated "considerable compensation" required during the deceleration phase.

For the external slung load configuration, a majority of the evaluations were performed in light winds and show a large dispersion in ratings ($3 \leq HQR \leq 7$), with an average of HQR=5.67. Going to the left, one pilot provided an HQR=3 ("mildly unpleasant deficiencies and minimal compensation"), while another pilot provided an HQR=7 (inconsistently met adequate performance and workload being not tolerable). This large spread in HQRs is disturbing and suggests possible training issues. Going to the right in light winds, two HQR=5s and one HQR=4 were provided. The primary complaint was fore-aft drift and control of the longitudinal axis during the deceleration phase. One pilot evaluated the external slung load configuration in calm conditions and provided an HQR=7 in both directions. The pilot stated "adequate performance is not attainable with maximum tolerable pilot compensation, controllability is not in question." The main problem centered on roll oscillations (one-hertz) and the compensation required to correct for these, stating that it took 8–9 seconds to settle down the oscillations once the aircraft arrived at the end point. Three of the four pilots who evaluated the Lateral Reposition with an external slung load said the external load had a significant impact on the assigned HQR. This was likely exacerbated by having the same performance standards with and without an external slung load. Experience has shown that relaxing the external slung load MTE performance standards is appropriate.

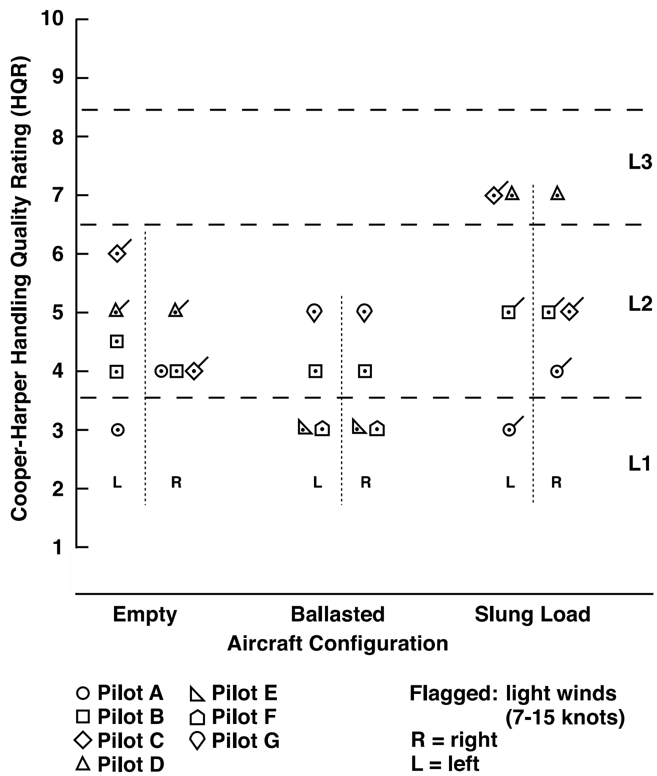


Figure 4.6 Lateral Reposition MTE Handling Quality Ratings

4.3.4 Slalom

The Slalom MTE was originally called the Rapid Slalom in ADS-33C and prior versions. The Rapid Slalom consisted of maneuvering rapidly to displace the aircraft 50 ft laterally from the centerline and immediately reverse direction to displace the aircraft 50 ft on the opposite side of the centerline followed by returning to the centerline. There were no ground-referenced markers (in an attempt to keep the maneuver simple and low-cost) and "Desired" performance included maintaining altitude within ±10 ft, airspeed at or above 60 knots, and maximum bank angles of 50 degrees. Subsequent flight tests by AQTD and lessons learned from the LHX evaluations led to a modification of the Rapid Slalom to the Slalom MTE in ADS-33D. Specifically, the Rapid Slalom was changed to include flight over specific objects (pylons) on the ground, which were ±50 ft off the maneuver centerline and 500 ft apart longitudinally. Experience showed that ground-referenced objects were essential to make the slalom a meaningful mission task element. Also, the altitude limit for "Desired" performance was relaxed from ±10 ft to simply remain below 100 ft. The primary objectives for the Slalom MTE are to check: the ability to maneuver aggressively in forward flight and with respect to objects on the ground; the turn coordination for aggressive forward flight maneuvering; and objectionable interaxis coupling during aggressive forward flight maneuvering.

For the ADS-33D-PRF assessment with the UH-60, the description of the maneuver is as follows: initiate the Slalom MTE in level unaccelerated flight, lined up with the centerline of the runway while passing through an entry gate consisting of two traffic cones on the centerline. Perform a series of smooth turns at 500 ft intervals. The turns shall be completed around traffic cones set 50 ft from the centerline of the runway; but will not extend off the runway edge line (maximum lateral error of 50 ft). Maneuvering through the final set of traffic cones on the centerline with the aircraft aligned with the centerline completes the MTE. The MTE is to be initiated at a reference altitude of 70 ft and must be completed below 100 ft. The performance standards for the maneuver are given in Table 4.8. For the external load configurations, a bank angle limit was set at 30 degrees.

Table 4.8 Slalom – Performance

	Day
DESIRED PERFORMANCE • Maintain an airspeed of at least X knots throughout the course:	60 kts
ADEQUATE PERFORMANCE • Maintain an airspeed of at least X knots throughout the course:	40 kts

Traffic cones were placed on the runway at 500-ft intervals to mark the entry/exit gates, the 50-ft offset from the centerline, and the 50-ft maximum lateral error offset (100 ft from the centerline). The Moffett Federal Airfield has unusually wide runways (200 ft) and hence the edge of the runway also served as the maximum lateral error cue. The course was flown in both directions and with the first turn to the right and to the left. Some pilots noted difficulty in seeing the 50-ft offset traffic cones while making left turns, adding that it was easy to see these while making right turns. A few pilots noted the lack of any altitude cues, requiring the pilot to come inside and look at the radar altimeter.

The Slalom MTE was performed in the empty and internal load configurations in calm and light winds. It was performed in the external load configuration only in light winds. For the empty and internal load configurations, the pilots were able to achieve desired performance standards. A sample time-history of a data run for the Slalom MTE in the internal load configuration is shown in Figure E-90. Some comments and/or issues were noted for evaluations performed with winds, i.e., with a 15-knot headwind, an airspeed of 65 knots results in 50-knot groundspeed. At this groundspeed, maneuvering through the course is easier. For the external load configurations, although there were a few exceptions, the evaluation pilots mainly achieved adequate performance. With the external load configuration, the perceived maneuver aggressiveness increased, leading to large bank angles and difficulty maintaining speed throughout the course. For the empty and internal load configurations, some evaluation pilots were able to rather easily increase the aggressiveness, flying the Slalom at 80 and 90 knots while still meeting desired performance standards.

Detailed pilot comments for the Slalom MTE are contained in Appendix F. Describing the aircraft characteristics, in general, the pilots did <u>not</u> have issues with controller force characteristics, aircraft response, oscillations or tendency to overshoot, non-linearity of response, or harmony issues. However, a few pilots noted some issues: one pilot noticed some time delay or lag in the roll response; another pilot noted performance through the turns was “sloppy with turn coordination so I came in the loop and used my pedals;” and aircraft oscillations were noticed with the external slung load configuration due to load swings as the pilot maneuvered through the course. Pilot control strategies focused on the need to be ON-speed and stabilized prior to maneuver entry, and making smooth (“ball centered”) turns. Yaw axis control strategies varied between the pilots from “fixed the pedal” and “no pedal application,” to putting in “a lot of pedal.” Follow-up comments from the pilots that didn’t use much or any pedals indicate this technique may have added to their workload for airspeed control due to the sideslip on the aircraft.

Figure 4.7 presents the HQRs for the Slalom MTE. The empty and internal ballast configurations were generally rated Level 1 for the Slalom MTE. The empty configuration received two HQR=3s in calm conditions and an HQR=3 and HQR=4 in light winds. For the internal ballast configuration, pilots provided an HQR=3 and HQR=4 in calm conditions and an HQR=3 in light winds. The two HQR=4 ratings were driven by minor but annoying deficiencies associated with the amount of rudder pedal required to perform the maneuver, resulting in moderate pilot compensation. The external slung load configuration was solid Level 2, with three HQR=5s in light winds. One of these pilots complained that the test-plan imposed 30-degree bank angle limit prevented desired performance and required considerable pilot compensation. Another pilot stated that the 30-degree limit prohibits the true maneuvering capability of the aircraft. Whereas, the third pilot achieved desired performance, but complained of moderately objectionable aircraft characteristics due to large pedal inputs (three to four inches) and large cyclic inputs, which drives the pilot compensation into moderate. All of the pilots who evaluated the Slalom MTE with the external slung load stated that the load had a major impact on their handling quality rating.

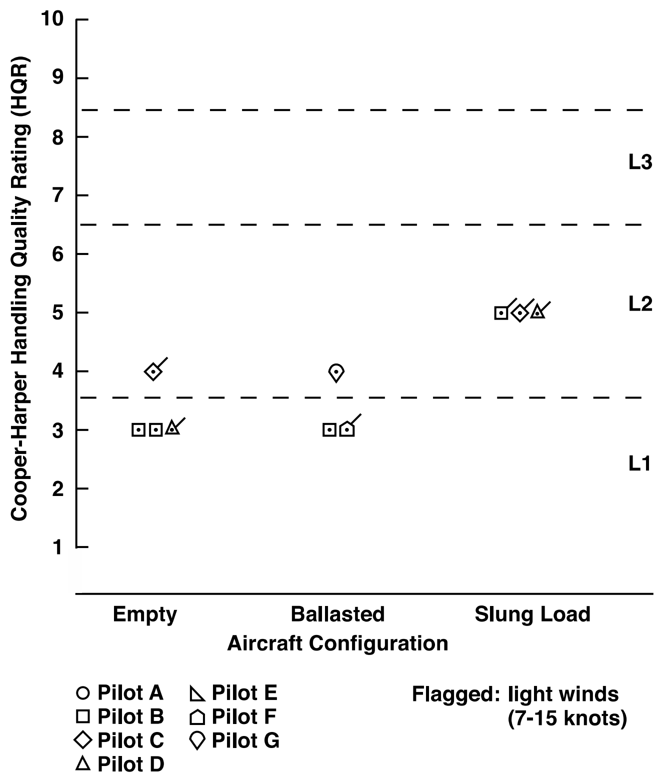
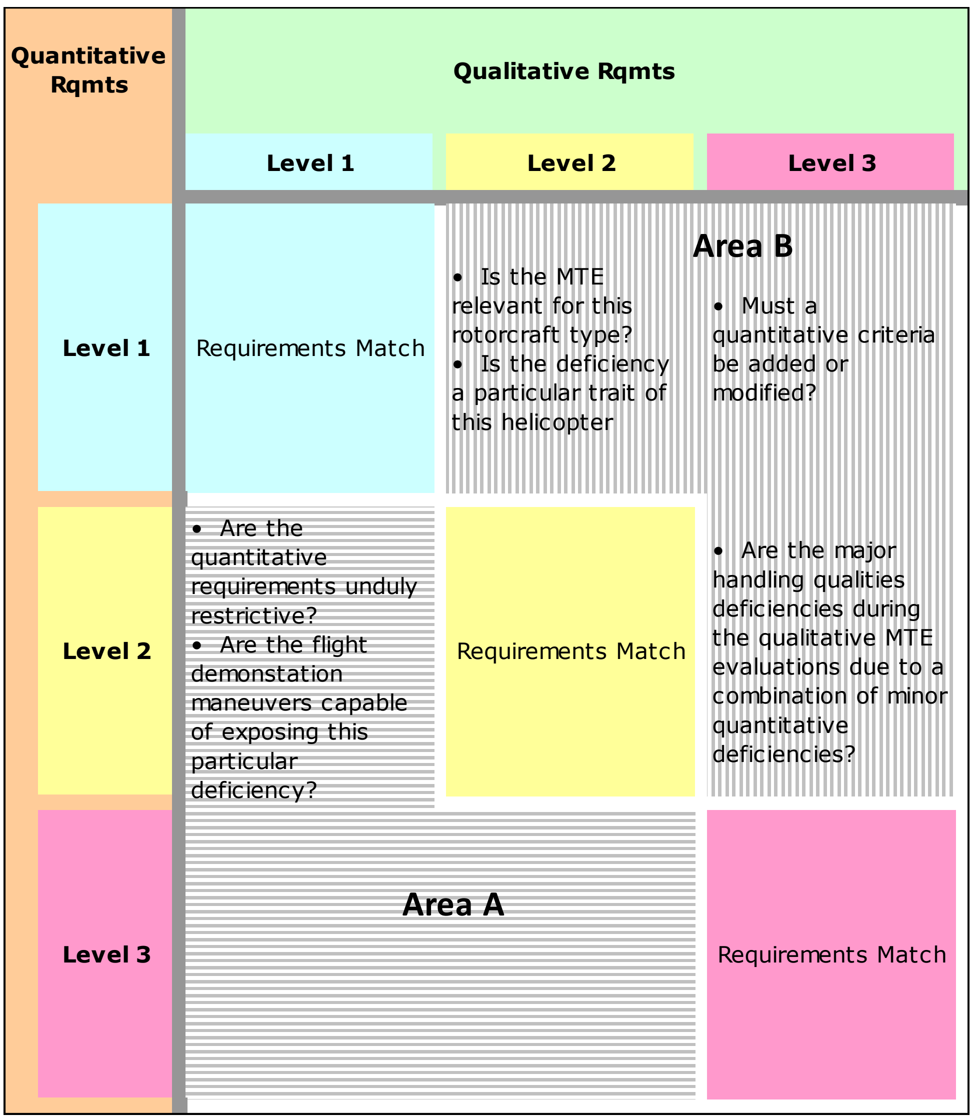


Figure 4.7 Slalom MTE Handling Quality Ratings

5 Comparison of Qualitative and Quantitative Results

This section is aimed at trying to connect the (assigned) qualitative results and comments with the (predicted) quantitative results, denoting where there is good coverage/agreement, and making suggestions for research and improvements where there is disagreements or lack of coverage.

Figure 5.1 illustrates the possible combinations of relationships between the quantitative and qualitative results. Along the "diagonal," the quantitative and qualitative results agree and match. Ideally, all the handling qualities data collected will lie along this diagonal. In Area A, the quantitative handling qualities are worse than the qualitative handling qualities. That is, a quantitative result was predicting degraded handling qualities, but the assigned qualitative result did not show degraded handling qualities. In Area B, the opposite is true. That is, a qualitative result was assigned degraded handling qualities, whereas the quantitative result did not predict degraded handling qualities.



Area A: Predicted (quantitative) handling qualities are worse than Assigned (qualitative) handling qualities
Area B: Assigned (qualitative) handling qualities are worse than Predicted (quantitative) handling qualities

Figure 5.1 Comparison of Predicted (Quantitative) and Assigned (Qualitative) Handling Qualities

Table 5.1 presents a top-level review of the quantitative and the average qualitative results from the ADS-33D-PRF assessment using the UH-60A. Review of the Hover / Low-speed quantitative results, shows nearly all results are Level 1, with the exception of: non-Level 1 residual oscillations; Level 2 yaw attitude quickness; some Level 2 results for interaxis coupling (yaw-due-to-collective and the frequency-domain pitch and roll coupling); and the Level 2 OGE height response. In addition, although the UH-60 would not be required to meet the target acquisition and tracking requirements, the roll and yaw bandwidth for target acquisition and tracking is Level 2. Also, there are a couple of potentially important Hover / Low-speed quantitative criteria that are "missing" from Table 5.1: the response-to-disturbance inputs was not tested/assessed. A new disturbance rejection bandwidth has been proposed to replace the response-to-disturbances criteria, however this was not in place when the flight test was conducted.

Review of the qualitative results for the Hover / Low-speed MTEs shows a mixture of Level 1 and Level 2 ratings, with a couple of configurations/maneuvers receiving Level 3 ratings. The addition of winds nearly universally degraded the handling qualities ratings. The Hover, Slope Landing, Vertical Maneuver, Normal Departure/Abort, and the Slalom MTEs show all, or nearly all, Level 1 assigned handling qualities. Whereas, the Hovering Turn, Pirouette, and Lateral Reposition MTEs show all, or nearly all, Level 2 assigned handling qualities. Note, there a few Level 3 assigned ratings.

In looking at Table 5.1, there are several combinations of quantitative and qualitative requirements that standout as either matching or not matching well. General observations include: there appears to be lots of Area B data (assigned handling qualities are worse than predicted handling qualities); lots of Level 1 matches (blue area); some Level 2 matches (yellow area); and some Area A data (predicted handling qualities are worse than assigned handling qualities). It is generally considered acceptable to be in Area B, in which the assigned handling qualities are worse than the predicted handling qualities. This could be due to several reasons: the MTE may not be appropriate or well suited to this class of rotorcraft; the quantitative criteria are insufficient to expose the handling quality problem observed by the pilot; or possibly the assigned handling qualities are due to a combination of minor quantitative deficiencies. However, being in Area A is typically considered a "no-no". That is, having "good" assigned handling qualities in a "bad" region of the predicted handling qualities implies: the quantitative boundaries are in the wrong location. Another interpretation is the particular MTE does not expose the deficiency predicted by the quantitative boundaries.

For the Hover MTE, closer examination reveals the evaluations performed in calm winds received Level 1 assigned handling qualities. Whereas, the evaluations in non-calm wind conditions received Level 2 assigned handling qualities. In general, the handling quality ratings were degraded by about one rating in winds. Pilots complained of roll oscillations and disharmony between the pitch and roll axes. The roll oscillations seem to be captured by the residual oscillations requirement. The pitch and roll disharmony comments does not seem to be captured by the quantitative data, although the residual oscillation in the roll axis could influence the pilot's opinion of pitch-roll harmony. The detrimental effect of winds on the qualitative rating is also not captured in the quantitative data, although the response to disturbances was not assessed.

For the Hovering Turn MTE, with the exception of the empty configuration performing a left turn in calm conditions, all of the assigned handling qualities were Level 2. The evaluation pilots complained of poor cueing during the turn, which adds to the workload. The course cueing was not altered/adjusted based on these pilot comments. The evaluation pilots also complained of: difficulty in capturing the final heading (with some pilots experiencing 6–10 overshoots in heading control); yaw-axis response predictability issues; and interaxis coupling (pitch-to-roll and yaw-to-roll). Although the yaw bandwidth was in the Level 1 region, these negative comments could be related and predicted by the Level 2 yaw attitude quickness response and the Level 2 pitch-roll inter-axis coupling criteria. It is not expected that the Level 2 height response would impact the constant altitude Hovering Turn MTE.

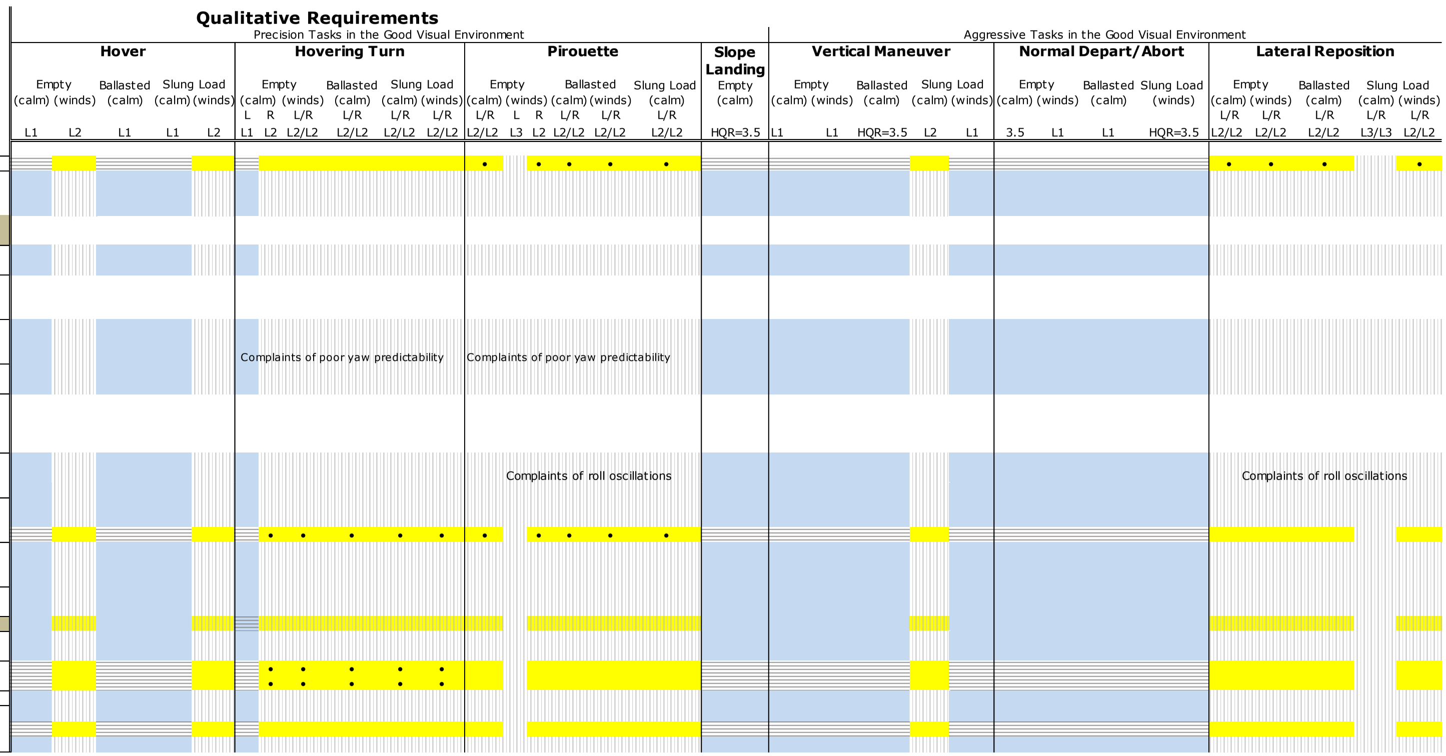
Table 5.1 Comparison of Quantitative and Qualitative Results for an Assessment of ADS-33 Using a UH-60A Black Hawk Helicopter

Quantitative Requirements

Hover/Low-Speed			UH-60A Results
Residual Oscillations			not L1
Required Response Type	(Rate Command)	Pitch	Yes
		Roll	Yes
		Yaw	Yes
		Heave	up-Yes / dn-No
Equilibrium		Pitch	OK
		Roll	OK
Bandwidth	Target Acquisition & Tracking	Pitch	L1
		Roll	L2
		Yaw	L2
	All Other MTEs (UCE=1)	Pitch	L1
		Roll	L1
		Yaw	L1
	All Other MTEs (UCE>1)	Pitch	L1
		Roll	L1
	Response to Disturbance Inputs	Pitch	Not assessed
		Roll	Not assessed
Mid-term response		Pitch	L1
		Roll	L1
		Yaw	L1
Attitude Quickness	All Other MTEs	Pitch	L1
		Roll	L1
		Yaw	L2
Large Amplitude	(moderate Agility)	Pitch	L1
	(aggressive Agility)	Roll	L1
	(moderate Agility)	Yaw	L1
Interaxis Coupling	Control inputs result in	Pitch	No
	Objectionable off-axis resps.	Roll	No
	Yaw-due-to-collective		L1 & L2
	Pitch-due-to-Roll (time domain)		L1
	Roll-due-to-Pitch (time domain)		L1
	Pitch-due-to-Roll (freq domain)		L2
	Roll-due-to-Pitch (freq domain)		L2
	Height-due-to-Pedal inputs		No Obj.
Vertical Axis	Height response (IGE)		L1
	Height response (OGE)		L2
	Control Power		L1

(Not required for Utility rotorcraft) (problem not observed)

Qualitative Requirements



• = suspected primary contributor to degraded HQs

Area A - Predicted (Quantitative) handling qualities worse than Assigned (Qualitative) handling qualities

Area B - Assigned (Qualitative) handling qualities worse than Predicted (Quantitative) handling qualities

Level 1 - Predicted and Assigned handling qualities match

Level 2 - Predicted and Assigned handling qualities match

Table 5.1 Comparison of Quantitative and Qualitative Results for an Assessment of ADS-33 Using a UH-60A Black Hawk Helicopter (cont.)

Quantitative Requirements | **Qualitative Requirements** — Aggressive Tasks in the Good Visual Environment — **Slalom**

Forward Flight			UH-60A Results	Empty (calm) L1	Empty (winds) HQR=3.5	Ballasted (calm) 3.5	Ballasted (winds) L1	Slung Load (winds) L2
Residual Oscillations			L1					
Pitch Bandwidth	Air Combat	Pitch	L1					
	All Other MTEs - VMC	Pitch	L1					
	All Other MTEs - IMC	Pitch	L1					
Mid-term response	Feel & stability (constant spe	Pitch	L1					
	Forces in maneuvering flight	Pitch	Marginally L1					
Pitch Control Power	(OFE not defined, only tested L2 requireme		L2					
Flight Path Control	Longitudinal cyclic inputs		No complaints					
	Collective inputs		No complaints					
	ADS-33E ~ front side		L1					
Interaxis Coupling	Collective-to-Attitude couplin	<20% input	L1					
	Collective-to-Attitude couplin	>20% input	L1					
	Pitch-to-Roll (aggressive)		L1					
Roll Bandwidth	Air Combat	Roll	L1					
	All Other MTEs - VMC	Roll	L1					
	All Other MTEs - IMC	Roll	L1					
Attitude Quickness	All Other MTEs	Roll	L1					
Large Amplitude	Roll Attitude Changes	Roll	L1					
	Linearity of Roll Response	Roll	No complaints					
Roll-Sideslip Coupling	Bank Angle Oscillations	Roll-Yaw	L1					
	Turn Coordination	Roll-Yaw	L1					
Yaw Bandwidth	Air Combat	Yaw	L2					
Large Amplitude	Heading Changes	Yaw	L1					
Linearity of Yaw Response		Yaw	No complaints					
Yaw Control with Speed Changes		Yaw	L1					
Lateral-Directional Stability	Lat-Dir Oscillations		L1					
	Spiral stability		L1					
Lat-Dir in Steady Sideslips	Yaw control in steady sideslips		L1					
	Bank angle in steady sideslips		Pass					
	Lateral control in steady sideslips		L1					
	Positive effective dihedral limit		L1					
Pitch, Roll, and Yaw responses to disturbance inputs			Not assessed					

"Air Combat" changed to "Target Acquisition and Tracking" in ADS-33E

(Not required for Utility rotorcraft) | (problem not observed)

Area B - Assigned (Qualitative) handling qualities worse than Predicted (Quantitative) handling qualities

Level 1 - Predicted and Assigned handling qualities match

The Pirouette MTE was assigned no Level 1 ratings; all of the ratings were Level 2, with a Level 3 rating for a leftward direction in non-calm wind conditions and an empty configuration. In general, the evaluation pilots could not consistently achieve "Desired" performance on all MTE performance standards for three evaluation data runs. Some pilots were able to achieve desired performance on one or two runs, but not on all. This was exacerbated by going to the left and with winds. There were some complaints on course cueing, roll oscillations, overshoots in heading control, and big detrimental effects from the slung load. The Pirouette is a multi-axis precision maneuver and the above complaints are all important ingredients that contribute to increased pilot workload/compensation and Level 2 ratings. The roll oscillations seem to be covered by the residual oscillation requirement. The overshoots in heading control are not predicted by the Level 1 yaw bandwidth, but may be influenced by the Level 2 yaw-axis attitude quickness and/or poor maneuver cueing. There was a suggestion to paint radial lines emanating from the center of the Pirouette circle to improve cueing, but this was not tried. The external slung load adds to the perceived roll oscillations and increases the pilot workload. It was decided that the external slung load does not increase any fundamental understanding of the maneuver and hence, performing the Pirouette with an external slung load should not be added to the ADS-33 MTE test maneuvers.

The Slope Landing MTE was assigned one HQR=3 and one HQR=4. The detrimental effects of predicted non-Level 1 residual oscillations, Level 2 yaw attitude quickness, Level 2 pitch-roll inter-axis coupling, and Level 2 height response out-of-ground-effect (OGE) do not seem to influence the assigned ratings for this maneuver. It appears this is an Area A case where this flight test demonstration maneuver is incapable of exposing a deficiency from the aforementioned quantitative criteria.

The Vertical Maneuver MTE was assigned Level 1 handling qualities, except for the external slung load case in calm winds. The predicted Level 2 criteria (residual oscillations, yaw attitude quickness, pitch-roll inter-axis coupling, and height response out-of-ground-effect) do not appear to influence this vertical-axis MTE. It is interesting that the predicted Level 2 height response (out-of-ground-effect) did not appear to influence this MTE, especially for the external slung configuration. The assigned Level 2 handling qualities with the slung load configuration were primarily driven by the poor heading control/response and the perceived tight heading tolerance. In addition, pilots complained of poor fore-aft cueing, which was amplified at the top of this maneuver. Cueing is an important parameter and should be carefully tailored to the pilot-vehicle configuration.

The Normal Depart/Abort MTE was assigned Level 1 (or HQR=3.5) handling qualities for all the configurations. The predicted Level 2 criteria (residual oscillations, yaw attitude quickness, pitch-roll inter-axis coupling in the frequency domain, and height response out-of-ground-effect) do not appear to influence this MTE. The pilots noted the highest workload in the performing this MTE was the lack of position cues during the high-nose attitude deceleration portion at the end of the maneuver. Extending the cues long past the end-line helps alleviate this problem.

The Lateral Reposition MTE was assigned a wide range of handling qualities ratings from HQR=3 to HQR=7, with the majority of ratings in the Level 2 range. The average assigned handling quality rating was Level 2 for all configurations and directions (left/right), except for the external slung load configuration in calm winds (Level 3). The predicted handling qualities are all Level 1, except Level 2 for residual oscillations, yaw attitude quickness, pitch-roll inter-axis coupling in the frequency domain, and height response out-of-ground-effect. There were complaints of roll oscillations, and the coupling into heading control during the position capture at the end of the maneuver. These predicted Level 2 criteria add to the required pilot compensation/workload in trying to achieve desired performance. Although the pitch-roll inter-axis coupling criteria in the frequency domain are intended to be aligned with target acquisition and tracking, the criteria may be pertinent to the low-altitude, precision Lateral Reposition MTE. The coupling into the pitch axis from rapid roll-axis inputs would seem to align well with target acquisition and tracking requirements. The pilots complained of coupling into the longitudinal axis during the acceleration and deceleration phases of this maneuver and the increased workload in trying to stay within the desired fore-aft position tolerances. So, it seems for the non-external slung load configurations, the few Level 2 predicted handling qualities criteria are able to capture the assigned handling quality issues. For the external slung load configurations, the assigned handling quality ratings range from HQR=3 to 7, with the majority of ratings in the Level 2 region. This could be a training issue; with a well-defined task description and performance standards, these large variations in handling quality ratings are not expected.

The lower section of Table 5.1 presents the Forward Flight top-level review of the quantitative and the average qualitative results from the ADS-33 assessment using the UH-60A. Review of the Forward Flight quantitative results shows nearly all results are Level 1, with the exception of: the pitch control power and the yaw bandwidth. However, the pitch control power and the yaw bandwidth results need to be caveated. The Operational Flight Envelope (OFE) for the Black Hawk was not defined, and hence, for the ADS-33 assessment, only the Level 2 requirement was tested. The UH-60A easily met the Level 2 pitch control power. The UH-60A yaw bandwidth was assessed and plotted on the Air Combat criteria, which is not appropriate for a Black Hawk. In ADS-33D-PRF, there was not a yaw bandwidth criteria for All Other MTEs, there was only Air Combat requirements. In ADS-33E-PRF, a forward flight yaw bandwidth criteria was added for All Other MTEs, and the UH-60A would easily meet the Level 1 requirements (> 2.0 rad/sec for phase delays below 0.14 sec).

The Slalom MTE was assigned Level 1 (or average HQR=3.5) for the empty and ballasted configurations. The assigned average was Level 2 for the external slung load configuration. For the empty and ballasted configurations, there were five assigned Level 1 ratings and two assigned Level 2 ratings. The two Level 2 ratings were due to pedal activity to get the heading and turning while the aircraft rolls. The pilot mentioned “minor but annoying” deficiencies, leading to “moderate compensation;” HQR=4. Although there were some complaints about the pedal activity, in general, the quantitative and qualitative assessments seem to align for the Slalom MTE without an external slung load. For the external slung load configuration, all the assessed qualitative ratings were HQR=5. The imposed 30-degree bank angle limit with the slung load made it nearly impossible to meet desired performance standards for the Slalom MTE. The Adequate performance standard for the Slalom requires the airspeed to be at least 40 knots throughout the course (at least 60 knots for desired). With this reduced airspeed, the course is manageable. The slung load definitely played a dominant role in the assigned handling qualities, as the slung load shifts back-and-forth and side-to-side while maneuvering through the course causing the pilot to compensate. It appears the predicted handling qualities do not account for this increased workload observed and documented in the qualitative handling qualities. Performing the Slalom with an external slung load was not adopted in ADS-33E-PRF.

6 Summary and Conclusions

Eighty hours of flight tests were performed using the UH-60A Black Hawk helicopter to assess the required compliance testing and evaluate the rotorcraft handling qualities criteria in ADS-33D-PRF in a good visual environment. The tests were performed in three phases. Six pilots participated in the Phase 1 effort to tailor the existing ADS-33D-PRF flight test maneuvers and develop new flight test maneuvers specifically designed to appropriately evaluate the handling qualities of utility helicopters, with and without external slung loads. Course cueing for these flight test maneuvers was constructed and refined to provide sufficient cues such that the evaluation pilots could determine Desired and Adequate maneuver performance standards. Eight pilots participated in the Phase 2 formal handling qualities evaluations of these maneuvers in three aircraft configurations: empty (approximate mid-mission weight = 13,500 lbs); with an internal ballast (17,300 lbs); and empty but with a 6000-lb external slung load (19,300 lbs). Data were collected in calm (< 5 kts) and light wind conditions (7–15 kts). During the final phase of the test, Phase 3, the empty and internal ballast configurations were used to assess the compliance testing and criteria from the quantitative requirements in ADS-33D-PRF at hover and in forward flight. The following conclusions were drawn.

- Selected flight test maneuvers from ADS-33D-PRF and from a CH-47D cargo helicopter assessment were refined for the utility mission. The performance standards were generally aligned with those developed in the cargo helicopter flight test. For others, like the Slalom, Pirouette, and Slope Landing the performance standards turned out to be same for scout/attack, cargo, and utility classes of helicopters.
- Course cueing for the maneuvers must be sufficient for the pilot to determine the maneuver's Desired and Adequate performance standards. It appears this requirement can be met with rather simple and inexpensive traffic cones, and wooden hover boards with reference symbols.
- For the Section 3 quantitative requirements evaluated during this test, it appears that about two data flights are needed to acquire the data for a particular flight condition/configuration. With real-time monitoring of the control inputs and aircraft response from the ground station, the frequency sweep testing and the steps, doublets, and pulse control inputs were performed in a routine and efficient manner. A control fixture improved the data quality and efficiency/safety in collection. However, the collection of hover attitude quickness data was one of the more troublesome and time-consuming tests.
- For the internal ballast configuration and from the data analyzed, the identification of where the test aircraft falls on the ADS-33D-PRF criteria shows nearly all of the quantitative data lie within the predicted Level 1 regions.
- The initial lessons learned and results from this flight test assessment of ADS-33D-PRF using a UH-60A Black Hawk helicopter were instrumental in expanding the D-version of ADS-33 into an E-version that included a first-cut at criteria suitable for Utility classes of rotorcraft, with and without external slung loads.
- In general, the HQRs for each MTE were reasonably consistent among all pilots. The addition of light winds (7–15 knots) tended to degrade the handling qualities for some MTEs more so than others. The average amount of flight time needed to perform a maneuver evaluation ranged between 14 and 23 minutes with an overall average of just under 18 minutes. From the internal ballast configuration, the qualitative results for calm conditions suggest that except for the Hovering Turn and the Pirouette maneuvers, the average HQR for the UH-60A, as tested, is close to the Level 1-2 boundary.

7 Recommendations

Based on pilot feedback and lessons learned from setting up the course cueing and performing the quantitative and qualitative testing, the following recommendations are provided.

Real-Time Data Monitoring. The ability to monitor the control inputs and aircraft responses at the TM station during the test was found to be essential. The quality of the data and the frequency and magnitude of the input and response can be assessed in real time. This data monitoring ability provided an opportunity to repeat questionable data points and terminate test points when sufficient compliance data had been collected. Also, the real time monitoring of the frequency sweeps allowed for clear termination when the 2-Hz limit was reached, and allowed a qualitative “goodness” assessment of the overall sweep.

Forward flight pitch-roll coupling (time domain) data were somewhat difficult to collect. The difficulty stems from two issues: holding the on-axis input for 4 seconds dictates a rather small input to avoid excessively large attitude changes (as the aircraft response is a rate command). The other issue is the need for a “precise” trim in the off-axis and no off-axis inputs during the on-axis step input. These difficulties necessitated multiple repetitions of the test points on the flight test card to collect adequate data. Having real-time data available to assess the data quality, and repeat questionable data runs, was very helpful.

Test Techniques. Attitude quickness data was somewhat difficult to collect. For the larger attitude changes, it is acceptable to initiate the changes from a non-level equilibrium condition, provided the input is made with the aircraft near zero angular rate and near the desired trim airspeed. The use of a control fixture allows the flight crew a margin of safety and a method for buildup to the maximum input size. The fixture was used effectively for up to 20-degree bank angles from equilibrium followed by 4-inch control inputs; that is, for a positive peak roll rate with a 50-degree roll attitude change, the maneuver was initiated from a negative 20-degree bank angle. Thus, the excursions in roll attitude were from −20 to +30 deg.

Before performing specific test points to generate large-amplitude compliance data, data from prior test points were examined, e.g., data from performing the MTEs and the Attitude Quickness tests. For the UH-60A, Attitude Quickness data provided some of the needed data for the large-amplitude requirements. There are other examples, e.g., the data from the height response-type classification was used for the vertical axis control power.

During the directional sweeps, it was found that a higher coherence, and hence a higher quality of data, was obtained when one pilot performed the pedal sweep and the other pilot controlled the cyclic and collective; this reduced the overall correlation between the controls from biodynamic interaction and improved the data. This method was successfully used on yaw frequency sweeps at hover and 80 knots.

Cueing. MTE cueing for the aircrew is a very important ingredient and should be carefully tailored to the pilot-vehicle configuration. This point cannot be over-emphasized.

For the Hover MTE, it has been noted from other tests that by having the hover board on the ground, the pilot is only able to obtain altitude cue information from the board when the precision hover point is reached. By having the hover board elevated, the pilot can obtain altitude information during the 6–10 knot translation to the precision hover point. That is, the pilot is able to monitor and control altitude during the translation so the aircraft altitude is within the desired tolerance at arrival to the precision hover point, then the entire time-to-stabilize the aircraft to a hover can be used to get the horizontal axes “stable” and the aircraft over the hover point. If the aircraft arrives at the precision hover point not at the desired altitude, the pilot, in addition to getting the horizontal axes stable, must also monitor/adjust the heave axis and then the 5-second time to stabilize may be insufficient, and thus the HQRs may be degraded.

Another recommendation is to require the pilots to use the cues from the direction in which they are traveling. That is, when in the right seat and flying the Pirouette MTE to the left, the pilot should use the circle-cues to his left and not look to the right (behind his direction of travel) as this technique is totally unrealistic due to normal safety considerations. One problem with this recommendation is the reduction in cueing by having to look cross-cockpit. Perhaps for a cockpit with side-by-side seating, the evaluation pilot should be allowed to sit in the left seat when performing maneuvers to the left so as to reduce detrimental cueing effects on the handling qualities rating. This logic could also apply to the Lateral Reposition MTE, and possibly the Hovering Turn MTE.

Proposed Future Work. Acquiring good compliance data for the ADS-33D-PRF pitch-roll coupling requirements was also somewhat difficult. The peak off-axis response from trim occurs any time within the first 4 seconds, whereas the on-axis response from trim is measured at 4 seconds following the control input. Relatively small control inputs were needed to maintain the on-axis attitudes within the approved attitude excursion limit of four seconds after the step input, as defined in the test plan. The data points are within the Level 1 region, but the confidence and repeatability in obtaining these data were less than ideal. One approach to dealing with the difficulties of off-axis inputs may be that proposed in reference 20. Compliance data are obtained from the control frequency sweeps used in the bandwidth analysis. Employing a multi-input, multi-output analysis removes the off-axis control input effects, thus requiring no additional compliance testing. These frequency-domain based criteria should be expanded to cover a broader range of MTEs.

Compliance testing for demonstrating a minimum achievable roll rate was performed in a build-up fashion. Initially, one-inch lateral cyclic steps were used. These were increased in half-inch increments up to a 3.5-inch right step and a 4.0-inch left step. Once the control inputs reached 2.5 inches in magnitude, the pilots trimmed the aircraft in a 20-degree bank in the opposite direction before making the control input. The test plan had a 60-degree limit on roll attitude, and trimming 20-degrees in the opposite direction allowed the roll rate to be achieved before the roll attitude limit was reached.

Torque response criteria requires measurement of the "displayed" torque to the aircrew. This is difficult. A viable means of data collection should be investigated.

Turn Coordination was predicted to be Level 1. During assigned handling qualities evaluations, some pilots complained about the turn coordination response during the Slalom MTE. The turn coordination criteria should be investigated.

The ADS-33 calls for several MTE assessments in moderate winds (20–35 knots) from the most critical direction. This is difficult to accomplish, as the MTE course is usually set up in a specific orientation. If the winds change direction, the whole set of course cues would need to be rotated and verified. In addition, this ADS-33 assessment was conducted in light winds (7–15 knots), which were sufficient to drive up the pilot workload and resulted in degraded handling qualities. Testing in 35-knot winds from the most critical direction may be a good goal, but practically this may be very difficult.

From the initial flight testing, the following maneuvers were considered either inappropriate or too aggressive for utility helicopters: Vertical Remask, Acceleration and Deceleration, Sidestep, Turn-to-Target, and the High and Low Yo-Yo maneuvers. Two new maneuvers from the Cargo helicopter evaluation (refs. 8 and 9), the Depart/Abort and Lateral Reposition maneuvers, were evaluated and found to be appropriate for the Utility class of helicopters.

During the maneuver applicability assessment, the evaluation pilots felt the CH-47D recommended heading tolerances (±5 deg for Desired, and ±10 deg for Adequate performance) for the Hover MTE were a bit too lenient. Consequently, they recommended that the heading tolerances for utility-class rotorcraft should be ±3 degrees for Desired and ±7 degrees for Adequate.

Slope Landing MTE. To be more in-line with the Aircrew Training Manual (ATM) (ref. 24) slope landing maneuver, for this test, the ADS-33 Slope Landing MTE description was modified to say the landing shall be completed by lowering the collective to the full down position and neutralizing the other controls. One pilot commented that he did not like leveling the tip path plane (with respect to the aircraft) as part of the task. This was considered inappropriate for a slope landing if the crew is really concerned about the ability to keep the aircraft on the slope, "there is no reason to give yourself a downslope vector." The ADS-33E-PRF does not incorporate the requirement to neutralize the controls once landed on the slope.

A couple of other observations were noted. After landing on the slope, there's a tendency for the aircraft attitude to increase in the direction of the slope as the downhill landing gear strut collapses more than the uphill strut. Also, for the UH-60A, the pilot and co-pilot's attitude indicator need to both be set to zero on the ramp prior to takeoff.

Vertical Maneuver MTE. For the ADS-33D-PRF Vertical Maneuver MTE assessment with a UH-60A, the maneuver description and performance requirements from the CH-47D test results were used with one minor change toward more precision: the 2-second stabilization at the top of the maneuver was increased to four seconds and 2 seconds were added to the total maneuver time.

Lateral Reposition and Depart/Abort MTEs. For the Lateral Reposition and the Depart/Abort MTE, it has been observed that if the evaluation pilot is having trouble completing the MTE in the specified time, the pilot should try to initiate the maneuver acceleration phase quicker to save time as opposed to trying to complete the deceleration phase quicker to save time. The technique of trying to complete the deceleration phase quicker to save time has been observed to actually increase pilot workload and overall maneuver completion times.

Lessons learned from prior Depart/Abort MTE tests were incorporated into the course cues at Ames. Specifically, the four columns of traffic cones laid out along the taxiway centerline to provide lateral track information were extended past the endpoint. This was found to be very helpful during the deceleration phase, where a high-nose attitude obscures the pilot's view of these cues. In addition, the two rows of traffic cones indicating the endpoint and the 20 ft-short line were extended into the in-field on the right side to improve the evaluation pilot's detection of these lines during the nose-high attitude in the deceleration phase.

For the Depart/Abort MTE, the description of the maneuver calls for the aircraft to accelerate to approximately 40 knots ground speed, before aborting the departure and decelerating to a hover (ADS-33E-PRF says between 40–50 knots before aborting to a hover). It was found in the evaluation of this MTE with the UH-60A that the pilots could accomplish the maneuver in the desired time without accelerating to 40 knots. In fact, accelerating to 30–35 knots was sufficient to accomplish the MTE within desired time. This should be reflected in the next ADS-33 update.

Appendix A. References

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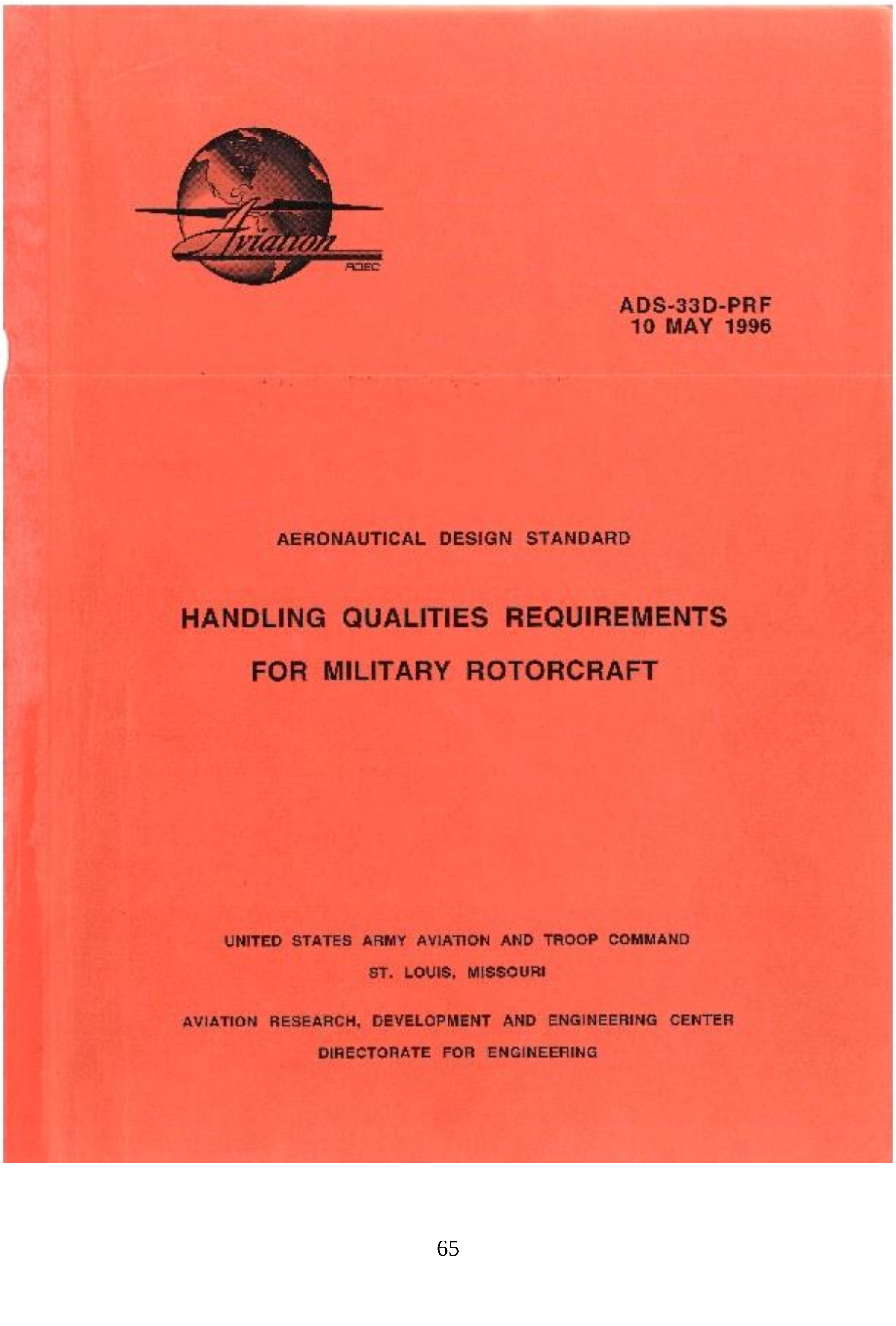
Appendix B. ADS-33D-PRF

Throughout the planning and conduct of this test campaign, ADS-33D-PRF (dated 10 May 1996) was the basis. As many paragraphs in ADS-33D-PRF (ref. 11) are referred to in this report, a complete copy of ADS-33D-PRF is contained in this Appendix. Following the UH-60A flight assessment, a new version of ADS-33 (the "E" version) was released. Many lessons from this flight assessment were incorporated into the "E" version.



ADS-33D-PRF
10 MAY 1996

AERONAUTICAL DESIGN STANDARD

HANDLING QUALITIES REQUIREMENTS
FOR MILITARY ROTORCRAFT

UNITED STATES ARMY AVIATION AND TROOP COMMAND
ST. LOUIS, MISSOURI

AVIATION RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
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ADS-33D-PRF

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Rationale for certification:

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Decision:

General Type	Decision (check)	Certification
Specification	XX	**Performance**
		Detail
Standard		Interface Standard
		Standard Practice
		Design Standard
		Test Method Standard
		Process Standard
Handbook		Handbook (non-mandatory use)
Alternative Action		

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1. SCOPE AND CONPLIANCE

1.1 SCOPE

This specification contains the requirements for the flying and ground handling qualities of rotorcraft.

1.2 APPLICATION

The requirements of this specification are intended to assure that no limitations on flight safety or on the capability to perform intended missions will result from deficiencies in flying qualities. Flying qualities for the rotorcraft shall be in accordance with the provisions of this specification unless specific deviations are authorized by the procuring activity. Additional or alternate special requirements may be specified by the procuring activity. For example, if the form of a requirement should not fit a particular vehicle configuration or control mechanization, the procuring activity may, at its discretion, agree to a modified requirement that will maintain an equivalent degree of acceptability.

Violation of any one requirement is expected to degrade handling qualities. Violation of several individual requirements (e.g., to level 2) could have a synergistic effect so that overall the handling qualities degrade to level 3, or worse. Depending on the requirement(s) violated, the contractor will define more extensive and comprehensive flight tests to demonstrate that the overall handling qualities are satisfactory. In any event, final acceptance will be subject to Government flight testing.

1.3 COMPLIANCE

Compliance with the requirements will be demonstrated using analysis, simulation, and flight test at appropriate milestones during the rotorcraft design and development. In absence of other guidance from the procuring activity, the following will be observed:

- Prior to critical design review - analytical checks computed using available math models (Section 3).
- Prior to first flight - analytical checks using full nonlinear math models including the feel system and SCAS elements (Section 3), and pilot assessments using flight simulators (Section 4).
- After first flight - flight test verification of all maneuvers except those deemed too hazardous or impractical. These exceptions will be demonstrated on a flight simulator which has been shown to be valid by comparison with flight test at adjacent conditions (Sections 3 and 4).

2. DEFINITIONS

2.1 Mission-Task-Element (MTE). An element of a mission that can be treated as a handling qualities task. For the purpose of this specification, all proposed missions will be subdivided into Mission Task-Elements.

2.2 Response-Type. A characterization of the rotorcraft response to a control input in terms of well recognized stability augmentation systems (i.e., rate, rate command/attitude hold, etc.). However, it is not necessary to use a stability augmentation system to achieve the specified characteristics.

2.3 Near-Earth Operations. Operations sufficiently close to the ground or fixed objects on the ground, or near water and in the vicinity of ships, oil derricks, etc., that flying is primarily accomplished with reference to outside objects.

2.4 IMC Operations. Operation of the rotorcraft solely with reference to the flight instruments. Occurs when the rotorcraft is clear of all obstacles.

2.5 Extent of Divided Attention Operation. Some requirements are based on the extent to which the pilot must attend to tasks other than flying the rotorcraft.

2.5.1 Fully Attended Operation. The pilot flying the rotor-craft can devote full attention to attitude and flight path control. Requirements for divided attention are minimal.

2.5.2 Divided Attention Operation. The pilot flying the rotorcraft is required to perform non-control-related sidetasks for a moderate period of time.

2.6 Speed Ranges. In the following definitions, ground speed is intended to be the speed with respect to a hover reference which may itself be moving, such as for shipboard operations.

2.6.1 Hover. Hovering flight is defined as all operations occurring at ground speeds less than 15 knots (7.7 m/s).

2.6.2 Low Speed. Low-speed flight is defined as all operations occurring at ground speeds between 15 and 45 knots (7.7 and 23 m/s).

2.6.3 Forward Flight. Forward flight is defined as all operations with a ground speed greater than 45 knots (23 m/s).

2.7 Step Input. For the purpose of this specification, a step input is defined as a rapid change in the controller force or position from one constant value to another. The input should be made as rapidly as possible without exciting undesirable structural or rotor modes, or approaching any aircraft safety limits. This differs from the classical definition, where the change occurs in zero time.

2.8 Levels of Flying Qualities. The acceptability of flying qualities of rotorcraft is quantified herein in terms of “Levels” that are defined for each specific mission task in Figure 1(2.8). Where possible, the requirements of Section 3 are stated in terms of three limiting values of one or more flying qualities parameters. Each value, or combination of values, represents a minimum condition necessary to meet one of the three “levels” of acceptability. In some cases sufficient simulation or flight test data do not exist to allow the specification of numerical values of a flying quality parameter. In such cases it is not possible to define explicitly the lower boundary of each “level.” These cases are handled by stating the required “level” of flying qualities for specified piloting tasks, and require compliance by demonstration in flight or via piloted simulation.

2.9 Flight Envelopes

2.9.1 Operational Flight Envelopes (OFE). The operational flight envelopes define the boundaries within which the rotorcraft must be capable of operating in order to accomplish the operational missions of 3.1.1. These envelopes shall be defined in terms of combinations of airspeed, altitude, load factor, rate-of-climb, side-velocity, and any other parameters specified by the procuring activity, as necessary to accomplish the operational missions.

Any warnings or indications of limiting or dangerous flight conditions, required by paragraph 3.8.1, shall occur outside the OFEs.

2.9.2 Service Flight Envelopes (SFE). The service flight envelopes are derived from aircraft limits as distinguished from mission requirements. Based on a list of normal states (obtained from those tabulated in Paragraph 3.1.6.1), found to be most critical in terms of rotorcraft limits, the contractor shall establish SFEs. These envelopes shall be expressed in terms of the parameters used to define the OFEs, plus any additional parameters deemed necessary to define the appropriate limits. The inner boundaries of the SFEs are defined as coincident with the outer boundaries of the OFEs. The outer boundaries of the SFEs are defined by one or more of the following: uncommanded aircraft motions, or structural, engine/power-train, or rotor system limits. The magnitude of the differences between the inner and outer boundaries of the SFEs shall be based on the guarantee of adequate margins between operations to complete the specified missions, and rotorcraft limits as required by Paragraph 3.1.8.

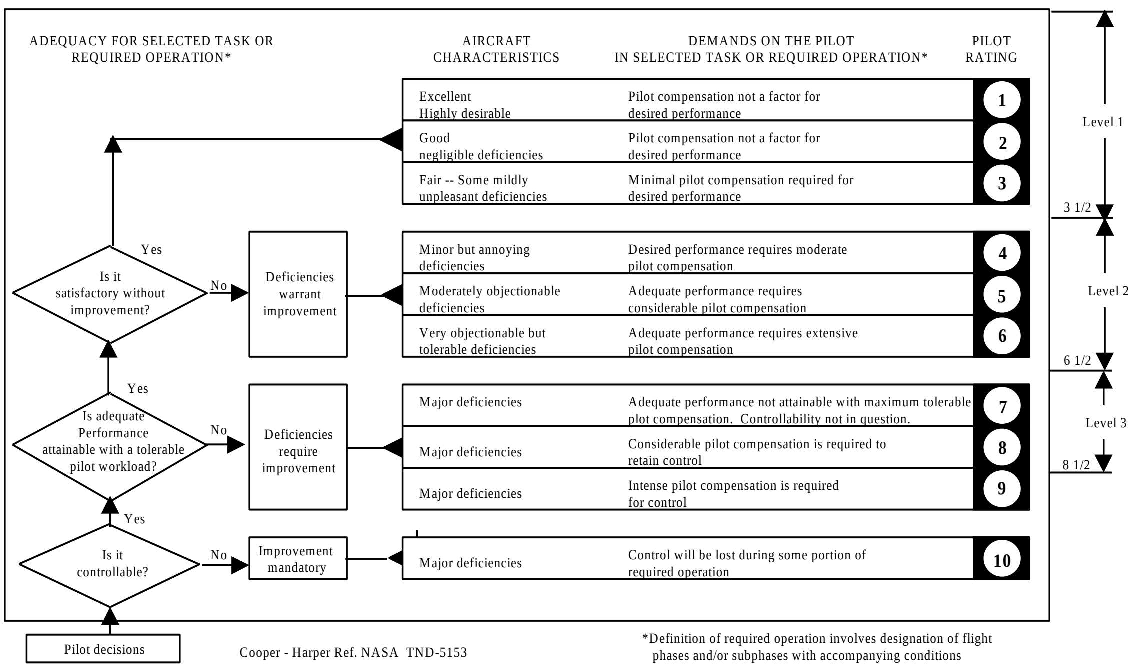


Figure 1(2.8) Definition of Flying Qualities Levels

3. REQUIREMENTS

3.1 GENERAL

3.1.1 Operational Missions. The procuring activity will define the operational missions and will specify the mission-task-elements to be considered by the contractor in designing the rotorcraft to meet the flying qualities requirements of this specification. These mission-task-elements will include the entire spectrum of intended operational usage and will in most cases be selected from those listed in Table 1(3.2) or 2(3.2). The procuring activity will specify any degraded visual environment (DVE), the atmospheric disturbances, weather performance criterion, and degree of divided attention operation (see paragraph 2.5) to be considered.

3.1.1.1 Multi-Crew Rotorcraft. Unless otherwise stated, all requirements shall apply for the primary pilot station. The procuring activity will define the mission-task-elements, degraded visual environment, degree of divided attention, and level of flying qualities that are applicable to any other pilot stations.

3.1.2 Loadings. The envelope of center-of-gravity and weight for each mission-task-element shall be specified by the contractor. In addition, the contractor shall specify the maximum center-of-gravity excursion attainable through failure in systems or components for each mission-task-element.

3.1.3 Moments and Products of Inertia. The contractor shall define the moments and products of inertia of the rotorcraft associated with all loadings of paragraph 3.1.2. The requirements of this specification shall apply for all moments and products of inertia so defined.

3.1.4 External Stores. The requirements of this specification shall apply for all combinations of external stores and sling loads required by the operational missions. The effects of external stores on the weight, moments of inertia, center-of-gravity position, and aerodynamic characteristics of the rotorcraft shall be considered for each mission-task-element. When the stores contain expendable loads, the requirements of this specification apply throughout the range of store loadings.

3.1.5 Configurations. A configuration is defined by the positions and adjustments of the various selectors and controls available to the crew, except for longitudinal, lateral, directional, vertical, power, and trim controls. The selected configurations to be examined must consist of those required for performance of the operational missions of paragraph 3.1.1. Additional configurations to be investigated may be defined by the procuring activity. Control positions which activate stability augmentation necessary to meet the requirements of this specification are considered to be always ON unless otherwise specified.

3.1.6 Normal States. The rotorcraft normal states (no component or system failures) are defined by the selected configuration together with the functional status of each of the rotorcraft components or systems, thrust magnitude, weight, moments and products of inertia, center-of-gravity position, and external store complement. The trim setting and the positions of the pitch, roll, and yaw controls are not included in the definition of the rotorcraft state since they are often specified in the requirements. The position of the thrust magnitude control shall not be considered an element of the rotorcraft state when the thrust magnitude is specified in a requirement.

3.1.6.1 Tabulation of Normal States. The contractor shall define those normal states which represent the characteristics of the rotorcraft throughout the OFES and SFEs. Certain items -- such as configurations, weight, moments of inertia, center-of-gravity position, rotor-tilt angle, or power setting - - may vary continuously over a range of values during a mission-task-element. The contractor shall replace this continuous variation by a limited number of combinations of the parameters in question. These will be treated as specific states and will include the most critical values and the extremes encountered during the required mission-task-element in question.

3.1.6.2 Allowable Levels for Normal States. The allowable levels in the operational and service flight envelopes are specified in Table 1(3.1).

TABLE 1(3.1). ALLOWABLE LEVELS FOR ROTORCRAFT NORAAL STATES

	OPERATIONAL FLIGHT ENVELOPE	SERVICE FLIGHT ENVELOPE
Minimum Handling Qualities	Level 1	Level 2

3.1.6.3 Flight Beyond the Service Flight Envelopes. Flight beyond the service flight envelope that does not involve structural failure, or unrecoverable loss of rotor RPM, shall be recoverable to the SFE without undue pilot skill. If such an excursion involves an engine failure, the requirements of 3.7.2 or 3.7.3 apply.

3.1.7 Rotorcraft Failures. When one or more rotorcraft failure states exist, a degradation in rotorcraft handling qualities is permitted. The required tabulation and definition of failure states as well as the allowable handling qualities degradations are specified in this paragraph.

3.1.7.1 Tabulation of Failure States. The contractor shall tabulate all rotorcraft failure states, which consist of rotorcraft normal states modified by one or more malfunctions in rotorcraft components or systems which affect rotorcraft response or UCE (paragraph 3.2.2.l). Each mode of failure shall be considered.

3.1.7.2 Methods of Compliance. Two methods are presented in order to provide the procuring agency with an option of using probability calculations or considering specific failures. The first option involves the following procedure:

a. Determine the degree of handling qualities degradation associated with the transient for each rotorcraft failure state (3.1.7.6).

b. Determine the degree of handling qualities degradation associated with the subsequent steady rotorcraft failure state.

c. Calculate the probability of encountering each identified rotorcraft failure state per flight hour.

d. Compute the total probability of encountering levels 2 and 3 flying qualities in the Operational and service flight envelopes. This total will be the sum of the rate of each failure only if the failures are statistically independent.

The second option assumes that certain failures or combinations of failures will occur regardless of their probability of failure. Steps 3 and 4 of the first option are therefore not performed. The contractor and procuring agency shall mutually agree on which failures in Paragraph 3.1.7.1 shall be treated as "specific failures."

3.1.7.3 Option 1 -- Allowable Levels Based on Probability. A degradation in flying qualities, due to the rotorcraft failure states (3.1.7.1), is permitted only if the probability of encountering the degraded level is sufficiently small. These probabilities shall be less than the values shown in Table 2(3.1).

TABLE 2(3.1). LEVELS FOR ROTORCRAFT FAILURE STATES

PROBABILITY OF ENCOUNTERING	WITHIN OPERATIONAL FLIGHT ENVELOPE	WITHIN SERVICE FLIGHT ENVELOPE
Level 2 after failure	$<2.5 \times 10^{-3}$ per flight hr	
Level 3 after failure	$< 2.5 \times 10^{-5}$ per flight hr	$< 2.5 \times 0^{-3}$ per flight hr

3.1.7.4 Option 2 -- Allowable Levels for Specific Failures. The requirements on the effects of specific failures shall be met on the basis that the failure has actually occurred. The allowable level of flying qualities for each specific failure shall be specified by the procuring activity. Alternatively, the procuring activity may specify specific piloting tasks and associated performance requirements in the failed state. As a minimum, the failures in paragraph 3.7 shall be treated as specific failures.

3.1.7.5 Rotorcraft Special Failure State. Certain components, systems, or combinations thereof may have extremely remote probability of failure during a given flight. These failure probabilities may, in turn, be very difficult to predict with any degree of accuracy. Special failure states of this type need not be considered in complying with the requirements of Section 3 if justification for considering the failure states as special is submitted by the contractor and approved by the procuring activity.

3.1.7.6 Transients Following Failures. The transient following a failure or combination of flight control system failures shall be recoverable to a safe steady flight condition without exceptional piloting skill. The contractor shall conduct tests to define the transients for comparison with the values in Table 3(3.1), and the results shall be made available to the procuring activity. For rotorcraft without failure warning and cueing devices, the perturbations encountered will not exceed the limits of Table 3(3.1).

TABLE 3(3.1). TRANSIENTS DUE TO FAILURES

LEVEL	FLIGHT CONDITION		
	HOVER AND LOW SPEED	FORWARD FLIGHT	
		NEAR-EARTH	UP-AND-AWAY
1	3 deg roll, pitch, yaw 0.05g n_x n_y n_z No recovery action for 3.0 sec	Both hover & low speed & forward flight up & away requirements apply	Stay within the OFE. No recovery action for 10 sec
2	10 deg attitude change or 0.2g acceleration. No recovery action for 3.0 sec	Both hover & low speed & forward flight up & away requirements apply	Stay within OFE. No recovery action for 5.0 sec
3	24 deg attitude change or 0.4g acceleration. No recovery action for 3.0 sec	Both hover & low speed & forward flight up & away requirements apply	Stay within OFE. No recovery action for 3.0 sec

3.1.7.7 Indication of Failures. Immediate and easily interpreted indications of failures shall be provided, if such failures require a change of strategy or crew action.

3.1.8 Rotorcraft Limits. Limiting and potentially dangerous conditions may exist where the rotorcraft should not be flown. When approaching such limits, it shall be possible by clearly discernible means for the pilot to recognize the situation and take preventive action.

3.1.8.1 Warning and Indication of Rotorcraft Limits Warning and indication of approach to a rotorcraft limit shall be clear and unambiguous so that the pilot can avoid dangerous conditions. In near-earth operations, the pilot shall be able to interpret warnings and avoid limiting and potentially dangerous conditions with eyes out of the cockpit.

3.1.8.2 Devices for Indication Warning. Prevention and Recovery. It is intended that limiting and dangerous flight conditions be eliminated and the requirements of this specification be met by appropriate aerodynamic design and mass distribution rather than through incorporation of special devices for indication, warning, prevention, and recovery. Neither normal nor inadvertent operation of such devices shall create a hazard to the rotorcraft or prohibit flight within the operational flight envelope.

3.1.9 Interpretation of Subjective Requirements. In several instances throughout the specification, subjective terms have been employed where insufficient information exists to establish absolute quantitative criteria. Quantitative definition of these requirements shall be agreed upon by the procuring activity and the contractor prior to contract initiation.

3.1.10 Pilot-Induced Oscillations. There shall be no tendency for pilot-induced oscillations (PlO), that is, sustained or uncontrollable oscillations resulting from the efforts of the pilot to control the rotorcraft.

3.1.11 Residual Oscillations Any sustained oscillations in any axis in calm air shall not interfere with the pilot's ability to perform the specified mission-task-elements. For level 1, oscillations in attitude and in acceleration at the pilot's station greater than 0.5 degrees and 0.05 g will be considered excessive for any response-type and mission-task-element. These requirements shall apply with the cockpit controls fixed and free. Residual motions which are classified as a vibration shall be excluded from this requirement. The distinction between residual motions and vibration shall be based on mutual agreement between the manufacturer and procuring activity.

3.2 REQUIRED RESPONSE-TYPE

3.2.1 Applicability of Requirements. The required response-types are specified as a function of the mission-task-elements, and the usable cue environments resulting from mission visual environments, including available vision aids and displays. These specified response-types are intended to be minimums, and an upgrade may be provided if superior or equivalent flying qualities can be demonstrated. If such an upgrade is selected, the detailed requirements in Paragraphs 3.3 and 3.4 pertaining to the upgraded response-type apply.

3.2.2 Required Response-Type for Specified Mission-Task-Elements And Usable Cue Environments. The response-types required for applicable mission-task-elements and usable cue environments (UCE) are specified for each axis of control for hover and low speed (Table 1(3.2)) and forward flight (Table 2(3.2)). Unless response-types consistent with UCE=3 are already incorporated, the UCE is to be determined according to paragraph 3.2.2.1. If the mission-task-elements and UCE that comprise the required operational missions for the rotorcraft dictate more than one response-type, the response-type transfer requirements of paragraph 3.8 must be complied with.

Nominally, the performance requirements for each required MTE will be specified by the procuring activity. If such performance requirements are not specified, the limits in Sections 4.1 and 4.2 will apply. Furthermore, it is recognized that maneuvering will in general, be less aggressive in a degraded visual environment. If relaxed performance standards are not specified by the procuring activity, the criteria in Sections 4.4 and 4.5 will apply.

TABLE 1(3.2) REQUIRED RESPONSE-TYPE FOR HOVER AND LOW SPEED -- NEAR EARTH

	UCE = 1		UCE = 2		UCE 3	
	Level 1	Level 2	Level 1	Level 2	Level 1	Level 2
Vertical takeoff and transition to forward flight - clear of earth.	Rate	Rate	Rate	Rate	Rate	Rate
Precision Hover. Slung load pickup and delivery. Slung Load carrying. Shipboard landing including RASI recovery. Vertical takeoff and transition to near-earth flight. Hover-taxi/NOE-traveling. Rapid Slalom (note a).			ACAH +RCDH +RCHH ↓	Rate +RCDH	TRC+RCDH +RCHH+PH	ACAH +RCDH +RCHH ↓
Slope landing. Precision vertical landing. Pull-up/Push-over (note a).			ACAH+RC DH ~			ACAH +RCDH ↓
Rapid Bob-up & Bob-down (note a). Rapid Hovering turn.	↓		ACAH+RC DH +RCHH+P H			Rate +RCDH +RCHH+PH
Tasks involving divided attention operation (see Para. 2.5.2). Sonar dunking (note b). mine sweeping (note b).	Rate+RCDH +RCHH+PH ↓					
Rapid transition to precision hover (note a). Rapid sidestep (note a). Rapid accel and dcccl (note a). Target acquisition and tracking (note a and c).	Rate ↓	↓	↓	↓	↓	↓

Notes:
a. High Levels of aggressiveness may not be achievable for UCE = 2 and 3.
b. These tasks are normally accomplished in an environment where the visual cueing may 2 or 3 even in “day VFR conditions”.
c. Increase in rank to TRC not recommended for pitch pointing tasks.

1. A requirement for RCHH mat be deleted if the vertical translational rate visual cue rating is 2 or better, and divided attention operation is not required. If RCHH is not specified, an altitude rate response type is required. (see paragraph 3.2.9
2. Turn coordination (TC) is always required as an available response type for the slalom HTE in the low speed flight range as defined in paragraph 2.6.2. However, TC is not required at airspeeds less than 15 knots.
3. For UCE = 1, a specific response type may be replaced with a higher rank of stabilization, providing that the moderate and large amplitude attitude change requirements are satisfied.
4. For UCE 2 or 3, a specified response type may be replaced with higher rank of stabilization.
5. The rank ordering of combinations of response types from least to lost stabilization is defined as:
   a. Rate
   b. ACAH+RCDH
   c. ACAH+RCDH+RCHH
   d. Rate+RCDH+RCHH+PH
   e. ACAH+RCDH+RCHH+PH
   f. TRC+RCDH+RCHH+PH

Rate => Rate or rate command attitude mold (RCAH) response type (paragraph 3.2.5 and 3.2.6

TC => Turn coordination (paragraph 3.2.10.1).

ACAM => Attitude command attitude hold response type (paragraph 3.2.6 and 3.2.7).

RCHH => Vertical rate command with altitude (height) mold response type (paragraph 3.2.9.1)

RCDH => Rate command with heading (direction) hold response type (paragraph 3.2.5 and 3.2.6).

PM => Position hold response type (paragraph 3.3.11).

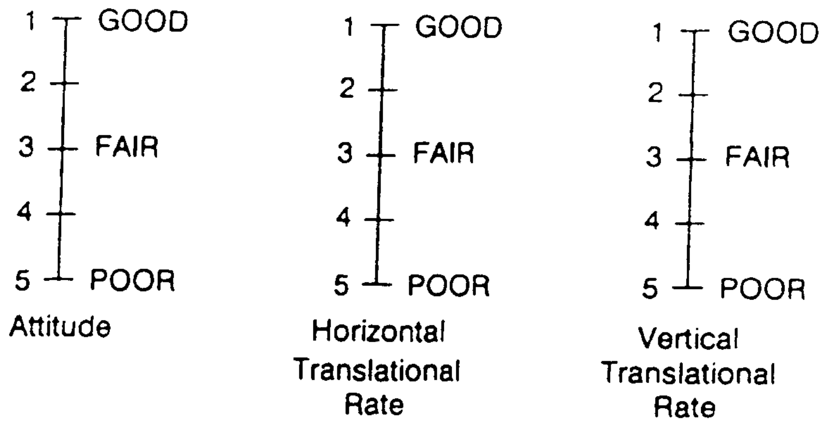
TRC => Translational rate command response type (paragraph 3.2.8).

TABLE 2(3.2). REQUIRED RESPONSE-TYPES IN FORWARD FLIGHT

Pitch and Roll Attitude	
Rate	PITCH - Rate or Attitude, Attitude Hold Required (ACAH or ACAH ROLL - Rate with Attitude Hold (RCAH
Ground attack Slalom Pull-up/Push-over Assault landing Sonobuoy deploy Descent Air combat	IMC cruise/climb/descent IMC departure IMC autorotation IMC approach (constant speed) IMC decelerating approach (3-cue flight director required Air-to-air refueling Mid-air retrieval Weapons delivery requiring a stable platform
Heading - - All require turn coordination (see paragraph 3.4.6.2)	
Height - - No specific response-type (see paragraph 3.4.3)	

3.2.2.1 Determination of the Usable Cue Environment. The displays and vision aids provided to the pilot shall be assessed to determine their effectiveness for stabilization and control. The visual cue ratings shall be determined using all displays and/or vision aids that are expected to be operationally available to the pilot, in the degraded visual environments specified in paragraph 3.1.1. The usable cue environment (UCE) is defined in Figure 2(3.2) using the visual cue ratings obtained from the Figure 1(3.2) scale during the flight assessments specified below. Points falling on a boundary in Figure 2(3.2) will be considered to lie in the region of numerically higher UCE.

The translational rate visual cue rating to be applied to Figure 2(3.2) is the poorer (higher numerically) of the horizontal and vertical axis ratings obtained from Figure 1(3.2). The visual cue ratings (VCRs) are to be made by at least 3 pilots and the UCE shall be obtained by using the mean VCRs in Figure 2(3.2). The test rotorcraft must meet the requirements for a rate response-type as defined in paragraph 3.2.5 and have a level 1 mean pilot rating (Figure 1(2.8) scale) by at least 3 pilots operating without any vision aids in good visual conditions (UCE = l) and negligible turbulence. The following mission-task-elements shall be flown when making the UCE assessments: hover, vertical landing, pirouette, acceleration and deceleration, sidestep, bob-up and bob-down. The task descriptions and performance limits specified in Sections 4.4 and 4.5 for each of these maneuvers shall apply when making the VCR ratings except that the maneuvers may be flown in calm winds.



DEFINITIONS OF CUES

X = Pitch or roll attitude and lateral, longitudinal, or vertical translational rate.

Good X Cues: Can make aggressive and precise X corrections with confidence and precision is good.

Fair X Cues: Can make limited X corrections with confidence and precision is only fair.

Poor X Cues: Only small and gentle corrections in X are possible, and consistent precision is not attainable.

Figure 1(3.2). Visual Cue Rating (VCR) Scale to be Used When Making UCE Determinations

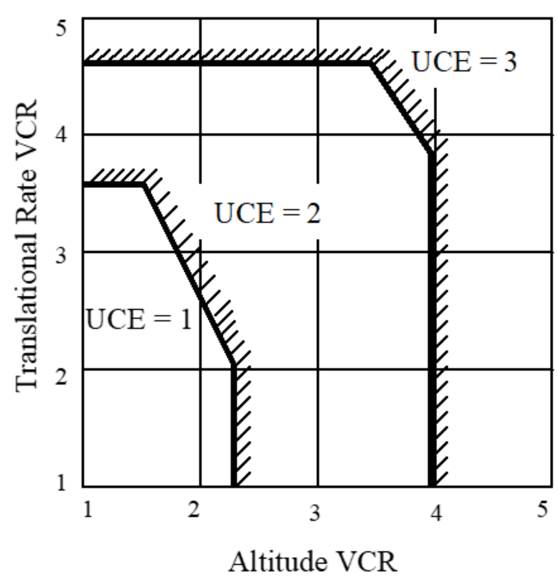


Figure 2(3.2) Definition of Useable Cue Environments

If the standard deviation of the visual cue ratings among the pilots is greater than 0.75, either additional pilots shall be employed, or the procuring activity shall assign a level of UCE.

3.2.3 Combinations of Degraded Response-Type and UCE. Table 1(3.2) allows a reduction in response-type for level 2 for some selected cases. If the dynamics of the particular response-type are level 2 or 3 based on one or more of the requirements of Section 3.3, the combination of degraded response-type, dynamics, and UCE may result in flying qualities levels that are worse than for any single degradation alone. Table 3(3.2) defines the levels corresponding to these combinations.

TABLE 3(3.2). LEVELS FOR COMBINATIONS OF DEGRADED RESPONSE-TYPE, DYNAMICS, AND UCE

UCE	LEVEL FOR RESPONSE-TYPE (TABLE 1(3.2))	LEVEL FOR DYNAMICS (SECTION 3.3)	OVERALL LEVEL
2	1	2	2
2	2	1	2
2	2	2	3
3	1	2	2
3	2	1	2
3	2	2	3

3.2.4 Rotorcraft Guidance. For near-earth operations at night and in poor weather, sufficient visual cues shall be provided to allow the pilot to navigate over the terrain, and to maneuver the rotorcraft to avoid obstacles while accomplishing the mission-task-elements. The contractor shall make calculations which determine three-dimensional maneuvering envelopes defined by the required mission-task-elements (paragraph 3.1.1), and indicate on these envelopes the maneuvering limits imposed by the visual field of the available displays and/or vision aids. The detailed assumptions regarding limiting performance (pilot delays, reaction time, and rotorcraft limits) must be approved by the procuring activity.

3.2.5 Character of Rate Response-Types. A response which meets the bandwidth requirements of Sections 3.3 and 3.4 (paragraphs 3.3.2.1, 3.3.5.1, 3.4.1.1, 3.4.5.1, and 3.4.7.1), may be classified as a rate response-type. No requirement on the specific shape of the response to control inputs is specified, except that the initial and final cockpit control force required to change from one steady attitude to another shall not be of opposite sign.

3.2.6 Character of Attitude Hold and Heading Hold Response-Types. If attitude hold or heading (direction) hold is specified as a required response-type in paragraph 3.2.2, the pitch attitude shall return to within $\pm$10 percent of the peak excursion, following a pulse input, in less than 20 seconds for UCE=1, and in less than 10 seconds for UCE>1, as illustrated in Figure 3(3.2). Roll attitude and heading shall always return to within 10 percent of peak in less than 10 seconds. The peak attitude excursions for this test shall vary from barely perceptible to at least 10 degrees. The attitude or heading shall remain within the specified 10 percent for at least 30 seconds for Level 1. The pulse input shall be inserted directly into the control actuator, unless it can be demonstrated that a pulse cockpit controller input will produce the same response.

For heading hold, following a release of the directional controller the rotorcraft shall capture the reference heading within 10 percent of the yaw rate at release. In no case shall a divergence result due to activation of the heading hold mode.

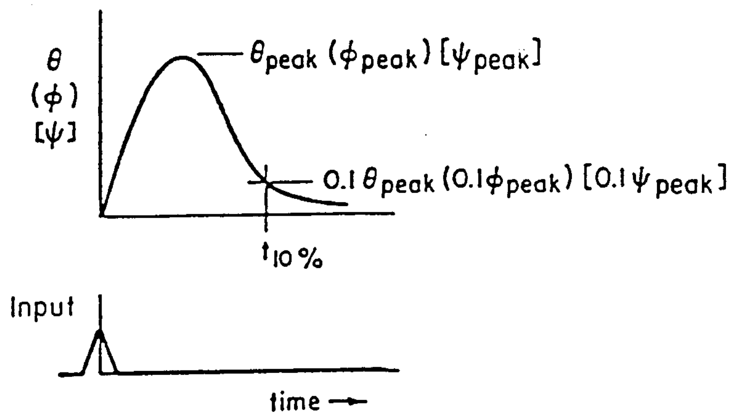


Figure 3(3.2). Illustration of Pulse Response Required for Attitude Hold and Direction Hold Response-Types

3.2.7 Character of Attitude Command Response-Types. If attitude command is specified as a required response-type in paragraph 3.2.2, a step cockpit pitch (roll) controller force input shall produce a proportional pitch (roll) attitude change within 6 seconds. The attitude shall remain essentially constant between 6 and 12 seconds following the step input. However, the pitch (roll) attitude may vary between 6 and 12 seconds following the input, if the resulting ground-referenced translational longitudinal (lateral) acceleration is constant, or its absolute value is asymptotically decreasing towards a constant. A separate trim control must be supplied to allow the pilot to null the cockpit controller forces at any achievable steady attitude.

3.2.8 Character of Translational Rate Response-Type. If translational rate command is specified as a required response-type in paragraph 3.2.2, constant pitch and roll controller force and deflection inputs shall produce a proportional steady translational rate, with respect to the earth, in the appropriate direction.

3.2.9 Character of Altitude Rate Response-Types. The rotorcraft is defined as having an altitude rate response-type if a constant deflection (force if an isometric controller is used) of the vertical axis controller from trim produces a constant steady-state vertical velocity. It must be possible for the pilot to null the cockpit controller force at any achievable vertical rate.

3.2.9.1 Character of Altitude Rate Command With Altitude Hold. Following an altitude deviation induced by insertion and removal of an input directly into the vertical-axis actuator, the rotorcraft shall return to its original altitude without objectionable delays and with no overshoot. For hover and low speed, the rotorcraft shall automatically hold altitude with respect to a flat surface for land based operations, or a rough sea for sea-based operations, with the altitude controller free. The altitude deviation may not exceed 1 m (3.3 ft) during the performance of the mission-task-elements specified in paragraph 3.1.1. This may be relaxed to 2 m (6.6 ft) if the bank angle exceeds 30 degrees. Engagement of altitude hold shall be obvious to the pilot through clear tactile and visual indication. The pilot shall be able to disengage altitude hold, change altitude and reengage altitude hold without removing his hands from the flight controls. This requirement shall be met for level 1, and relaxed according to paragraph 3.2.12 for levels 2 and 3.

3.2.10 Character of Yaw Response to Lateral Controller

3.2.10.1 Turn Coordination. For low speed flight, during banked turns with any available heading hold modes disengaged, the rotorcraft heading response to lateral controller inputs shall remain sufficiently aligned with the direction of flight so as not to be objectionable to the pilot. Complex coordination of the yaw and roll controls shall not be required.

3.2.10.2 Rate Command with Direction Hold. For Hover, the yaw controller inputs required to maintain constant heading during rolling maneuvers shall not be objectionably large or complex.

3.2.11 Limits on Nonspecified Response-Types. It may be desirable, or even necessary, to incorporate response-types that are not explicitly defined in this specification. Examples of such response-types are airspeed hold, linear acceleration command with velocity hold, and hybrid responses such as ACAH for small attitudes which blend to rate for larger commands or attitudes. It is required that these response-types meet their stated objectives (e.g., airspeed hold systems must hold airspeed), and the requirements of this specification.

3.2.12 Requirements for Inputs to Control Actuator. The requirements to check for adequate disturbance rejection via inputs directly into the control actuator (paragraphs 3.2.6, 3.2.9.1, 3.3.2.3, 3.3.7, and 3.4.10) are waived for levels 2 and 3. This is to allow the use of control input shaping to achieve the necessary command-response relationship for backup flight control systems.

3.2.13 Transition Between Airborne and Ground Operations. There shall be no tendency for uncommanded, divergent motions of any primary flight control surface when the rotorcraft is in contact with any potential landing platform. This requirement is aimed specifically at integrators in the flight control system that must be turned off when rotorcraft motion is constrained by contact with a fixed object.

3.3 HOVER AND LOW SPEED

The Hover and Low Speed requirements apply to those mission-task-elements designated as hover and low speed tasks in Table 1(3.2) and apply over the applicable portions of the flight envelopes.

3.3.1 Equilibrium Characteristics The equilibrium pitch and roll attitude required to achieve a no-wind hover, and to achieve equilibrium flight in a 35 knot relative wind from any direction, shall not result in pilot discomfort, disorientation, or restrictions to the field-of-view that would interfere with the accomplishment of the mission-task-elements of paragraph 3.1.1. Nose-up trim attitudes which potentially result in tail boom clearance problems are discouraged.

3.3.2 Small-Amplitude Pitch (Roll) Attitude Changes

3.3.2.1 Short-Term Response to Control Inputs (Bandwidth). The pitch (roll) response to longitudinal (lateral) cockpit control force or position inputs shall meet the limits specified in Figure 1(3.3). The bandwidth (ω_{BW}) and phase delay (τ_p) parameters are obtained from frequency responses as defined in Figure 2(3.3).

It is desirable to meet this criterion for both controller force and position inputs. If the bandwidth for force inputs falls outside the specified limits, flight testing should be conducted to determine that the force feel system is not excessively sluggish.

3.3.2.2 Mid-Term Response to Control Inputs. The mid-term response characteristics apply at all frequencies below the bandwidth frequency obtained in paragraph 3.3.2.1. Use of an attitude hold response-type constitutes compliance with this paragraph, as long as any oscillatory modes following a pulse controller input have an effective damping ratio of at least 0.35. If attitude hold is not available, the applicable criterion (paragraph 3.3.2.2.1 or 3.3.2.2.2) depends on the degree of divided attention necessary to complete the mission-task-elements according to paragraph 3.1.1.

3.3.2.2.1 Fully Attended Operations. For those mission-task-elements specified in 3.1.1 as requiring fully attended operation, the mid-term response shall meet the limits of Figure 3(3.3).

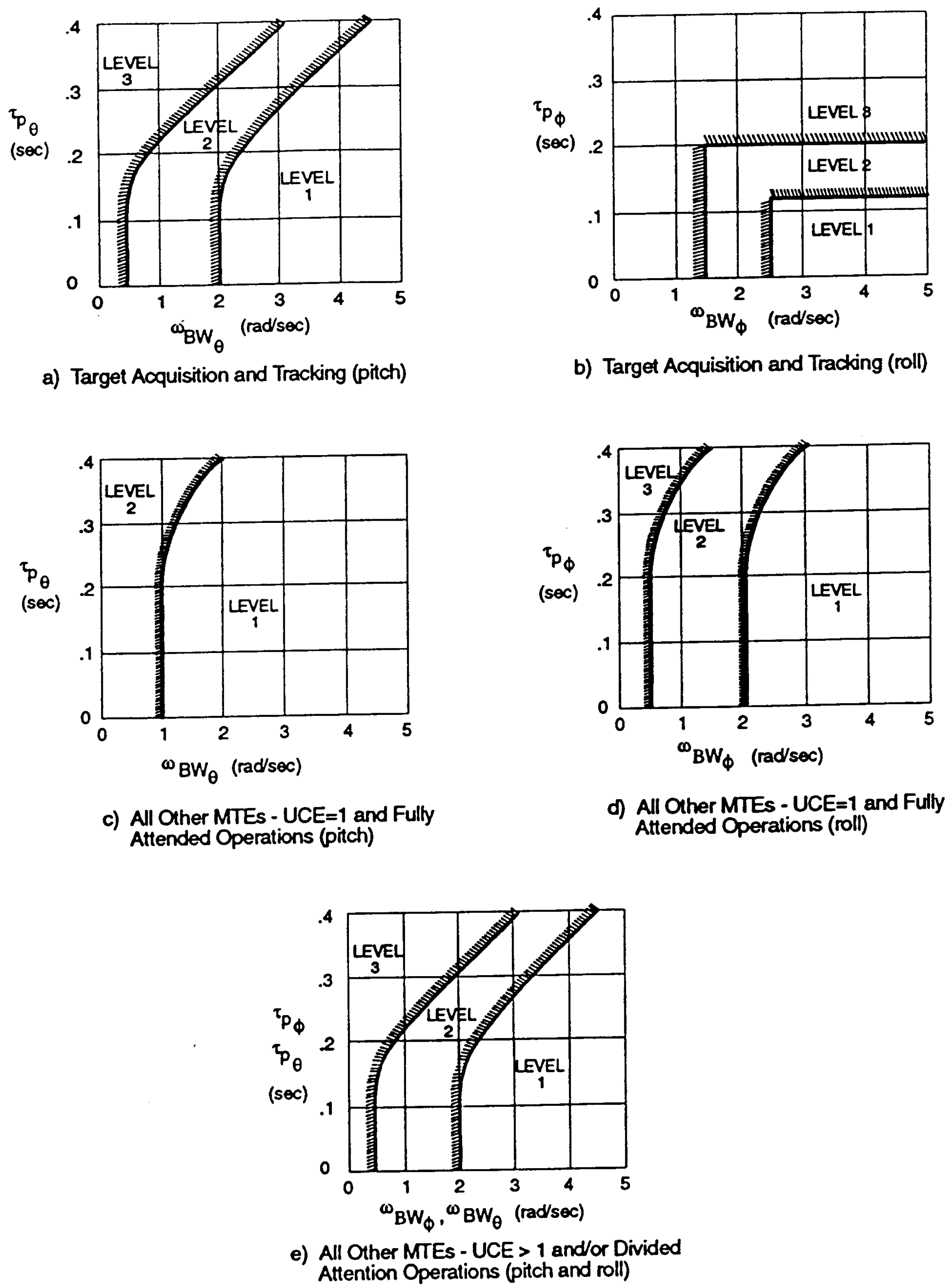


Figure 1(3.3). Requirements for Small-Amplitude Pitch (Roll) Attitude Changes -- Hover and Low Speed

Phase Delay:

$$\tau_p = \frac{\Delta\Phi 2\omega_{180}}{57.3\,(2\omega_{180})}$$

*Note: if phase is nonlinear between ω_{180} and $2\omega_{180}$, τ_p shall be determined from a linear least squares fit to phase curve between ω_{180} and $2\omega_{180}$

CAUTION:
For ACAH, if $\omega_{BW_{gain}} < \omega_{BW_{phase}}$, or if $\omega_{BW_{gain}}$ is indeterminate, the rotorcraft may be PIO prone for super-precision tasks or aggressive pilot technique.

Rate Response-Types:

ω_{BW} is lesser of $\omega_{BW_{gain}}$ and $\omega_{BW_{phase}}$

Attitude Command/Attitude Hold Response-Types (ACAH):

$\omega_{BW} \equiv \omega_{BW_{phase}}$

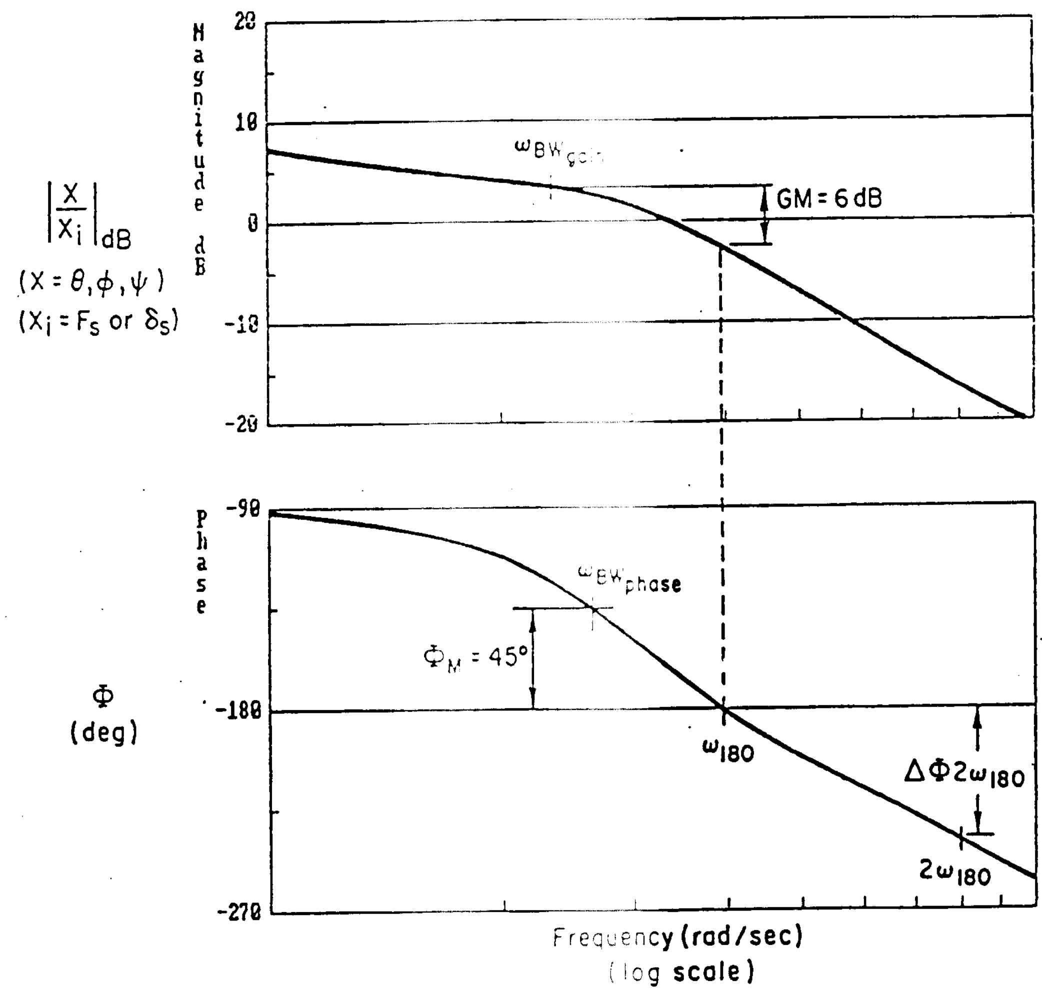


Figure 2(3.3). Definitions of Bandwidth and Phase Delay

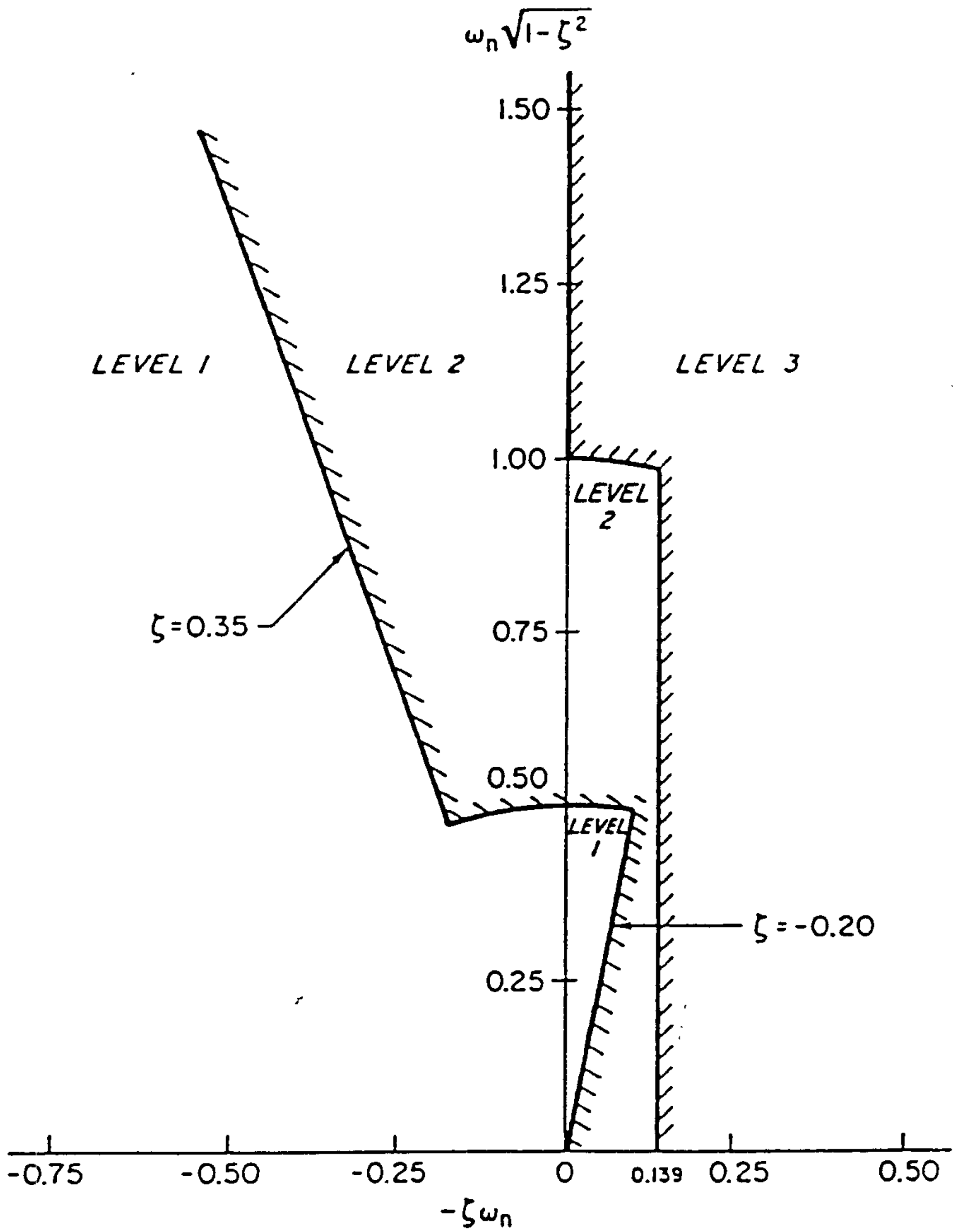


Figure 3(3.3). Limits on Pitch (Roll) Oscillations for Fully Attended Operations -- Hover and Low Speed

3.3.2.2.2 Divided Attention Operations. For those mission-task-elements specified in Paragraph 3.1.1 as requiring divided attention operations (Paragraph 2.5), the limits of Figure 3(3.3) shall be met, except that the Level 1 damping shall not be less than $\varsigma = 0.35$ at any frequency.

3.3.2.3 Short-Term Pitch and Roll Resoonses to Disturbance Inputs. Pitch and roll responses to inputs directly into the control surface actuator shall meet the bandwidth limits based on cockpit controller inputs as specified in paragraph 3.3.2.1. If the bandwidth and phase delay parameters based on inputs to the control surface actuator can be shown to meet the cockpit control input bandwidth requirements by analysis, no testing is required. This requirement shall be met for level 1, and relaxed according to paragraph 3.2.12 for levels 2 and 3.

3.3.3 Moderate-Amplitude Pitch (Roll) Attitude Changes (Attitude Quickness). The ratio of peak pitch (roll) rate to change in pitch (roll) attitude, $q_{pk}/\Delta\theta_{pk}$ ($P_{pk}/\Delta\phi pk$) shall exceed the limits specified in Figure 4(3.3). The required attitude changes shall be made as rapidly as possible from one steady attitude to another without significant reversals in the sign of the cockpit control input relative to the trim position. The initial attitudes, and attitude changes, required for compliance with this requirement, shall be representative of those encountered while performing the required mission-task-elements (Paragraph 3.1.1). It is not necessary to meet this requirement for response-types which are designated as applicable only to UCE = 2 or 3.

TABLE 1(3.3). REQUIREMENTS FOR LARGE-AMPLITUDE ATTITUDE CHANGES

MISSION TASK ELEMENT	RATE RESPONSE-TYPES						ATTITUDE RESPONSE-TYPES			
	MINIMUM ACHIEVABLE ANGULAR RATE (deg/sec)						MINIMUM ACHIEVABLE ANGLE (deg)			
	LEVEL 1			LEVELS 2 AND 3			LEVEL 1		LEVELS 2 AND 3	
	q	p	r	q	p	r-	θ	ϕ	θ	ϕ
Limited Maneuvering All MTEs not otherwise specified	±6	- ±21	±9.5	±3	±15	±5	±15	±15	±7	±10
Moderate Maneuvering Rapid transition to precision hover Slope landing Shipboard landing	±3	±50	±22	±6	±21	±9.5	+20 -30	±60	±13	±30
Aggressive Maneuvering Rapid accel and decel Rapid sidestep Rapid hovering turn Rapid slalom Target acquisition and tracking Pullup/pushover Rapid bobup-bobdown	±30	±50	±60	±3	±50	±22	±30	±60	+20 -30	±30

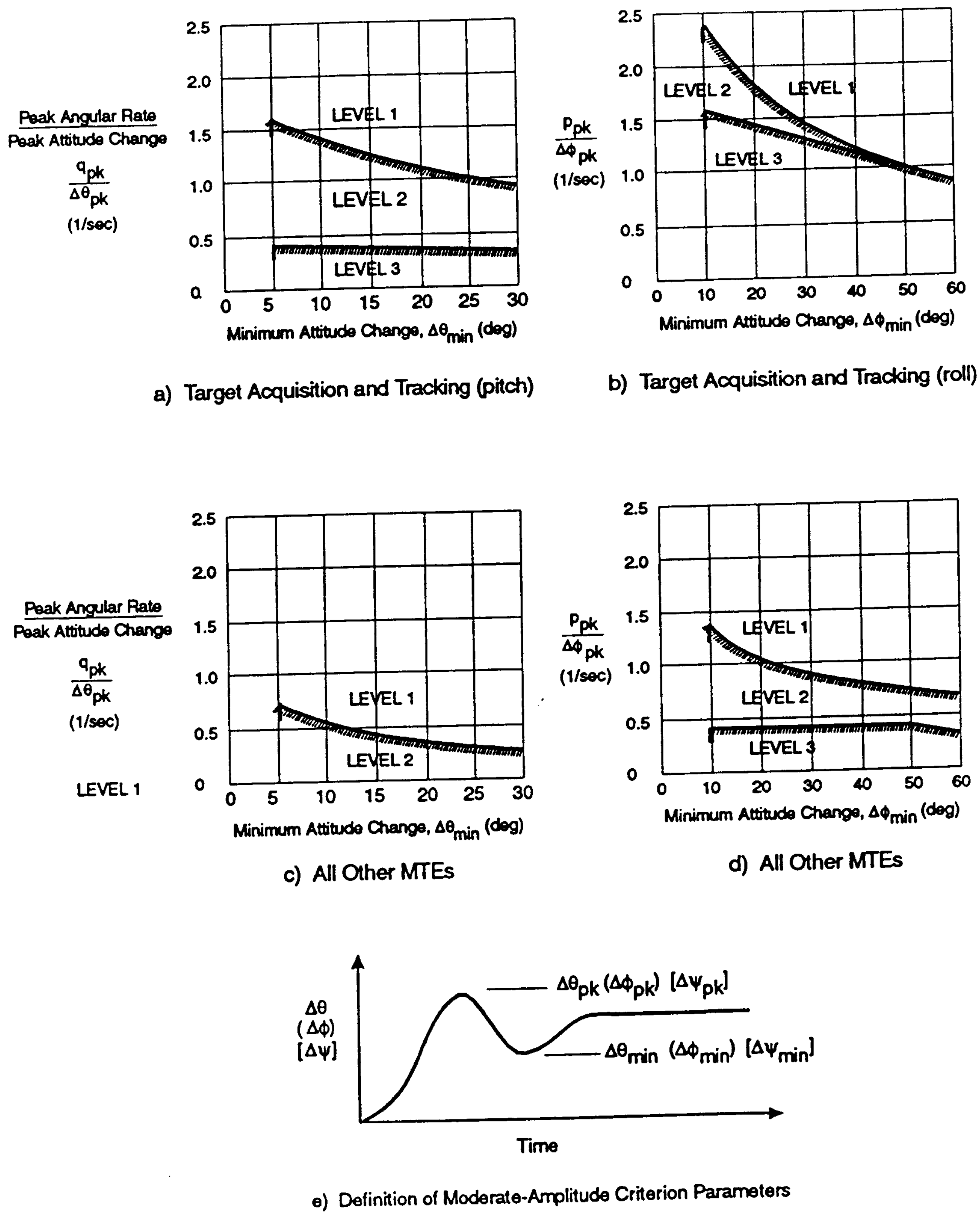


Figure 4(3.3). Requirements for Moderate-Amplitude Pitch (Roll) Attitude Changes -- Hover and Low Speed

3.3.4 Large-Amplitude Pitch (Roll) Attitude Changes. The minimum achievable angular rate (for rate response-types) or attitude change from trim (for attitude response-types) shall be no less than the values specified in Table 1(3.3). The specified rates or attitudes must be achieved in each axis while limiting excursions in the other axes with the appropriate control inputs. Response-types which are designated as applicable exclusively to UCE = 2 or 3 are only required to meet the limited maneuvering requirements.

3.3.5 Small-Amplitude Yaw Attitude Changes

3.3.5.1 Short-Term Response to Yaw Control Inputs (Bandwidth). The heading response to directional cockpit control force or position inputs shall meet the limits specified in Figure 5(3.3). The bandwidth (ω_{BW_ψ}) and phase delay ($\tau_{p\psi}$) parameters are obtained from frequency responses as defined in Figure 2(3.3).

It is desirable to meet the requirement for both controller force and position inputs. If the bandwidth for force inputs falls outside the specified limits, flight testing should be conducted to determine if the force feel system is excessively sluggish.

3.3.5.2 Mid-Term Response. The mid-term response characteristics apply at all frequencies below the bandwidth frequency obtained in paragraph 3.3.5.1. Use of a heading hold response-type (paragraph 3.2.6) constitutes compliance with this paragraph, as long as any oscillatory modes following a cockpit controller pulse input have an effective damping ratio of at least 0.35. If heading hold is not available, the applicable criterion (paragraph 3.3.5.2.1 or 3.3.5.2.2) depends on the degree of divided attention necessary to complete the mission-task-elements according to paragraph 3.1.1.

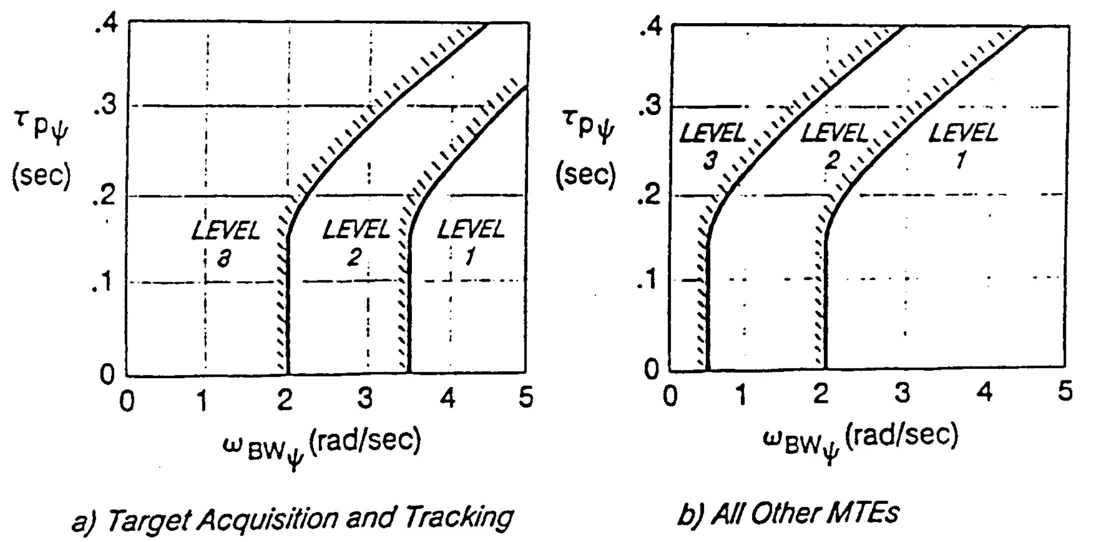


Figure 5(3.3). Requirements for Small-Amplitude Heading Changes -- Hover and Low Speed

3.3.5.2.1 Fully Attended Operations For those mission-task-elements specified in Paragraph 3.1.1 as requiring fully attended operation (paragraph 2.5.1), the mid-term response shall meet the requirements of Figure 3(3.3), except that the Level 1 limit on effective damping ratio for any oscillation is relaxed from 0.35 to 0.19

3.3.5.2.2 Divided Attention Operations. For those mission-task-elements specified in Paragraph 3.1.1 as requiring divided attention operations (paragraph 2.5.2), the limits of Figure 3(3.3) shall be met, except that the Level 1 damping shall not be less than 0.19 at any frequency.

3.3.6 Moderate-Amplitude Heading Changes (Attitude Quickness). The ratio of peak yaw rate to change in heading, $r_{pk}/\Delta\Psi_{pk}$, shall exceed the limit specified in Figure 6(3.3). The required heading changes shall be made as rapidly as possible from one steady heading to another and without significant reversals in the sign of the cockpit control input relative to the trim position. It is not necessary to meet this requirement for response-types which are designated as applicable only to UCE = 2 or 3.

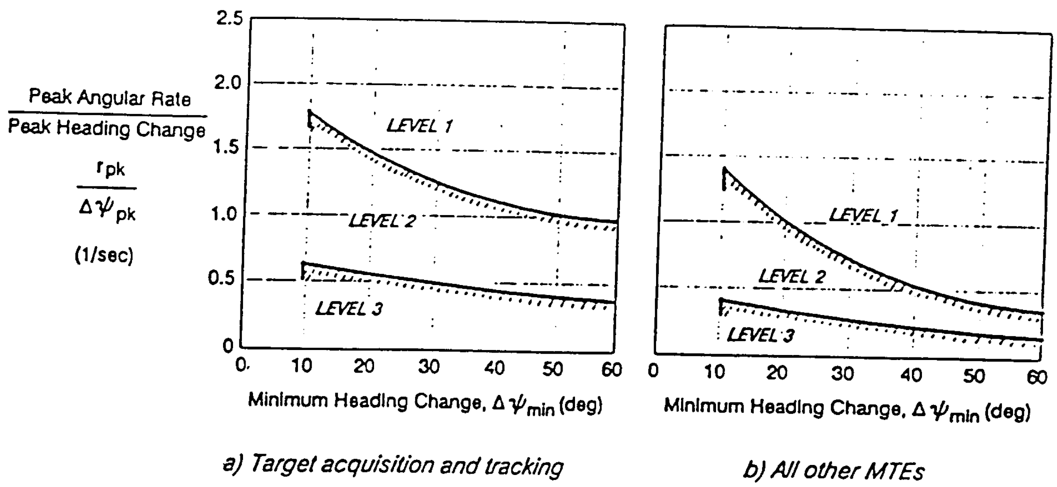


Figure 6(3.3). Requirements for Moderate-Amplitude Heading Changes -- Hover and Low Speed

3.3.7 Short-Term Yaw Response to Disturbance Inputs. Yaw response to inputs directly into the control surface actuator shall meet the bandwidth limits of Paragraph 3.3.5.1. If the bandwidth and phase delay parameters based on inputs to the control surface actuator can be shown by analysis to meet the cockpit control input bandwidth requirements, no testing is required. This requirement shall be met for Level 1 only.

3.3.7.1 Yaw Rate Response to Lateral Gusts. The yaw rate following a step lateral gust input shall not exceed the limits 2(3.3). The parameter r_{pk} in Table 2(3.3) is defined as the rate within the first three seconds following the input.

TABLE 2 (3.3). MAXIMUM ALLOWABLE YAW RATE RESPONSE TO LATERAL GUSTS

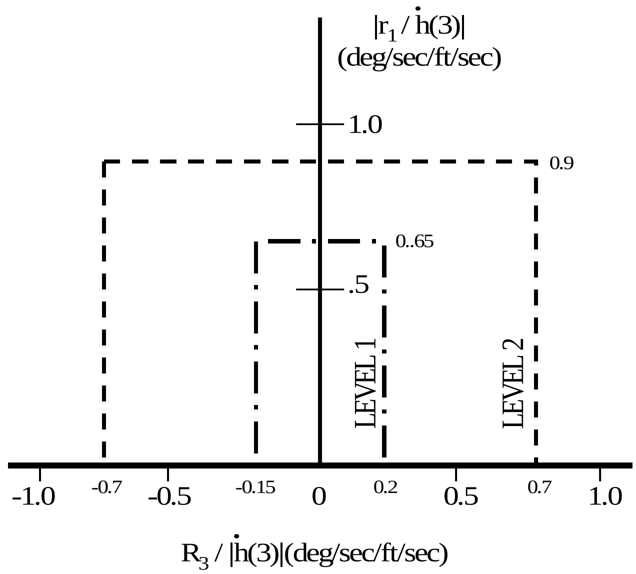
MISSION-TASK-ELEMENT	r_{pk}/V_g $\frac{\text{deg/s}}{\text{m/s}}$ $\left[\frac{\text{deg/sec}}{\text{ft/sec}}\right]$	
	LEVEL 1	LEVEL 2
Target acquisition and tracking	0.66 [0.20]	2.95 [0.90]
All MTEs not otherwise specified	0.98 (0.30)	3.3 (1.0)

Demonstration of compliance may be shown by analysis or simulation. The magnitude of the lateral gust input shall be varied from 10 to 25 knots (5.1 to 13 m/s) in the presence of a steady wind of up to 25 knots (13 m/s) from the most critical direction, except that the total wind velocity need not exceed 35 knots (18 m/s). The largest value of r_{pk}/V_g shall be used for comparison with Table 2(3.3).

3.3.8 Large-Amplitude Heading Changes. The achievable yaw rate in hover shall be no less than the values specified in Table 1(3.3). The specified angular rates must be achieved about the yaw axis while limiting excursions in the other axes with the appropriate control inputs, and with main rotor RPM at the lower sustained operating limit. response-types which are designated as applicable only to UCE 2 or 3 must meet only the limited maneuvering requirements.

3.3.9 Interaxis Coupling. Control inputs to achieve a response in one axis shall not result in objectionable responses in one or more of the other axes. This shall hold for control inputs up to and including those required to achieve the moderate amplitude responses in Paragraphs 3.3.3 and 3.3.6. Specific limits on interaxis coupling are given in Paragraphs 3.3.9.1, 3.3.9.2, and 3.3.9.3.

3.3.9.1 Yaw Due to Collective. The yaw rate response to abrupt collective inputs with the directional controller free shall not exceed the boundaries specified in Figure 7(3.3). In addition, there shall be no objectionable yaw oscillations following step or ramp collective changes in the positive and negative directions. Oscillations involving yaw rates greater than 5 deg/sec shall be deemed objectionable.



Where:

r_1 = first peak (before 3 seconds) or r(1) if no peak occurs before 3 seconds

$$r_3 = \begin{cases} (r(3) - r_1) \text{ for } r_1 > 0 \\ (r_1 - r(3)) \text{ for } r_1 < 0 \end{cases}$$

r(1) and r(3) are yaw rate response measured at 1 and 3 seconds, respectively, and $\dot{h}$ (3) is altitude rate response measured at 3 seconds, following a step collective input a t = 0

In the unlikely event of more than one peak before 3 seconds, the largest peak (by amplitude) should be designated as r_1

Figure 7(3.3). Collective-to-Yaw Coupling Requirements

3.3.9.2 Pitch-to-Roll and Roll-to-Pitch Coupling During Aggressive Maneuvering. The following requirement applies for the aggressive maneuvering mission-task-elements in Table 1(3.3). The ratio of peak off-axis attitude response from trim within 4 seconds to the desired (on-axis) attitude response from trim at 4 seconds, $\Delta\theta_{pk}/\Delta\phi_4$ ($\Delta\phi_{pk}/\Delta\theta_4$) following an abrupt lateral (longitudinal) control step input, shall not exceed the limits specified in Table 3(3.3). Heading excursions shall be limited by use of the heading controller. This shall hold for control inputs up to and including those required to achieve the moderate-amplitude responses in Paragraph 3.3.3.

TABLE 3(3.3). MAXIMUM VALUES FOR PITCH-TO-ROLL AND ROLL-TO- PITCH COUPLING

PARAMETER	LEVEL 1	LEVEL 2
$(\Delta\theta_{pk}/\Delta\phi_4)\ \delta_A$ or $(\Delta\phi_{pk}/\Delta\theta_4)\ \delta_B$	± 0.25	± 0.60

3.3.9.3 Height Due to Yaw Control The height response due to yaw control inputs shall not be objectionable.

3.3.10 Response to Collective Controller

3.3.10.1 Height Response Characteristics The vertical rate response shall have a qualitative first-order appearance for at least 5 seconds following a step collective input. The limits on the parameters defined by the following equivalent first-order vertical-rate-to-collective transfer function are given in Table 4(3.3).

$$\frac{\dot{h}}{\delta_c} = \frac{\mathbf{K}\ \mathbf{e}^{\tau_{\dot{h}_{eq}} s}}{\mathbf{T}_{\dot{h}_{eq}} s + 1}$$

TABLE 4(3.3). MAXIMUM VALUES FOR HEIGHT RESPONSE TO COLLECTIVE CONTROLLER

LEVEL	$T_{\dot{h}_{eq}}$ (sec)	$\tau_{\dot{h}_{eq}}$ (sec)
1	5.0	0.20
2	∞	0.30

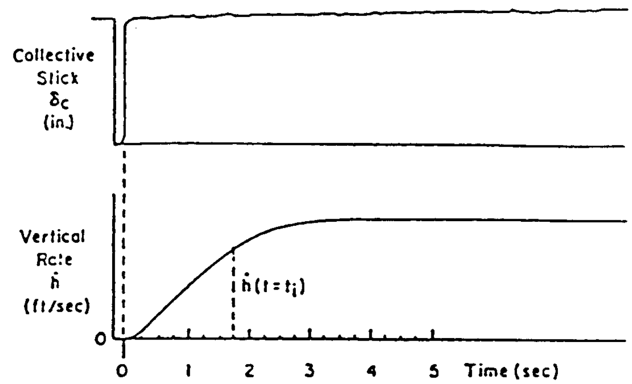
The equivalent system parameters are to be obtained using the time domain fitting method defined in Figure 8(3.3). The coefficient of determination, r^2, shall be greater than 0.97 and less than 1.03 for compliance with this requirement.

3.3.10.2 Torque Response. Torque, or any other parameter displayed to the pilot as a measure of the maximum allowable power that can be commanded without exceeding engine or transmission limits, shall have dynamic response characteristics that fall within the limits specified in Figure 9(3.3). This requirement shall apply if the displayed parameter must be manually controlled by the pilot to avoid exceeding displayed limits.

3.3.10.3 Vertical Axis Control Power. While maintaining a spot hover with the wind from the most critical direction at a velocity of up to 35 knots (18 m/s), and with the most critical loading and altitude, it shall be possible to produce the vertical rates specified in Table 5(3.3), 1.5 seconds after initiation of a rapid displacement of the vertical axis controller from trim. Applicable engine and transmission limits shall not be exceeded.

TABLE 5(3.3). VERTICAL AXIS CONTROL POWER

LEVEL	ACHIEVABLE VERTICAL RATE IN 1.5 SECONDS --m/s (ft/min)
1	0.81 (160)
2	0.28 (55)
3	0.20 (40)



- Obtain $\dot{h}$ readings (ft/sec or m/s) from $\dot{h}$ response to step collective input at intervals of no greater than $\Delta t = 0.05$ sec for a time span of 0-5 sec (see sketch above) – a total of $n = 5/\Delta t + 1$ data points (minimum $n = 101$).

- Use a three variable nonlinear least squares algorithm to obtain a best fit curve to this data in the time domain using the following form for the estimated $\dot{h}$ ($\dot{h}_{est}$),

$$\dot{h}_{est}(t) = K \left\{ 1 - \exp\left[-(t - \tau_{\dot{h}_{eq}})/T_{\dot{h}_{eq}} \right] \right\} \quad \text{for } t > 0$$

where t is time (sec) and K, $\frac{1}{T_{\dot{h}_{eq}}}$ and $\tau_{\dot{h}_{eq}}$ are the variables. (Note: $\tau_{\dot{h}_{eq}}$ may be less than zero.)

- The function to be minimized is the sum of squares of the error (e), defined as,

$$e^2 = \sum_{i=1}^{n} [\dot{h}(t = t_i) - \dot{h}_{est}(t = t_i)]^2$$

where t_i is the time (sec) at the i^{th} observed data point (see sketch)

- The goodness of fit of the estimated curve is determined by the coefficient of determination (r^2) which is defined as,

$$r^2 = \frac{\sum_{i=1}^{n} [\dot{h}_{est}(t = t_i) - \bar{\dot{h}}]^2}{\sum_{i=1}^{n} [\dot{h}(t = t_i) - \bar{\dot{h}}]^2}$$

where $\bar{\dot{h}}$ is the mean of the observed $\dot{h}$,

$$\bar{\dot{h}} = \sum_{i=1}^{n} \frac{\dot{h}(t = t_i)}{n}$$

Figure 8(3.3). Procedure for Obtaining Equivalent Time Domain Parameters for the Height Response to Collective Controller

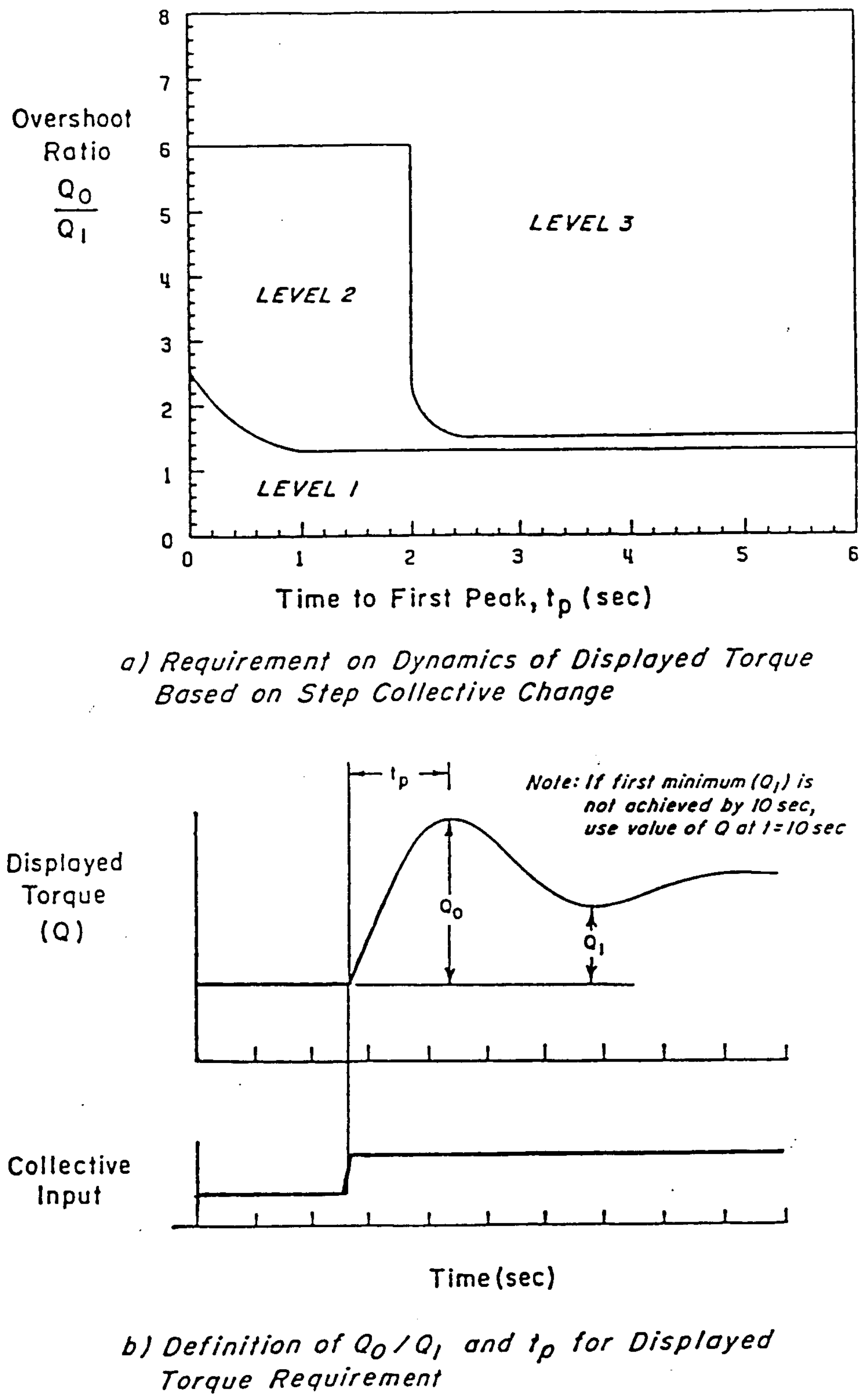


Figure 9(3.3). Displayed Torque Response Requirement

3.3.10.4 Rotor RPM Governing. The rotor RPM shall remain within the limits set by the service flight envelopes during the execution of all specified mission-task-elements conducted within the operational flight envelopes. It shall be possible to meet all directional control requirements at the lowest sustained operating RPM limit.

3.3.11 Position Hold. When position hold is required by Table 1(3.2), the rotorcraft shall be capable of automatically holding its position with respect to a ground fixed or shipboard hover reference. The rotorcraft shall maintain its position within a 3 m (10 ft) diameter circle during a 360 degree turn in a steady wind of up to 35 knots (18 m/s). The 360 degree turn shall be accomplished by the use of the directional controller with the other controls free, and shall be completed in less than 10 seconds if "aggressive" maneuvering is required in Table 1(3.3), 30 seconds if only "moderate" maneuvering is required and 45 seconds for "limited" maneuvering. The pitch and roll attitude shall not exceed $\pm$l8 degrees at any point in the 360 degree turn. The pitch and roll attitude responses to pitch and roll controller inputs shall meet the requirements of paragraph 3.3.2 with the position hold system engaged. There shall be a clear annunciation to the pilot indicating status of the position hold function.

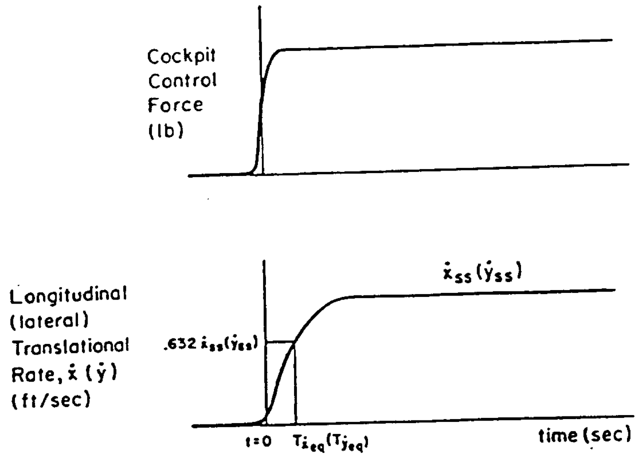
3.3.12 Translational Rate Response-Type. The translational rate response to step cockpit pitch (roll) control position or force inputs shall have a qualitative first order appearance, and shall have an equivalent rise time, $T_{\dot{x}_{eq}}$ ($T_{\dot{y}_{eq}}$) no less than 2.5 sec and no greater than 5 sec. The parameter $T_{\dot{x}_{eq}}$ ($T_{\dot{y}_{eq}}$) is defined in Figure l0a(3.3). For level 1, the following requirements/recommendations apply:

a. The pitch and roll attitude shall not exhibit objectionable overshoots in response to a step cockpit controller input.

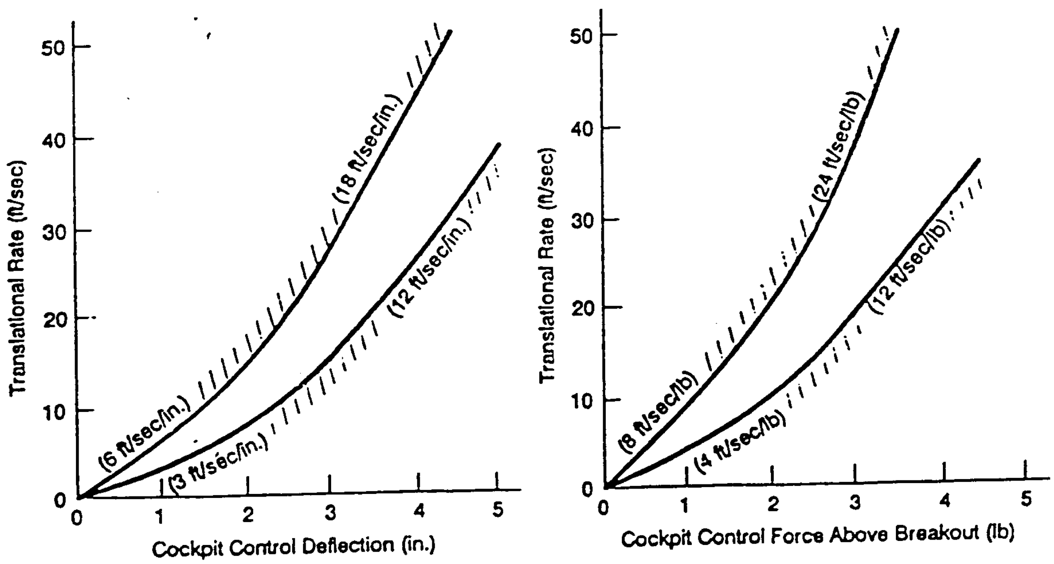
b. Zero cockpit control force and deflection shall correspond to zero translational rate with respect to fixed objects, or to the landing point on a moving ship.

c. There shall be no noticeable overshoots in the response of translational rate to control inputs. The gradient of translational rate with control input shall be smooth and continuous.

In addition, for centerstick controllers, it is recommended that the variation in translational rate with control deflection shall lie within the limits of Figure l0b(3.3). For sidestick controllers, it is recommended that the variation in translational rate with control force shall lie within the limits of Figure l0c(3.3)



a) Definition of equivalent rise time, $T_{\dot{x}_{eq}}$ ($T_{\dot{y}_{eq}}$)



b) Control/response requirement for centerstick controllers

c) Control/response requirement for sidestick controllers

Figure 10(3.3) Requirements for Longitudinal (Lateral) Translational Rate Response-Types -- Hover and Low Speed

3.4 FORWARD FLIGHT

The forward flight requirements apply to those mission task elements designated as forward flight tasks in paragraph 3.1.1 and apply over the applicable portions of the flight envelopes as defined by paragraph 2.6.3.

3.4.1 Pitch Attitude Response to Longitudinal Controller.

3.4.1.1 Short Term Response (Bandwidth). The pitch attitude response to longitudinal cockpit control force or position inputs shall meet the limits specified in Figure 1(3.4). The bandwidth ($\omega_{BW\theta}$) and phase delay ($\tau_{P\theta}$) parameters are obtained from frequency responses as defined in Figure 2(3.3).

It is desirable to meet this criterion for both controller force and position inputs. If the bandwidth for force inputs falls outside the specified limits, flight testing should be conducted to determine that the force feel system is not excessively sluggish.

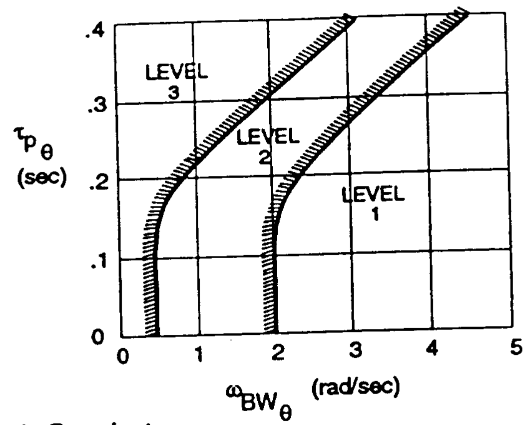
3.4.1.2 Mid-Term Response to Control Input. The mid-term response characteristics apply to all frequencies below the bandwidth frequency obtained in paragraph 3.4.1.1. Use of an attitude hold response-type (paragraph 3.2.6) constitutes compliance with this paragraph, as long as any oscillatory modes following a pulse controller input have an effective damping ratio of at least 0.35. If attitude hold is not available, the applicable criterion (paragraph 3.4.1.2.1 or 3.4.1.2.2) depends on the degree of divided attention necessary to complete the mission-task-elements according to paragraph 3.1.1.

3.4.1.2.1 Fully Attended Operations. For those mission-task-elements specified in paragraph 3.1.1 as requiring fully attended operation (paragraph 2.5.1), the mid-term response shall meet the requirements of Figure 3(3.3)

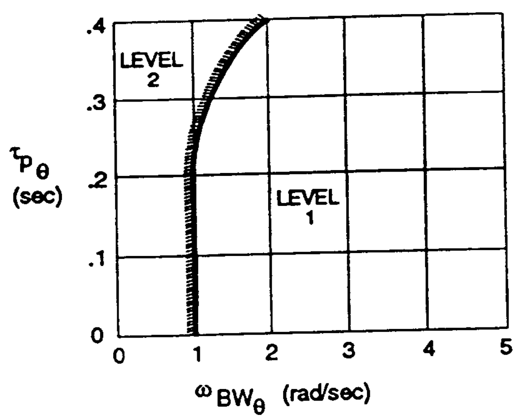
3.4.1.2.2 Divided Attention Operations. For those mission-task-elements specified in paragraph 3.1.1 as requiring divided attention operations (paragraph 2.5.2), the limits of Figure 3(3.3) shall be met, except that the level 1 damping shall not be less than $\varsigma = 0.35$ at any frequency.

3.4.1.3 Mid-Term Response -- Maneuvering Stability.

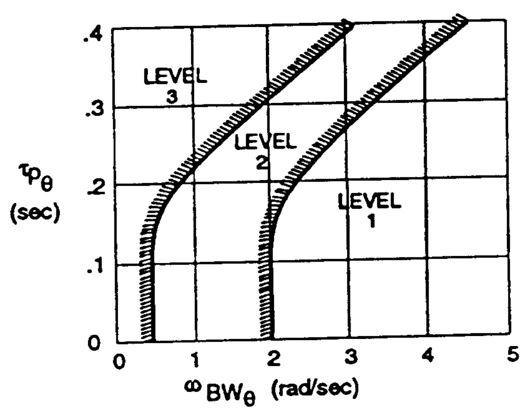
a. Control Feel and Stability in Maneuvering Flight at Constant Speed. In steady turning flight at constant air speed, and in pullups and pushovers, for levels 1 and 2 there shall be no tendency for the aircraft pitch attitude or angle of attack to diverge aperiodically. For the above conditions, the incremental control force required to maintain a change in normal load factor and pitch rate shall be in the same sense (aft - more positive, forward - more negative) as those required to initiate the change. These requirements apply for local gradients throughout the range of operational and service load factors defined in paragraphs 2.9.1 and 2.9.2.



a) Air Combat



b) All Other MTEs - VMC and Fully Attended Operations



c) All Other MTEs - IMC and/or Divided Attention Operations

Figure 1(3.4): Requirements For Small-Amplitude Pitch Attitude Changes - Forward Flight

b. Control Forces in Maneuvering Flight The variations in longitudinal cockpit control force with steady-state normal acceleration shall have no objectionable nonlinearities throughout the operational flight envelope. At no time will a negative local gradient be permitted. In addition, deflection of the pilot's cockpit controller must not lead the control force at any frequency below 5 rad/sec. For Level 1 the following requirements apply:

- For centerstick controllers, the local force gradient, F_S/n, shall be no less than 13 N/g (3 lb/g) and no greater than 67 N/g (15 lb/g).
- For sidestick controllers, the local force gradient shall be no less than 13 N/g (3 lb/g) and no greater than 26 N/g (6 lb/g).
- The local slope of F_S vs. n should be relatively constant over the range of normal accelerations within the operational flight envelopes. A variation of more than 50 percent shall be considered as excessive.

3.4.2 Pitch Control Power. For Level 1, it shall be possible from trimmed, unaccelerated flight to achieve the steady load factor specified in the operational flight envelopes. For level 2, there shall be sufficient pitch control authority to accelerate from 45 knots (23 m/s) to the maximum level flight airspeed, and to decelerate back to 45 knots (23 m/s) at constant altitude.

3.4.3 Flight Path Control. The flight path response to collective or longitudinal cyclic control inputs shall not be objectionable to the pilot.

3.4.4 Interaxis Coupling. Control inputs to achieve a response in one axis shall not result in objectionable responses in one or more of the other axes while performing any of the mission-task-elements specified in Paragraph 3.1.1. This shall hold for control inputs up to and including those required to perform any of the specified mission-task-elements. Specific limits on interaxis coupling are given in Paragraph 3.4.4.1.

3.4.4.1 Collective-to-Attitude Coupling

3.4.4.1.1 Small Collective Inputs (Less Than 20% of Full Control) The peak change in pitch attitude, θ_{peak} occurring within the first 3 seconds following an abrupt change in collective, shall be such that the ratio $|\theta_{peak}/n_{z_{peak}}|$ is no greater than 3.0 deg/m/s^2 (1.0 deg/ft/sec^2), where $n_{z_{peak}}$ is the peak normal acceleration.

3.4.4.1.2 Large Collective Inputs (Greater Than or Equal to 20% of Full Control). The peak change in pitch attitude, θ_{peak} occurring within the first 3 seconds following a step change in collective, δ_{COL} shall be such that the ratio $|\theta_{peak}/n_{z_{peak}}|$ is no greater than 1.5 deg/m15^2 (0.5 deg/ft/sec^2) in the up direction and 0.76 deg/m/s^2 (0.25 deg/ft/sec^2) in the down direction. In addition, during an autorotation to touchdown from any point in the operational flight envelopes,

- It shall not require more than 15 percent of full (stop-to-stop) cockpit pitch controller travel or force to hold pitch attitude constant.
- There shall be at least 5 percent of the total (stop-to-stop) pitch controller effectiveness remaining throughout the maneuver.

3.4.4.2 Pitch-to-Roll and Roll-to-Pitch Coupling During Aggressive Maneuvering. The following requirement applies for the ground attack, slalom, pull-up/push-over, assault landing, and air combat mission-task-elements. The ratio of peak off-axis attitude response from trim within 4 seconds to the desired (on-axis) attitude response from trim at 4 seconds, $\Delta\theta_{Pk}/\Delta\phi_4$ ($\Delta\phi_{Pk}/\Delta\theta_4$), following an abrupt lateral (longitudinal) control step input, shall not exceed the limits specified in Table 1(3.4). Heading excursions shall be limited by use of the heading controller. This shall hold for control inputs up to and including those required to perform the specified mission-task-elements.

TABLE 1(3.4). MAXIMUM VALUES FOR PITCH-TO-ROLL AND ROLL-TO- PITCH COUPLING

PARAMETER	LEVEL 1	LEVEL 2
$(\Delta\theta_{Pk}/\Delta\phi_4)\ \delta_A$ or $(\Delta\phi_{Pk}/\Delta\theta_4)\ \delta_B$	$\pm$0.25	$\pm$0.60

3.4.5 Roll Attitude Response to Lateral Controller

3.4.5.1 Small-Amplitude Roll Attitude Response to Control Inputs (Bandwidth). The roll attitude response to lateral cockpit control force or position inputs shall meet the limits specified in Figure 2(3.4). The bandwidth ($\omega_{BW\phi}$ and phase delay ($T_{p\phi}$) parameters are obtained from frequency responses as defined in Figure 2(3.3).

It is desirable to meet the requirement for both controller force and position inputs. If the bandwidth for force inputs falls outside the specified limits, flight testing should be conducted to determine that the force feel system is not excessively sluggish.

Any oscillatory modes following a pulse controller input shall meet the requirements of Figure 9(3.4).

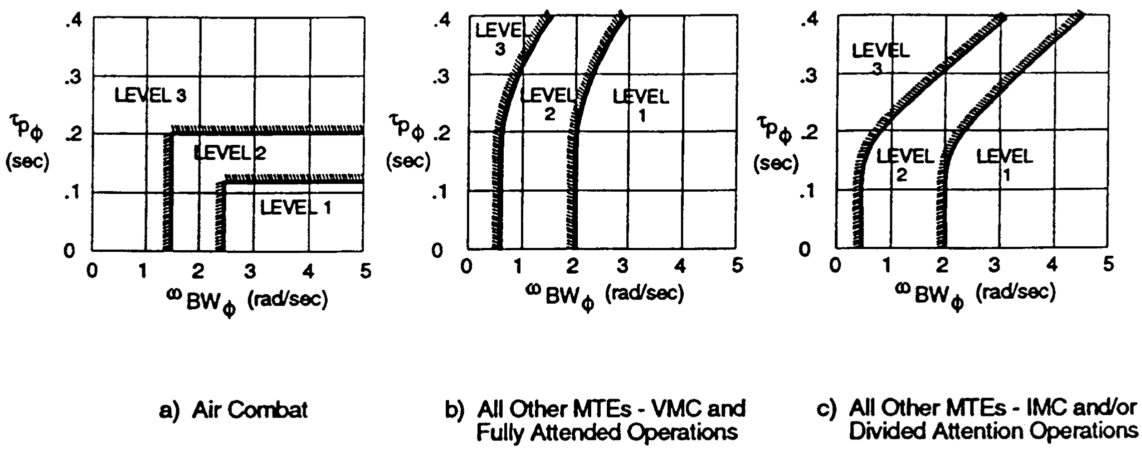


Figure 2(3.4). Roll Response Limits for Small-Amplitude Roll Attitude Changes - - Forward Flight

3.4.5.2 Moderate-Amplitude Attitude Changes (Attitude Quickness). The ratio of peak roll rate to change in bank angle, $P_{pk}/\Delta\phi_{pk}$, shall exceed the limits specified in Figure 3(3.4). The required attitude changes shall be made as rapidly as possible without significant reversals in the sign of the cockpit control input relative to the trim position. The initial attitudes, and attitude changes, required for compliance with this requirement, shall be representative of those encountered while performing the required Mission-Task-Elements (Paragraph 3.1.1). The parameters in Figure 3(3.4) are defined in Figure 4f(3.3).

3.4.5.3 Large-Amplitude Roll Attitude Changes. The minimum achievable roll rate (for rate response-types) or attitude change from trim (for attitude response-types) shall be no less than the limits specified in Table 2(3.4). Yaw control may be used to reduce sideslip that retards roll rate (not to produce sideslip that augments roll rate)

3.4.5.4 Linearity of Roll Response. There shall be no objectionable nonlinearities in the variation of rolling response with roll control deflection or force.

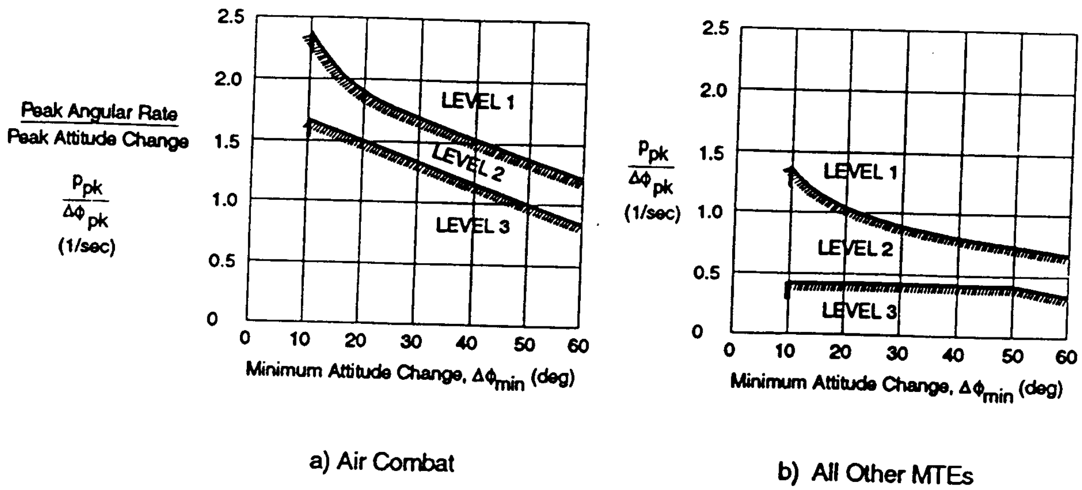


Figure 3(3.4). Roll Response Limits for Moderate-Amplitude Roll Attitude Changes -- Forward Flight

TABLE 2(3.4). REQUIREMENTS FOR LARGE-AMPLITUDE ROLL ATTITUDE CHANGES

MISSION-TASK-ELEMENT (MTE)	RATE RESPONSE-TYPES MINIMUM ACHIEVABLE ROLL RATE (deg/sec)		ATTITUDE RESPONSE-TYPES MINIMUM ACHIEVABLE ROLL RATE (deg/sec)	
	LEVEL 1	LEVEL 2	LEVEL 1	LEVEL
Limited Maneuvering All MTEs not otherwise specified	30	15	25	15
	15	12	25	15
Aggressive Maneuvering Ground Attack Slalom Pull-Up/Push-Over Assault Landing				
	50	21	90	30
	90	50	Unlimited	60

3.4.6 Roll-Sideslip Coupling. The requirements on roll-sideslip coupling apply for both right and left lateral control commands of all magnitudes up to the magnitude required to meet the roll performance requirements of Paragraph 3.4.5.2. The cockpit yaw controller shall remain free. The parameters used are defined in Figure 4(3.4).

3.4.6.1 Bank Angle Oscillations The value of the parameter ϕ_{OSC}/ϕ_{AV} following a pulse lateral control command for Rate Response-Types or step command for Attitude Response-Types shall be within the limits specified in Figure 5(3.4) for Levels 1 and 2. The input shall be as abrupt as practical. For Levels 1 and 2, ~AV shall always be in the direction of the lateral control command.

3.4.6.2 Turn Coordination. The amount of sideslip resulting from abrupt lateral control commands shall not be excessive or require complicated or objectionable directional control coordination. The ratio of the maximum change in sideslip angle to the initial peak magnitude in roll response, $|\Delta\beta/\phi_1|$ for an abrupt lateral control pulse command for rate response-types or step command for attitude response-types, shall not exceed the limit specified on Figure 6(3.4). In addition, $|\Delta\beta/\phi_1|$ x $|\phi/\beta|_d$ shall not exceed the limit specified on Figure 7(3.4).

3.4.7 Yaw Response to Yaw Controller

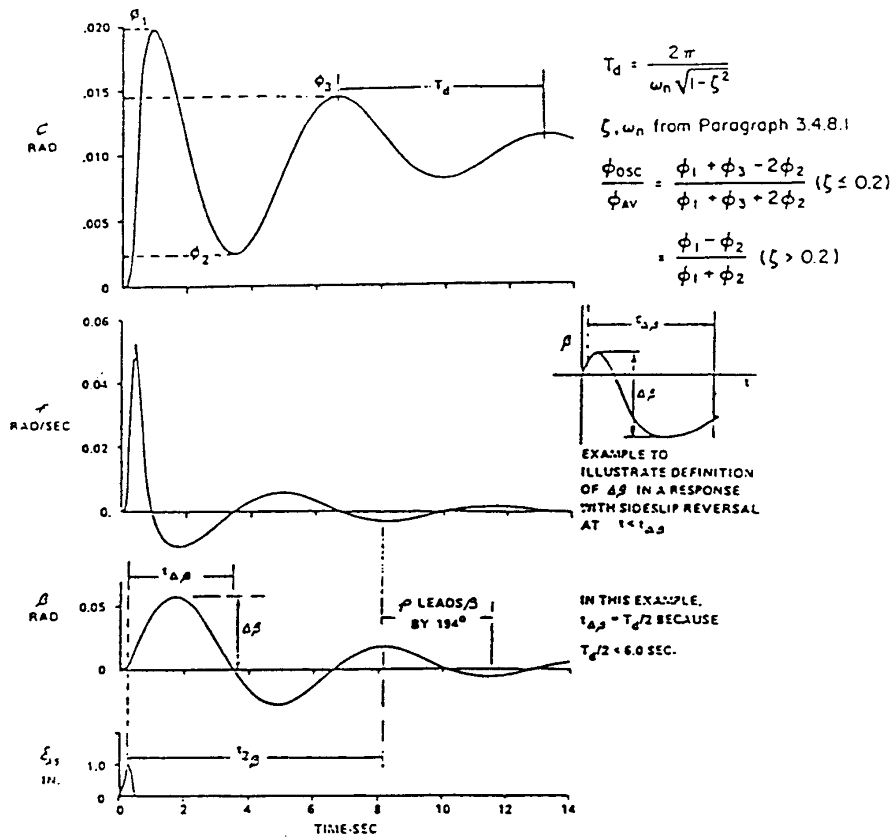
3.4.7.1 Small-Amplitude Yaw Response for Air Combat (Bandwidth). The heading response to cockpit yaw control force or position inputs shall meet the limits specified in Figure 8(3.4). The bandwidth $\omega_{BW\psi}$) and phase delay ($\tau_{P\psi}$) parameters are obtained from frequency responses as defined in Figure 2(3.3).

It is desirable to meet this criterion for both controller force and position inputs. If the bandwidth for force inputs falls outside the specified limits, flight testing should be conducted to determine that the force feel system is not excessively sluggish.

3.4.7.2 Large-Amplitude Heading Changes. The heading change following an abrupt step displacement of the yaw control, with all other cockpit controls fixed, shall not be less than:

- Level 1: the lesser of 16 degrees or β_L
- Level 2: the lesser of 8 degrees or 1/2 β_L
- Level 3: the lesser of 4 degrees or 1/4 β_L

where β_L is the sideslip limit of the operational flight envelope in degrees.



ϕ, β, δ_{AS} - change in roll attitude, sideslip, and lateral control position from trim

$\Delta\beta$ - the maximum change in sideslip following an abrupt roll control pulse command within time $t_{\Delta\beta}$ where $t_{\Delta\beta}$ is the lesser of 6 seconds or $T_d/2$.

t_{n_β} - time for the lateral-directional oscillation in the sideslip response to reach the n^{th} local maximum for a right command.

ψ_β - phase angle expressed as a lag for a cosine representation of the lateral-directional oscillation in sideslip, where

$$\psi_\beta = \frac{-360}{T_d} t_{n_\beta} + (n-1)360 \text{ (degrees)}$$

with n as in t_{n_β} above.

$|\phi/\beta|_d$ - at any instant, the ratio of amplitudes of the bank angle and sideslip angle envelopes in the lateral-directional oscillatory mode.

Figure 4(3.4) Roll-Sideslip Coupling Parameters

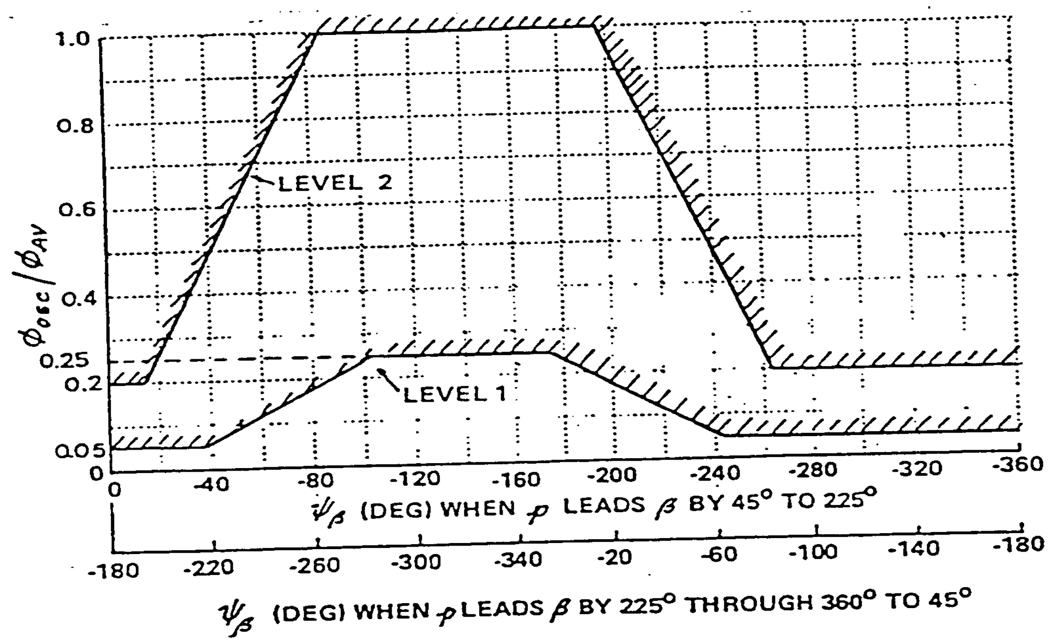


Figure 5(3.4). Bank Oscillation Limitations

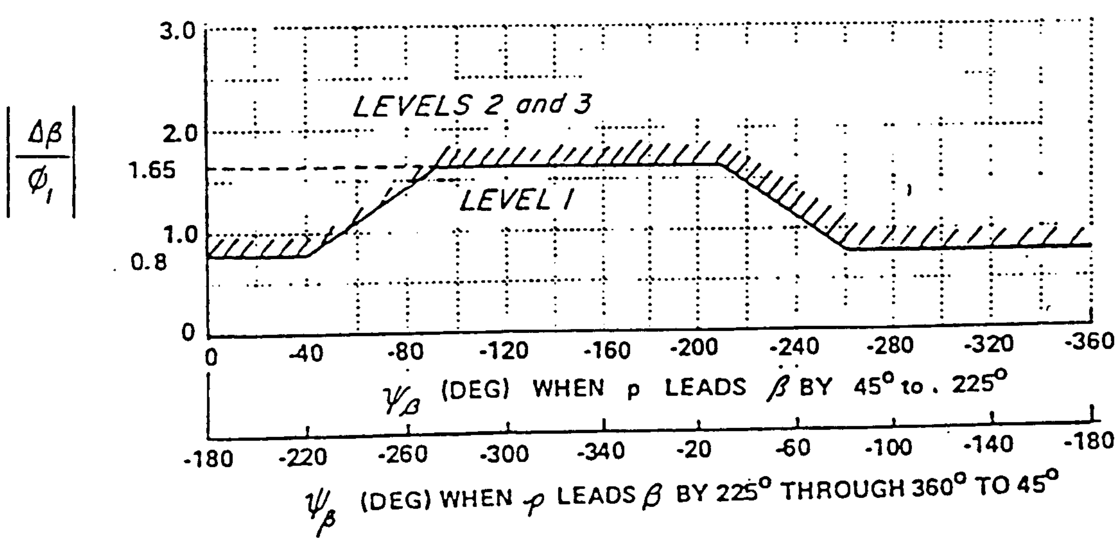


Figure 6(3.4). Sideslip Excursion Limitations (Boundary for $|\Delta\beta/\theta_1|$)

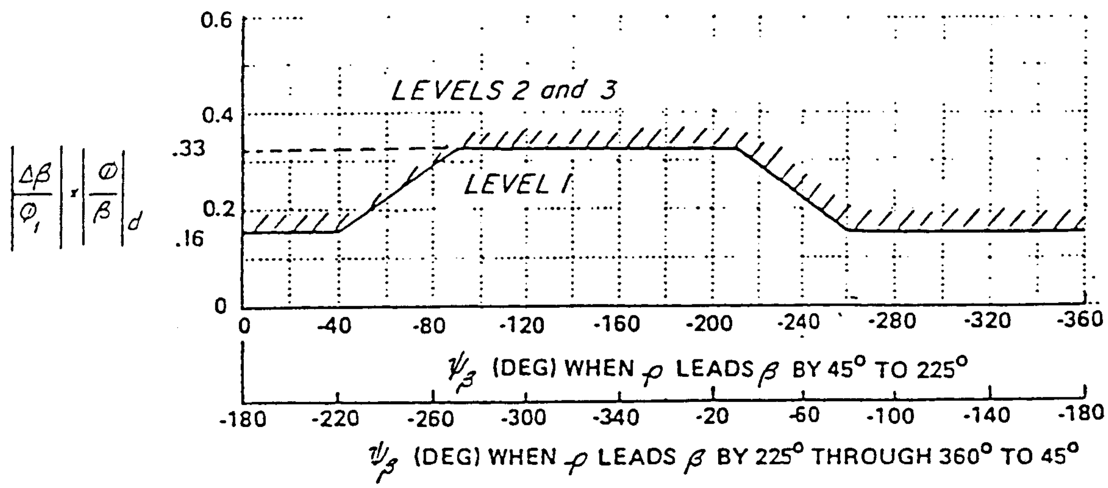


Figure 7(3.4). Sideslip Excursion Limitations (Boundary for $|\Delta\beta/\theta_1| \times |\phi/\beta|_d$)

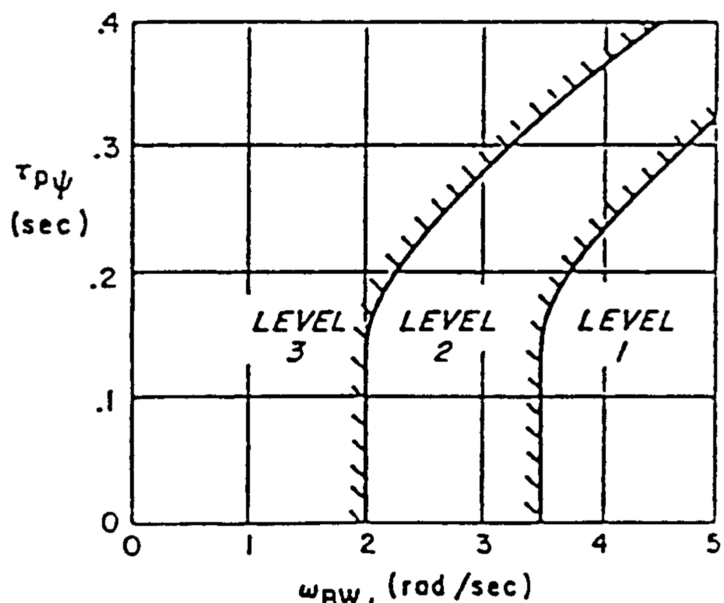


Figure 8(3.4). Requirement for Small-Amplitude Heading Changes for Air Combat - - Forward Flight

3.4.7.3 Linearity of Response. There shall be no objectionable nonlinearities in the variation of directional response with yaw control deflection or force.

3.4.7.4 Yaw Control with Speed Change With the rotorcraft initially trimmed directionally, it shall be possible to maintain heading constant with the yaw controller, with no perceptible change in bank angle, over a speed range of ±30 percent of the trim speed or ±20 knots (±10 m/s), whichever is less (except where limited by the boundaries of the service flight envelope). For pedal controllers, the yaw control forces shall not be greater than one-half those of Table 4(3.6). For other yaw control types, the forces required shall not be objectionable to the pilot. These requirements must be satisfied without retrimming, and should be accomplished at constant power (altitude varies), and at constant altitude (power varies).

3.4.8 Lateral-Directional Stability

3.4.8.1 Lateral-Directional Oscillations. The frequency, ω_n, and damping ratio, ς, of the lateral-directional oscillations following a yaw control doublet, shall exceed the minimums specified on Figure 9(3.4). The requirements shall be met with controls fixed and with them free for oscillations of any magnitude that might be experienced in operational use. If the oscillation is nonlinear with amplitude, the requirements shall apply to each cycle of the oscillation.

3.4.8.2 Spiral Stability. Following a lateral pulse control input, the time for the bank angle to double amplitude shall be greater than the following:

- Level 1: 20.0 seconds
- Level 2 12.0 seconds
- Level 3: 4.0 seconds

These requirements shall be met with the cockpit controls free and the aircraft trimmed for straight and level flight. The values specified apply to an exponential divergence and should not depend on the size of the control input. If the variation of roll angle with time is linear following the pulse control input, this requirement is satisfied.

3.4.9 Lateral-Directional Characteristics in Steady Sideslips. The requirements of 3.4.9.1 through 3.4.9.3.1 are expressed in terms of characteristics in yaw-control-induced, steady zero-yaw-rate sideslips with the aircraft trimmed for straight and level flight. Sideslip angles to be demonstrated shall be to the limits of the Operational Flight Envelope.

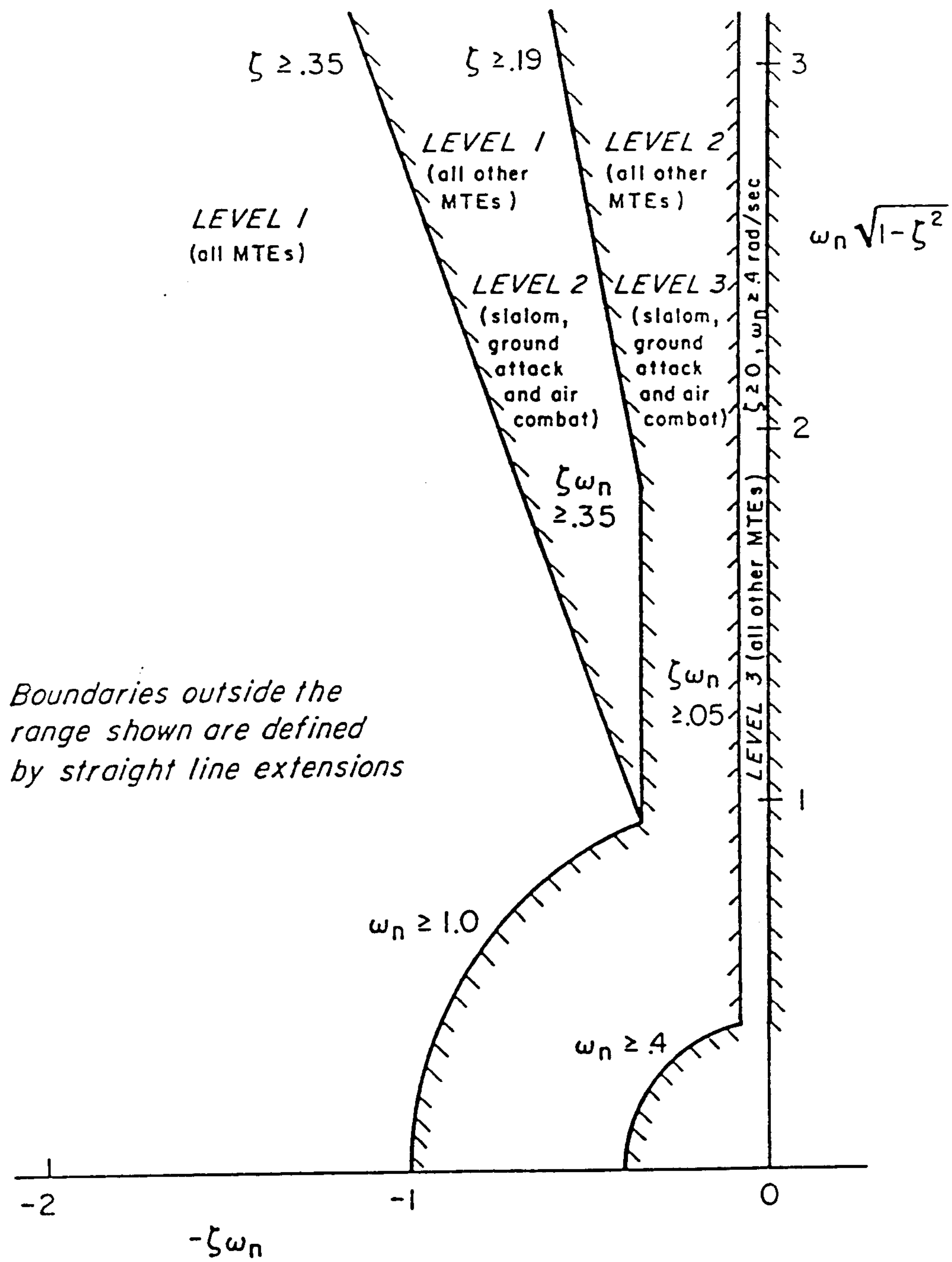


Figure 9(3.4). Lateral-Directional Oscillatory Requirements

3.4.9.1 Yaw Control in Steady Sideslips. For the sideslips specified in 3.4.9, right yaw control deflection and force shall be required in left sideslips and left yaw control deflection and force shall be required in right sideslips. For levels 1 and 2, the following requirements apply. Between sideslip angles of ± 15 degrees, or the sideslip limit of the operational flight envelop, whichever is less, the variation of yaw controller deflection and force shall be essentially linear with sideslip. For larger sideslip angles, an increase in yaw control deflection shall always be required for an increase in sideslip, and the following requirements shall apply:

- Level 1 The gradient of sideslip angle with yaw control force shall not reverse slope.
- Level 2 The gradient of sideslip angle with yaw control force is permitted to reverse slope provided the sign of the yaw control does not reverse.

The term gradient does not include that portion of the yaw control force versus sideslip-angle curve within the preloaded breakout force or friction band.

3.4.9.2 Bank Angle in Steady Sideslips. For the sideslips specified in 3.4.9, an increase in right bank angle shall accompany an increase in right sideslip, and an increase in left bank angle shall accompany an increase in left sideslip.

3.4.9.3 Lateral Control in Steady Sideslips. For sideslips specified 3.4.9, left lateral control deflection and force shall be required in left sideslips and right control deflection and force shall be required in right sideslips. For level 1 and 2, the variation of lateral control deflection and force with sideslip angle shall be essentially linear.

3.4.9.3.1 Positive Effective Dihedral Limit. For level 1, positive effective dihedral (right roll control for right sideslip and left roll control for left sideslip) shall never be so great that more than 75% of the roll control power available to the pilot and more than 49 N (11 pounds) of roll control force (for centerstick controllers) are required for sideslip angles which might be experienced in performing the required mission task element. The corresponding limits for level 2 shall be 90% and 60 N (13.5 pounds).

3.4.10 Pitch, Roll, and Yaw Response to Disturbance Inputs. Pitch, roll, and yaw responses to inputs directly into the control surface actuator shall meet the bandwidth limits based on cockpit controller inputs specified in Paragraphs 3.4.1.1 (pitch), 3.4.5.1 (roll), and 3.4.7.1 (yaw). If the bandwidth and phase delay parameters based on inputs to the control surface actuator can be shown by analysis to meet the cockpit control input requirements, no testing is required. This requirement shall be met for level 1, and relaxed according to paragraph 3.2.12 for levels 2 and 3

3.5 TRANSITION OF A VARIABLE CONFIGURATION ROTORCRAFT BETWEEN ROTOR-BORNE AND WING-BORNE FLIGHT

This section is reserved for future requirements.

3.6 CONTROLLER CHARACTERISTICS

3.6.1 Conventional Controllers

3.6.1.1 Centering and Breakout Forces. Pitch, roll, and yaw controls shall exhibit positive centering in flight at any normal trim setting. The combined effects of centering, breakout force, stability, and force gradient shall not produce objectionable flight characteristics or permit noticeable departures from trim conditions with controls free. Breakout forces, including friction, preload, etc., refer to the cockpit control force required to start movement of the control surface in flight. The requirements for breakout force are given in Tables 1(3.6) and 2(3.6). Table 1(3.6) applies for hover and low speed whereas the values in Table 2(3.6) apply for forward flight (Paragraph 2.6). The change in breakout force with speed shall not be objectionable.

TABLE 1 (3.6). ALLOWABLE BREAKOUT FORCES, NEWTONS (POUNDS) - HOVER AND LOW SPEED

COCKPIT CONTROL	LEVEL 1	LEVEL 2	LEVEL 3
	mm/max	mm/max	max
Pitch (Centerstick)	2.2/6.7 (0.5/1.5)	2.2/8.9 (0.5/3.0)	26.7 (6.0)
Roll (Centerstick)	2.2/6.7 (0.5/1.5)	2.2/8.9 (0.5/2.0)	17.8 (4.0)
Yaw (Pedals)	8.9/31.1 (2.0/7.0)	8.9/31.1 (2.0/7.0)	62.3 (14.0)
Collective	4.4/13.3 (1.0/3.0)	4.4/13.3 (1.0/3.0)	26.7 (6.0)

TABLE 2(3.6). ALLOWABLE BREAKOUT FORCES, NEWTONS (POUNDS) FORWARD FLIGHT

CONTROL	SCOUT/ATTACK		UTILITY	
	mm	max	mm	max
Pitch (Centerstick)	2 2 (0:5)	13.3 (3.0)	2.2 (0.5)	22.2 (5.0)
Roll (Centerstick)	2.2 (0.5)	8.9 (2.0)	2.2 (0.5)	17.8 (4.0)
Yaw (Pedals)	8.9 (2.0)	31.1 (7.0)	8.9 (2.0)	62.3 (14.0)

NOTE: The values in Table 2(3.6) are for Levels 1 and 2. For Level 3 the maximum values may be doubled.

The minimum collective-control breakout force may be measured with adjustable friction set. Measurement of breakout forces on the ground will ordinarily suffice in lieu of actual flight measurement, provided qualitative agreement between ground measurement and flight observation can be established.

3.6.1.2 Force Gradients. The pitch, roll, and yaw control force gradients shall be within the range specified in Table 3(3.6) throughout the range of control deflections. In addition, the force produced by a 2.54 cm (one inch) travel from trim by the gradient chosen shall not be less than the breakout force. For the remaining control travel, the local gradients shall not change by more than 50 percent in 2.54 cm (one inch) of travel. The thrust magnitude control should preferably have zero force gradient unless an auto-throttle function is active.

3.6.1.3 Limit Control Forces. Unless otherwise specified in particular requirements, the maximum control forces required without retrimming, for any maneuver consistent with the anticipated mission task-elements (3.2.2), shall not exceed the values stated in Table 4(3.6).

3.6.2 Sidestick Controllers. This paragraph is reserved for future requirements.

TABLE 3(3.6) ALLOWABLE CONTROL FORCE GRADIENTS, NEWTONS/CENTIMETER (POUNDS/INCH)

CONTROL	LEVEL 1		LEVEL 2	
	mm	max	mm	max
Pitch	0.9 (0.5)	5.3 (3.0)	0.9 (0.5)	8.8 (5.0)
Roll	0.9 (0.5)	4.4 (2.5)	0.9 (0.5)	8.8 (5.0)
Yaw	8.8 (5.0)	17.5 (10.0)	8.8 (5.0)	35.0 (20.0)

3.6.3 Sensitivity and Gradients. The pitch, roll, yaw, and collective controller sensitivities and gradients shall be consistent with the aircraft dynamic response characteristics in each axis at all flight conditions. In no case shall the controller sensitivity or gradient produce responses which are objectionably abrupt or sluggish. Compliance with this requirement must be in actual flight, and must include at least the maneuvers in Sections 4.1 and 4.2, and transitions between cruise and hover.

TABLE 4(3.6). LIMIT COCKPIT CONTROL FORCE VALUES, NEWTONS (POUNDS)

COCKPIT CONTROL	HOVER AND LOW SPEED			FOREWARD FLIGHT		
	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 1	LEVEL 2	LEVEL 3
Pitch (Centerstick	67 (15.0)	69 (20.0)	178 (40.0)	133 (30.0)	156 (35.0)	178 (40.0)
Roll (Centerstick)	45 (10.0)	67 (15.0)	89 (20.0)	67 (15.0)	89 (20.0)	111 (25.0)
Yaw (Pedals)	133 (30.0)	178 (40.0)	356 (80.0)	334 (75.0)	445 (100.0)	556 (125.0)
Collective	45 (10.0)	45 (10.0)	45 (10.0)	45 (10.0)	45 (10.0)	45 (10.0)

3.6.4 Cockpit Control Free Play. The free play in each control, that is, any motion of the cockpit control which does not move the appropriate moment or force-producing device in flight, shall be compatible with the required level of flying qualities.

3.6.5 Control Harmony. The control forces, displacements, and sensitivities of the pitch, roll, yaw, and collective controls shall be compatible, and their responses shall be harmonious.

3.6.6 Dynamic Coupling. There shall be no tendency for dynamic coupling between the rotorcraft and the controller with or without the pilot in the loop. In particular, lightly damped, high frequency oscillations which cease when the pilot releases the controller are not permitted.

3.7 SPECIFIC FAILURES

The requirements in this paragraph relate to specific system failures that are to be treated without regard to their probability of occurrence (Paragraph 3.1.7.2).

3.7.1 Failures of the Flight Control System. The following events shall not cause dangerous or intolerable flying qualities:

- Complete or partial loss of any function of the flight control system following any single failure.
- Failure-induced transient motions and trim changes either immediately after failure or upon subsequent transfer to alternate control modes.
- Configuration changes required or recommended following failure.

3.7.2 Engine Failures. From any condition within the service flight envelope the rotorcraft shall be capable of:

- Safely sustaining a single-engine failure.
- Safely entering into power-OFF autorotation.
- Safely landing from all points outside the height-velocity curve.

3.7.2.1 Altitude Loss. For multi-engined rotorcraft, in level flight, at the minimum speed where altitude can be maintained with one engine inoperative, the allowable altitude loss following a single-engine failure shall be no more than 15 m (50 ft)

3.7.3 Loss of Engine and/or Electrical Power. Complete or partial loss of engine power and/or loss of an electrical subsystem shall not result in handling qualities worse than level 2. Engine start during single engine or autorotational flight shall not cause the flight control system(s) to fail or become inoperative.

3.8 TRANSFER BETWEEN RESPONSE-TYPES

The transients and trim changes caused by the intentional transfer between Response-Types shall not be objectionable.

3.8.1 Annunciation of Response-Type to the Pilot. If more than one response-type can be selected in a given axis, there shall be a clear and easily interpretable annunciation to the pilot indicating which of the response-types are currently engaged or armed. For near-earth operations, it shall not be necessary for the pilot to significantly shift his eye point of regard from the forward near-field or to look around, or refocus any vision aid to view the required annunciation.

3.8.2 Control Forces During Transfer. With the rotorcraft initially trimmed at a fixed operating point, the peak pitch, roll, yaw, and collective control forces required to suppress the transient aircraft motions resulting from the transfer and maintain the desired heading, attitude, altitude, rate of climb or descent, or speed without use of the trimmer control, shall not exceed one-third of the appropriate limit control force in Table 4(3.6). For blending, this applies over the time interval specified in 3.8.3 following completion of the pilot action initiating the blend. There shall be no objectionable buffeting or oscillations of the control device during the blend.

3.8.3 Control System Blending. Blending between response-types shall be essentially linear with time and shall occur within the time limitations specified below.

Blending During Deceleration $2 \text{ sec} < t_{blend} < 10 \text{ sec}$

Blending During Acceleration $2 \text{ sec} < t_{b1end} < 5 \text{ sec}$

When blending from a series to a parallel trim system, a longitudinal or directional trim follow-up may be used as long as the cockpit controller does not move more than 20 percent of its travel in either direction during the blend.

3.9 GROUND HANDLING AND DITCHING CHARACTERISTICS

3.9.1 Rotor Start/Stop. It shall be possible, while on the ground, to start and stop the rotor blades in mean winds up to at least 45 knots (23 m/s) from the most critical direction.

3.9.1.1 Shipboard Operation. It shall be possible to bring the engines to idle power without engaging the rotor(s), and to stop the blades within 20 seconds after engine shutdown.

3.9.2 Parked Position Requirement It shall be possible, without the use of wheel chocks or skid restraints, to maintain a fixed position on a level paved surface at the normal takeoff rotor speed as power is increased prior to lift-off.

3.9.3 Wheeled Rotorcraft Ground Requirements. The following ground handling conditions shall be met for all operational weather conditions.

a. It shall be possible, without the use of brakes, to maintain a straight path while taxiing or performing rolling takeoffs or landings in a wind of up to 45 knots (23 m/s) from any direction.

b. It shall be possible to make complete 360-degree turns in either direction by pivoting on either main landing gear in a wind of up to 45 knots (23 m/s) from any direction. These turns shall be made within a radius equaling the major dimension of the rotorcraft.

c. It shall be possible to perform all required maneuvers, including taxiing, rolling takeoffs and landings, and pivoting, without damage to rotor stops and without contact between the main rotor or tail rotor blades and any part of the rotorcraft structure.

3.9.4 Ditching Characteristics. If required by the procuring activity, the following characteristics shall be provided either as part of the rotorcraft design or in supplementary kit form.

3.9.4.1 Water Landing Requirement In both power-ON and power-OFF autorotative conditions, it shall be possible to make a safe landing on smooth water up to at least 20 knots (10.3 m/s) surface speed with an 8 ft/sec (2.4 m/s) rate of descent and at least 30 knots (15 m/s) with a 5 ft/sec (1.5 m/s) rate of descent at angles of yaw up to 15 degrees.

3.9.4.2 Ditching Requirement Techniques and procedures (i.e., recommended pitch attitude and air-speed conditions) shall be established for ditching the rotorcraft on water in the event of:

a. The loss of all engine power.

b. The failure of one engine in a multi-engine rotorcraft.

The state of the rotorcraft during ditching up to sea state 6 shall not be such as to cause immediate injury to the occupants or to make it impossible for the occupants to exit the rotorcraft from the emergency exits provided (i.e., due to an adverse static water level on the cabin emergency exits or the blocking of emergency exits by all or part of the flotation system).

3.9.4.3 Flotation and Trim Requirements. The flotation time and trim attitude characteristics of the rotorcraft shall be such that the crew and passengers are provided with a sufficient length of time to exit the rotorcraft safely and to enter life rafts without application of a rotor brake. A sea anchor, or similar device, shall not be used in demonstrating compliance; however, it may be used to assist in deployment of life rafts. The flotation time and trim attitude characteristics shall be investigated throughout the range of sea states from 0 to 6 and shall be satisfactory in waves having height/ length ratios typical of these sea states.

3.9.4.4 Single Failures of the Flotation Epuipment. The flotation time and trim attitude requirements of Paragraph 3.9.4.3 shall also be met with the most critical compartment of the flotation system inoperative (i.e., as caused by a leak deflating the compartment or a failure in actuation of the inflation mechanism) up to sea state 3, and if possible up to sea state 6.

4. FLIGHT TEST MANEUVERS

A selection of flight test maneuvers are specified to provide an overall assessment of the rotorcraft's ability to perform certain Critical tasks. These maneuvers correspond to mission task-elements specified in Tables 1(3.2) and 2(3.2). Only those maneuvers designated by the procuring activity must be accomplished. These maneuvers shall be performed with all combinations of manual flight control modes and displays available to the pilot and used as they would normally be used in the conduct of the maneuver. All NOE maneuvers shall be conducted in calm winds unless otherwise specified. Altitude and position requirements refer to a selected reference point on the rotorcraft that is to be determined by the testing activity. All altitudes given are above ground level. A description of a suggested test course is provided for each maneuver. However, the test course markings and detail are left to the discretion of the testing activity.

a. Conduct of tests. The demonstration maneuvers shall be accomplished by at least three pilots. These pilots shall assign subjective ratings using the Cooper-Harper Handling Qualities Rating scale. The arithmetic average of the Cooper-Harper Handling Qualities Ratings shall be 3.5 or better (lower numerically) when operating in the operational flight envelopes, and 6.5 or better when operating in the service flight envelopes. All individual ratings and associated commentary shall be documented and supplied to the procuring activity. The maneuvers should be performed at the normal states within the operational flight envelope that are most critical from the standpoint of flying qualities. It is emphasized that the rotorcraft performance is not an issue in these tests, and that the flight conditions should be selected accordingly. It is not necessary to test in a high density altitude environment unless the rotor-craft has been shown to not meet the boundaries in Section 3 for such a condition, and satisfactory results in this section are being used to support a deviation.

b. Performance standards. The use of Cooper-Harper Handling Qualities Ratings requires the definition of numerical values for desired and adequate performance. These performance limits are set primarily to drive the level of aggressiveness and precision to which the maneuver is to be performed. Compliance with the performance standards may be measured subjectively from the cockpit or by the use of ground observers. It is not necessary to utilize complex instrumentation for these measurements. Experience has shown that lines painted on the rotorcraft and markers on the ground are adequate to perceive whether the rotorcraft is within desired or adequate performance parameters. In any event, the contractor shall develop a scheme for demonstrating compliance that uses at least outside observers and in-cockpit observations. This plan will be subject to approval by the procuring activity. The evaluation pilot is to be advised any time his performance fails to meet the desired or adequate limits, immediately following the completion of the maneuver, and before the pilot rating is assigned. In cases where the performance does not meet the specified limits, it is acceptable for the evaluation pilot to make as many repeat runs as necessary to insure that this is a consistent result. Repeat runs to improve performance may expose handling qualities deficiencies. Such deficiencies should be an important factor in the assigned pilot rating. If the inability to meet a performance standard in 4.1 and 4.2 (i.e., in good visual conditions) is due to a lack of visual cueing, the test course should be modified to provide the required pilot cues. This is allowed in the context that the purpose of these maneuvers is to check rotorcraft handling, not problems associated with a lack of objects on the test course. The test courses may be modified to conduct the DVE maneuvers. If modifications in visual cueing are required they shall be defined and submitted to the procuring activity for approval prior to testing.

4.1 PRECISION TASKS IN THE GOOD VISUAL EVIRONMENT

4.1.1 Hover

a. Objectives.

- Check ability to transition from translating flight to a stabilized hover with precision and a reasonable amount of aggressiveness.

- Check ability to maintain precise position, heading, and altitude in the presence of a moderate wind from the most critical direction.

b. Description of maneuver. Initiate the maneuver at a ground-speed of between 6 and 10 knots, at an altitude less than 6.1 m (20 ft). The target hover point shall be oriented approximately 45 degrees relative to the heading of the rotorcraft. The target hover point is a repeatable, ground-referenced point from which rotorcraft deviations are measured. The ground track should be such that the rotorcraft will arrive over the target hover point (see illustration in “description of test course”). The maneuver is to be accomplished in calm winds and in moderate winds from the most critical direction. If a critical direction has not been defined, the hover shall be accomplished with the wind blowing directly from the rear of the rotorcraft.

c. Description of test course. The suggested test course for this maneuver is shown in Figure 1(4.1). Note that the hover altitude depends on the height of the hover sight and the distance between the sight, the hover target, and the helicopter. These dimensions may be adjusted to achieve a desired hover altitude.

d. Desired performance.

- Accomplish the transition to hover in one smooth maneuver. It is not acceptable to accomplish most of the deceleration well before the hover point and then to creep up to the final position. Attain a stabilized hover within 3 seconds of the initiation of deceleration.

- Maintain a stabilized hover for at least 30 seconds.

- Maintain the longitudinal and lateral position within ±0.91 m (±3 ft) of a point on the ground and altitude within ±0.61 m (±2 ft). Keeping the hover sight within the desired box on the hover target (Figure 1(4.1)) will insure desired lateral and vertical performance.

- Maintain heading within ±5 degrees.

- There shall be no objectionable oscillations in any axis either during the stabilized hover, or the transition to hover.

e. Adequate performance.

- Accomplish the transition to hover in one smooth maneuver. It is not acceptable to accomplish most of the deceleration well before the hover point and then to creep up to the final position. Attain a stabilized hover within 8 seconds of the initiation of deceleration.

- Maintain a stabilized hover for at least 30 second

- Maintain the longitudinal and lateral position within ±l.83 m (±6 ft) of a point on the ground and altitude within ±1.22 m (±4 ft). Keeping the hover sight within the adequate box on the hover target (Figure 1(4.1)) will insure adequate lateral and vertical performance.

- Maintain heading within ±10 degrees.

4.1.2 <u>Hovering Turn</u>

a. Objectives.

- Check for undesirable handling qualities in a moderately aggressive hovering turn.

- Check ability to recover from a moderate rate hovering turn with reasonable precision.

- Check for undesirable interaxis coupling.

b. Description of maneuver. From a stabilized hover at an altitude of less than 6.1 m (20 ft), complete a 180 degree turn. Perform the maneuver in both directions, with a moderate wind from the most critical azimuth. If a critical azimuth has not been defined, the turn shall be terminated with the wind blowing directly from the rear of the rotorcraft.

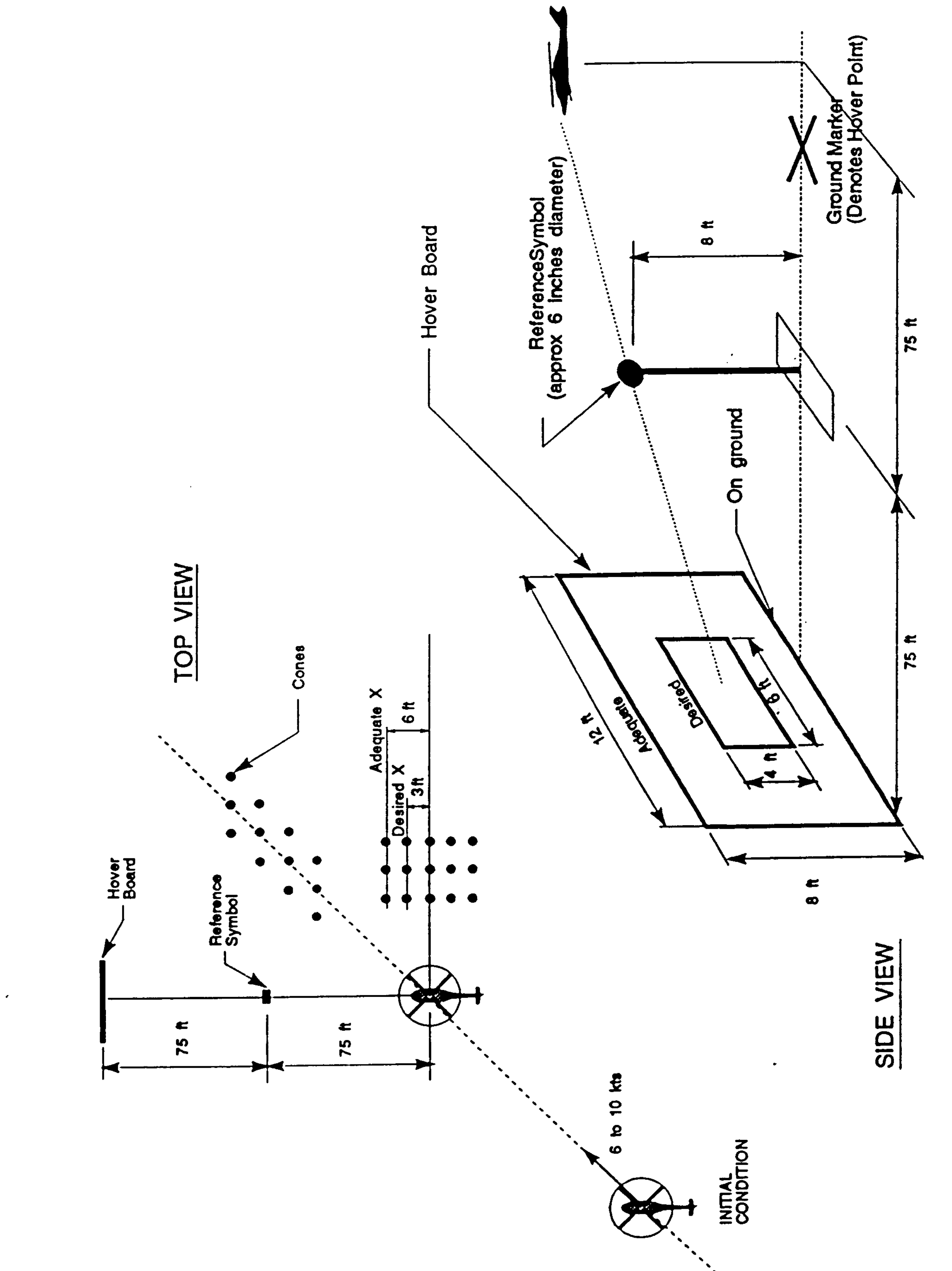


Figure 1(4.1) Suggested Course for Hover Maneuver

c. Description of test course. It is suggested that this maneuver use the test course described for the pirouette (4.1.1.4, Figure 2(4.1)) with the rotorcraft located at the center of the pirouette circle.

d. Desired performance.

- Maintain the longitudinal and lateral position within ±0.91 m (±3 ft) of a reference point on the ground.
- Maintain altitude within ±0.91 m (±3 ft)
- Stabilize the final rotorcraft heading at 180 degrees from the initial heading within ±3 degrees. Complete the turn to a stabilized hover (within the ±3 degree window) within 10 seconds from initiation of the maneuver.

e. Adequate performance.

- Maintain the longitudinal and lateral position within ±l.83 (±6 ft) of a reference point on the ground.
- Maintain altitude within ±1.83 m (±6 ft)
- Stabilize the final rotorcraft heading at 180 degrees from the initial heading within j6 degrees.
- Complete the turn to a stabilized hover (within the ~6 degree window) within 15 seconds from initiation of the maneuver.

4.1.3 Landing

a. Objectives.

- Check ability to precisely control the rotorcraft position during the final descent to a precision landing point.
- Check pilot-vehicle dynamics when pilot is forced into tight compensatory tracking behavior.

b. Description of maneuver. Starting from an altitude of greater than 3.05 m (10 ft), maintain an essentially steady descent to a raised platform. It is acceptable to arrest sink rate momentarily to make last-minute corrections before touchdown.

c. Description of test course. The landing platform shall be a rectangular shape that exceeds the dimensions of the rotorcraft landing gear by 0.91 m (3 ft) in width and 1.83 m (6 ft) in length. The platform shall be raised above the surface by an amount that will result in an obvious deck angle if the rotor-craft is landed with any part of the landing gear off the pad. However, the height of the platform should be less than a value that would cause the rotorcraft to exceed its slope landing limits if it is landed with any part of the landing gear off the platform.

d. Desired performance.

- Accomplish the landing with a smooth continuous descent, with no objectionable oscillations.
- Once altitude is below 3.05 m (10 ft), complete the landing within 10 seconds.
- Touch down within ±0.15 m (±0.5 ft) laterally and ±0.30 m (±l.0 ft) longitudinally of a designated position on the platform.

- Attain a rotorcraft heading at touchdown that is aligned with the longitudinal axis of the platform within ±5 degrees.

- The final position of the rotorcraft shall be the position that existed at touchdown. It is not acceptable to adjust the rotorcraft position and heading after all elements of the landing gear have made contact with the pad.

e. Adequate performance.

- Touch down on and remain on the platform.

- Attain a rotorcraft heading at touchdown that is aligned with the longitudinal axis of the platform within ±10 degrees.

4.1.4 Pirouette

a. Objectives.

- Check ability to accomplish precision control of the rotorcraft simultaneously in the pitch, roll, yaw, and heave axes.

- Check ability to control the rotorcraft precisely in a moderate wind that is continuously varying in direction relative to the rotorcraft heading.

b. Description of maneuver. Initiate the maneuver from a stabilized hover over a point on the circumference of a 30.5 m (100 ft) radius circle with the nose of the rotorcraft pointed at a reference point at the center of the circle, and at a hover altitude of approximately 3.05 m (10 ft). Accomplish a lateral translation around the circle, keeping the nose of the rotor-craft pointed at the center of the circle, and the circumference of the circle under a selected point on the helicopter. Terminate the maneuver with a stabilized hover over the starting point. Perform the maneuver in both directions. Perform the maneuver in calm and moderate winds.

c. Description of test course. The test course shall consist of markings on the ground that clearly denote the circular pathways that define desired and adequate performance. The suggested course shown in Figure 2(4.1) is considered adequate for the evaluation. It may also be useful to add objects to assist the pilot with vertical cueing, such a post at the center of the circle.

d. Desired performance.

- Maintain a selected reference point on the rotorcraft within ±3.05 m (±10 ft) of the circumference of the circle.

- Maintain altitude within ±0.9l m (±3 ft)

- Maintain heading so that the nose of the rotorcraft points at the center of the circle within ±10 degrees.

- Complete the circle and arrive back over the starting point within 45 seconds. Maintain essentially constant lateral groundspeed throughout the maneuver. Note: the nominal lateral velocity will be approximately 8 knots.

- Achieve a stabilized hover (within ±3.05 m (±10 ft)) within 5 seconds after returning to the starting point.

e. Adequate performance.

- Maintain a selected reference point on the rotorcraft within ±4.57 m (±15 ft) of the circumference of the circle.

- Maintain altitude within ±3.05 m (±10 ft)

- Maintain heading so that the nose of the rotorcraft points at the center of the circle within ±15 degrees.

- Complete the circle and arrive back over the starting point within 60 seconds. Maintain essentially constant lateral groundspeed throughout the maneuver. Note: the nominal lateral velocity will be approximately 6 knots.

- Achieve a stabilized hover (within ±4.57 m (±l5 ft)) within 10 seconds after returning to the starting point.

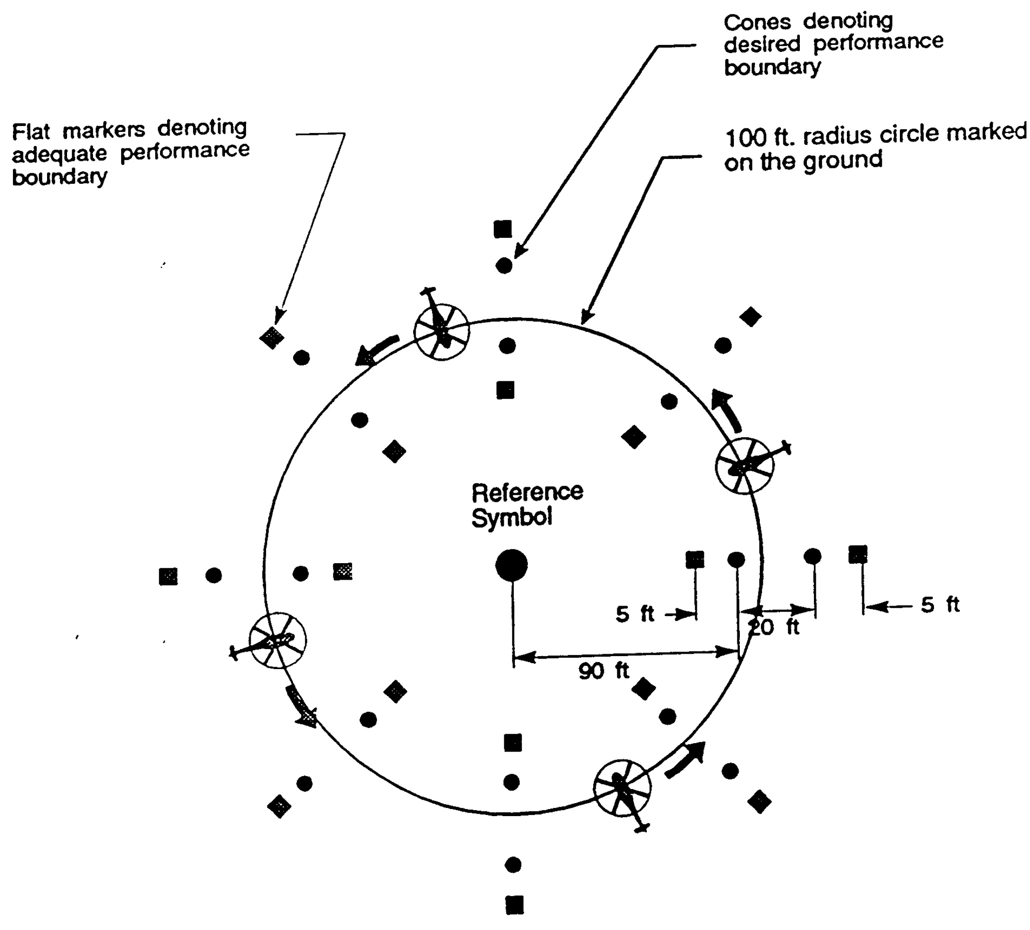


Figure 2(4.1) Suggested Course for Pirouette Maneuver

4.1.5 <u>Slope Landing</u>

a. Objectives.

- Check ability to precisely coordinate control of the heave axis and lateral axis with either the left or right part of the landing gear in contact with the ground.

- Check ability to precisely coordinate control of the heave axis and longitudinal axis with either the aft or forward part of the landing gear on the ground.

b. Description of maneuver. Perform a vertical landing to a sloped surface with the rotorcraft longitudinal axis oriented perpendicular to the fall line. Also perform vertical landings to a sloped surface with the rotorcraft longitudinal axis oriented parallel to the fall line. The landings shall be made with the nose pointed uphill and downhill with the up-slope to the left and right. For all of the slope landings, follow the following procedure. Once the upslope landing gear is in contact with the ground, maintain a level rotorcraft attitude for a short period of time, and then gently lower the downslope landing gear to the ground. Raise the downslope landing gear, keeping the upslope landing gear in contact with the ground, and maintain a level rotorcraft attitude for a short time before liftoff.

c. Description of test course. The test area shall consist of sloped terrain that is at least 75% of the rotorcraft slope landing performance limits. The landing area shall be clearly marked on the ground.

d. Desired performance.

- Touch down and maintain a final position within an area that is 1.22 m (4 ft) wider and 1.83 m (6 ft) longer than the rotorcraft landing gear.

- Maintain heading within $\pm$5 degrees.

- Maintain a level rotorcraft attitude with one part of the landing gear in contact with the ground and the rest in the air for at least 5 seconds before lowering and raising the downhill part of the landing gear.

- There shall be no perceptible horizontal drift at touchdown.

e. Adequate performance.

- Touch down and maintain a final position within an area that is 2.44 m (8 ft) wider and 3.66 m (12 ft) longer than the rotor-craft landing gear.

- Maintain heading within $\pm$l0 degrees.

- Maintain a level rotorcraft attitude with one part of the landing gear in contact with the ground and the rest in the air for at least 1 second before lowering and raising the downhill part of the landing gear.

- There shall be no perceptible lateral or rearward drift at touchdown.

4.2 AGGRESSIVE TASKS IN THE GOOD VISUAL ENVIRONMENT

4.2.1 <u>Turn to Target</u>

a. Objectives.

- Check for undesirable handling qualities during a maximum effort, rapid hovering turn.

- Check ability to recover from a rapid hovering turn with sufficient precision to fire a weapon.

- Check for undesirable interaxis coupling.

b. Description of maneuver. From a stabilized hover at an altitude of less than 6.1 m (20 ft), complete a 180 degree turn. Turns shall be completed in both directions, in a moderate wind from the most critical azimuth. If a critical azimuth has not been defined, the turn shall be completed with the wind blowing directly from the rear of the rotorcraft. The final heading tolerance should be based on a sight mounted on the rotorcraft, preferably the same sight to be used for operational missions.

c. Description of test course. The test course can consist of any convenient target.

d. Desired performance.

- Maintain the longitudinal and lateral position of a selected point on the rotorcraft within 1.83 m (6 ft) of a reference point on the ground.

- Maintain altitude within $\pm$0.91 m ($\pm$3 ft)

- Stabilize final rotorcraft heading within a tolerance based on the firing constraints of the weapon system to be deployed on the rotorcraft.

- Complete the turn so that a firing solution has been achieved within 5 seconds from initiation of the maneuver.

e. Adequate performance.

- Maintain the longitudinal and lateral position a selected point on the rotorcraft within 3.66 m (12 ft) of a reference point on the ground.

- Maintain altitude within $\pm$l.83 m ($\pm$6 ft)

- Stabilize final rotorcraft heading within $\pm$3 degrees.

- Complete the turn so that a firing solution has been achieved within 10 seconds from initiation of the maneuver.

4.2.2 <u>Bob-up and Bob-down</u>

a. Objectives.

- Check for adequate heave damping, i.e., the ability to precisely start and stop a vertical rate.

- Check for adequate vertical control power

- Check the characteristics of the heave axis controller, especially if a non-conventional controller is used, e.g., a four-axis sidestick.

- Check for undesirable coupling between collective and the pitch, yaw, and roll axes.

b. Description of maneuver. From a stabilized hover at 3.05 m (10 ft), bob-up to a defined reference altitude between 12.2 and 15.2 m (40 and 50 ft). The defined reference altitude, and associated outside cues, shall be established by the evaluation pilot prior to initiating the maneuver. Stabilize at the reference altitude for at least 2 seconds, simulating an attack with fixed guns. Bob-down to re-establish the 3.05-m (10-ft) stabilized hover. This maneuver is to be accomplished in moderate winds from the most critical azimuth. If the most critical azimuth has not been defined the maneuver shall be accomplished in a direct tailwind.

c. Description of test course. It is intended that the cue used to define the reference altitude be some vertical object in the field-of-view as opposed to using the radar altimeter. Experience has shown that aligning some object in the near field, such as a tree-top or street lamp, with an object in the far field works well. Some markers should be placed on the ground to allow the pilot to ascertain the horizontal position of the rotorcraft with respect to the desired and adequate performance requirements. A suggested test course is shown in Figure 1(4.2).

d. Desired performance.

- Complete the maneuver within 10 seconds.
- Maintain the longitudinal and lateral position of the rotorcraft within $\pm$1.83 m ($\pm$6 ft) of a reference point on the ground.
- Maintain heading within $\pm$3 degrees.
- Capture and maintain the final stabilized hover altitude within $\pm$0.91 m ($\pm$3 ft)

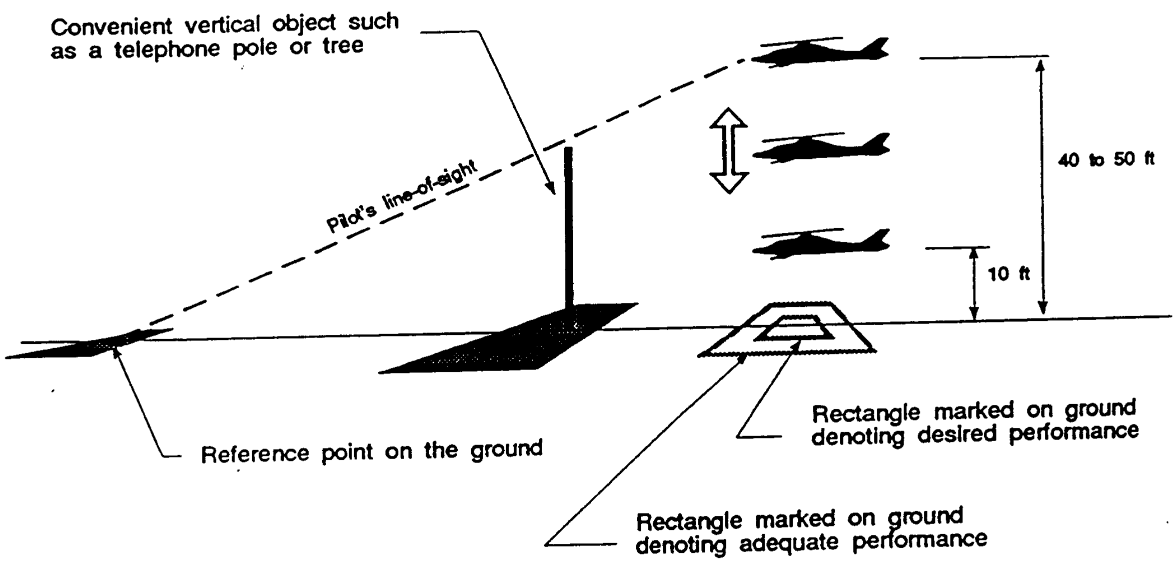


Figure 1(4.2). Suggested Course for Bob-up and Bob-down Maneuver

e. Adequate performance.

- Complete the maneuver within 15 seconds.
- Maintain the longitudinal and lateral position of the rotorcraft within $\pm$3.05 m ($\pm$10 ft) of a reference point on the ground.
- Maintain heading within $\pm$6 degrees.
- Capture and maintain the final stabilized hover altitude within $\pm$1.83 m ($\pm$6 ft)

4.2.3 <u>Vertical Remask</u>

a. Objectives

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- Check ability to accomplish an aggressive vertical descent close to the ground.

- Check ability to combine vertical and lateral aggressive maneuvering as required to evade enemy fire if observed during a bob-up.

b. Description of maneuver. From a stabilized hover at 22.9 m (75 ft), remask vertically to an altitude of 7.62 m (25 ft). Then rapidly displace the rotorcraft laterally 91.4 m (300 ft) and stabilize at a new hover position. During the vertical remask simulate deploying rotorcraft survivability equipment as appropriate. Accomplish the maneuver to the left and to the right.

c. Description of test course. The test course should include markers to denote the desired and adequate performance related to position during the vertical descent and final stabilized hover. It may also be desirable to include a vertical reference to provide cues related to the 7.62 m (25 ft) altitude reference. This maneuver assumes that the pilot is remasking behind some object, and such an altitude reference should therefore be available. A suggested test course for this maneuver is shown in Figure 2(4.2).

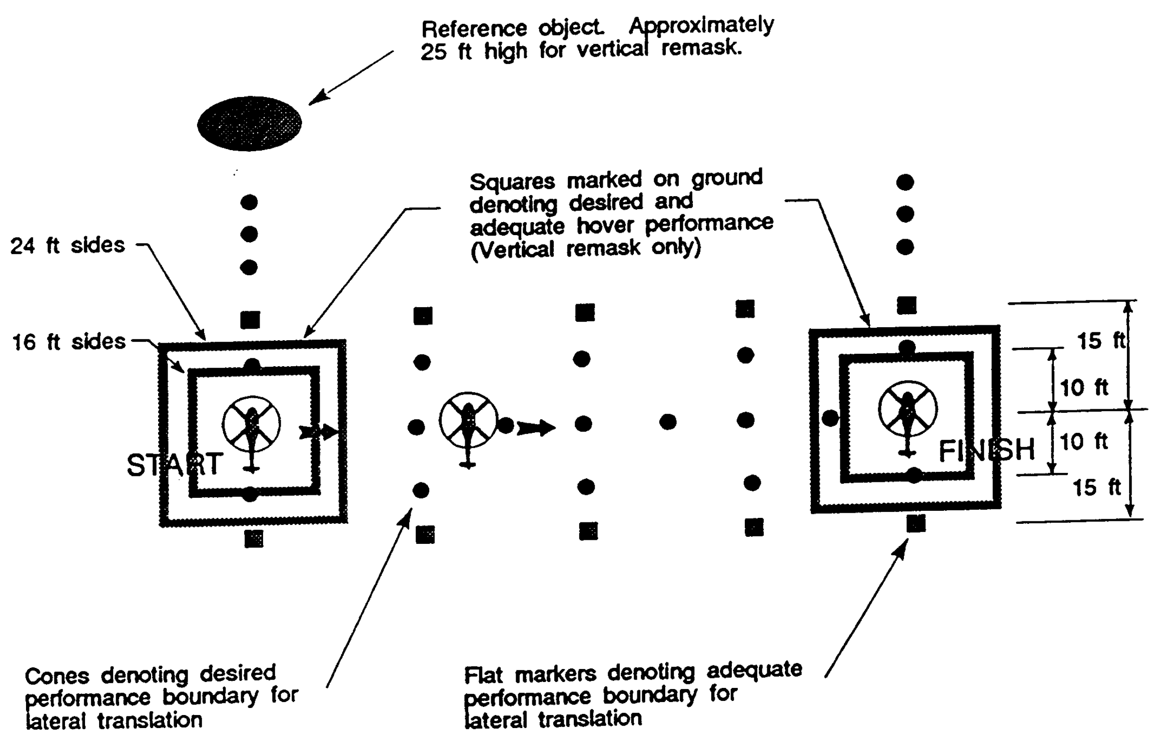


Figure 2(4.2). Suggested Course for Sidestep and Vertical Remask Maneuvers

d. Desired performance.

- During the initial stabilized hover, the vertical descent, and the final stabilized hover, maintain the longitudinal and lateral position within $\pm$2.44 m ($\pm$8 ft) of a reference point on the ground.
- Maintain altitude after the remask and during the displacement within $\pm$3.05 m ($\pm$10 ft).
- Maintain heading within $\pm$10 degrees.
- Maintain lateral ground track within $\pm$3.05 m ($\pm$10 ft).
- Achieve a stabilized hover within 5 seconds after reaching the final hover position.
- Achieve the final stabilized hover within 15 seconds of initiating the maneuver.
- Achieve an altitude of 7.62 m (25 ft) or less within 6 seconds of initiating the maneuver.

e. Adequate performance.

- During the initial stabilized hover, the vertical descent, and the final stabilized hover, maintain the longitudinal and lateral position within $\pm$3.66 m ($\pm$12 ft) of a reference point on the ground.
- Maintain altitude after the remask and during the displacement between +3.05 and -4.57 m (+10 and -15 ft).
- Maintain heading within $\pm$15 degrees.
- Maintain lateral ground track within $\pm$4.57 m ($\pm$15 ft).
- Achieve a stabilized hover within 10 seconds after reaching the final hover position.
- Achieve the final stabilized hover within 25 seconds of initiating the maneuver.

4.2.4 <u>Acceleration and Deceleration</u>

a. Objectives.

- Check pitch axis and heave axis handling qualities for highly aggressive maneuvering, i.e., near the limits of performance.
- Check for undesirable coupling between the longitudinal and lateral-directional axes during highly aggressive maneuvering in the longitudinal axis.
- Check for harmony between the heave axis and pitch axis controllers.
- Check for adequate rotor response to aggressive collective inputs.
- Check for overly complex power management requirements.

b. Description of maneuver. Starting from a stabilized hover, rapidly increase power to approximately maximum, and maintain altitude constant with pitch attitude. Hold collective constant during the acceleration to an airspeed of 50 knots. Upon reaching the target airspeed, initiate a deceleration by aggressively reducing the power and holding altitude constant with pitch attitude. The peak pitch attitude should occur just before reaching the final stabilized hover.

c. Description of test course. The test course shall consist of a reference line on the ground indicating the desired track during the acceleration and deceleration, and markers to denote the starting point and endpoint of the maneuver. The distance from the starting point to the final stabilized hover position is a function of the performance of the rotorcraft, and shall be determined based on trial runs consisting of accelerations to the target airspeed, and decelerations to hover as described above. The course should also include reference lines or markers parallel to the course centerline to allow the pilot and observers to perceive desired and adequate lateral tracking performance. A suggested test course for this maneuver is shown in Figure 3(4.2).

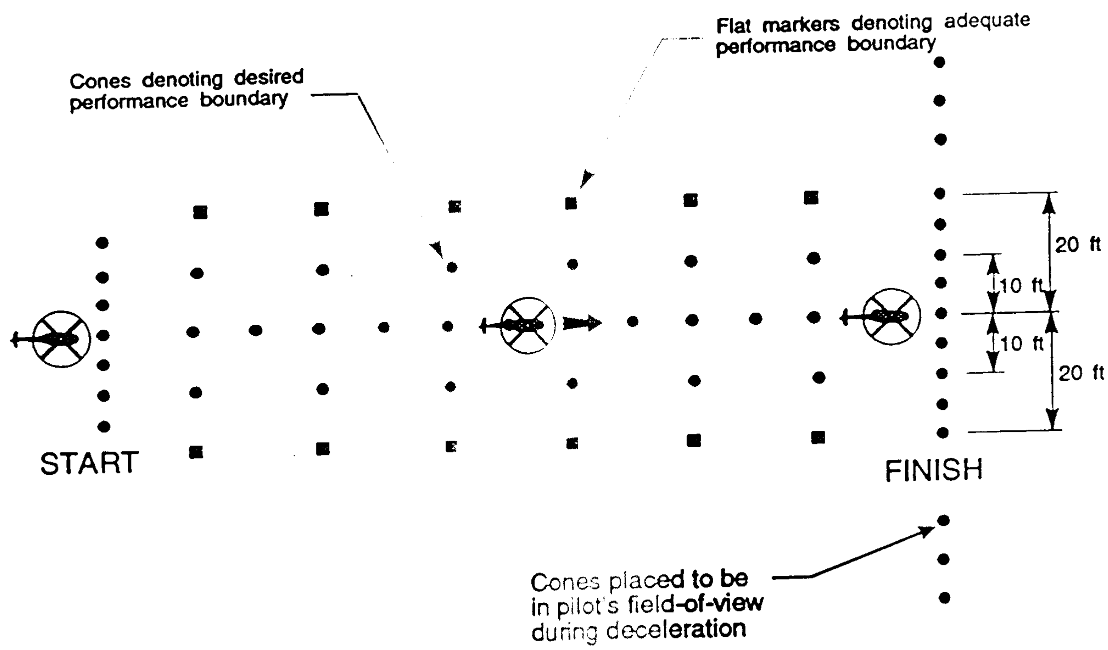


Figure 3(4.2). Suggested Course for Acceleration-Deceleration Maneuver

d. Desired performance.

- Complete the maneuver over the reference point at the end of the course. The longitudinal tolerance on the final hover position is plus zero and minus a distance equal to one half of the overall length of the helicopter (positive forward).

- Maintain altitude below 15.2 m (50 ft).

- Maintain lateral track within ±3.05 m (±10 ft).
-
- Maintain heading within ±10 degrees.

- Within 1.5 seconds from initiation of the maneuver, achieve at least the greater of 95% maximum continuous power or 95% maximum transient limit that can be sustained for the required acceleration, whichever is greater. If 95% power results in objectionable pitch attitudes, use the maximum nose-down pitch attitude that is felt to be acceptable. This pitch attitude shall be considered as a limit of the operational flight envelope for NOE flying.

- Decrease power to full down collective within 3 seconds to initiate the deceleration. Significant increases in power are not allowable until just before the final stabilized hover.

- Achieve a nose-up pitch attitude during the deceleration of at least 30 degrees above the hover attitude. This pitch attitude should occur shortly before the hover.

- Rotor RPM shall remain within the limits of the operational flight envelope without undue pilot compensation.

e. Adequate performance.

- Complete the maneuver over the reference point at the end of the course. The longitudinal tolerance on the final hover position is plus zero and minus a distance equal to the overall length of the rotorcraft (positive forward).

- Maintain altitude below 21.3 m (70 ft)

- Maintain lateral track within ±6.1 m (±20 ft)

- Maintain heading within ±20 degrees.

- Within 3 seconds from initiation of the maneuver, achieve at least the greater of 95% maximum continuous power or 95% maximum transient limit that can be sustained for the required acceleration, whichever is greater. If 95% power results in objectionable pitch attitudes, use the maximum nose-down pitch attitude that is felt to be acceptable. This pitch attitude shall be considered as a limit of the operational flight envelope for NOE flying.

- Achieve a nose-down pitch attitude during the acceleration of at least 7 degrees below the hover attitude.

- Decrease power to less than 30% of maximum within 5 seconds to initiate the deceleration. Significant increases in power are not allowable until just before the final hover.

- Achieve a nose-up pitch attitude during the deceleration of at least 10 degrees above the hover attitude.

- Rotor RPM shall remain within the limits of the service flight envelope.

4.2.5 Sidestep

a. Objectives.

- Check lateral-directional handling qualities for aggressive maneuvering near the rotorcraft limits of performance.

- Check for objectionable interaxis coupling.

- Check ability to coordinate bank angle and collective to hold constant altitude.

b. Description of maneuver. Starting from a stabilized hover with the longitudinal axis of the rotorcraft oriented 90 degrees to a reference line marked on the ground, initiate a rapid and aggressive lateral translation, with a bank angle of at least 25 degrees, holding altitude constant with power. When the rotorcraft has achieved a lateral velocity within 5 knots of its maximum allowable lateral airspeed, or 45 knots, whichever is less, immediately initiate an aggressive deceleration to hover at constant altitude. The peak bank angle during deceleration should be at least 30 degrees, and should occur just before the rotorcraft comes to a stop. Establish and maintain a stabilized hover for 5 seconds. Immediately repeat the maneuver in the opposite direction. The maneuver may be performed in calm winds, or in a headwind of less than 10 knots.

c. Description of test course. The test course consists of any reference line on the ground that is readily visible to the pilot. This may consist of a solid line or a series of markers, or any other method deemed acceptable by the testing activity. A suggested course using traffic cones and flat markers is shown in Figure 2(4.2).

d. Desired performance.

- Maintain the selected reference point on the rotorcraft within *3.05 m (*10 ft) of the ground reference line.
- Maintain altitude within ±3.05 m (±10 ft) at a selected altitude below 9.14 m (30 ft).
- Maintain heading within ±10 degrees.
- Achieve at least 25 degrees of bank angle within 1.5 seconds of initiating the maneuver.
- Achieve at least 30 degrees of bank angle within 1.5 seconds of initiating the deceleration.
- Achieve a stabilized hover within 5 seconds after reaching the hover point.

e. Adequate performance.

- Maintain the selected reference point on the rotorcraft within ±4.57m (±15 ft) of the ground reference line.
- Maintain altitude within ±4.57 m (±15 ft) at a selected altitude below 9.14 m (30 ft).
- Maintain heading within ±15 degrees.
- Achieve at least 25 degrees of bank angle within 3 seconds of initiating the maneuver.
- Achieve at least 30 degrees of bank angle within 3 seconds of initiating the deceleration.
- Achieve a stabilized hover within 10 seconds after reaching the hover point.

4.2.6 Slalom

a. Objectives.

- Check ability to maneuver aggressively in forward flight and with respect to objects on the ground.
- Check turn coordination for aggressive forward flight maneuvering.
- Check for objectionable interaxis coupling during aggressive forward flight maneuvering.

b. Description of maneuver. Initiate the maneuver in level unaccelerated flight and lined up with the centerline of the test course. Perform a series of smooth turns at 152-rn (500-ft) intervals. The turns shall be at least 15.2 m (50 ft) from the centerline, with a maximum lateral error of 15.2 m (50 ft). The maneuver is to be accomplished at a reference altitude below 30.5 m (100 ft). Complete the maneuver on the centerline.

c. Description of test course. The suggested test course for this maneuver is shown in Figure 4(4.2). Most runways have touch down stripes at 152 rn (500-ft) intervals that can be conveniently used instead of the pylons. However, if the runway is not 30.5 m (100 ft) wide, it will be necessary to use two cones to define each gate (as opposed to one cone and the runway edge as shown in Figure 4(4.2)).

d. Desired performance.

- Maintain an airspeed of at least 60 knots throughout the course.

e. Adequate performance.

- Maintain an airspeed of at least 40 knots throughout the course.

4.2.7 Deceleration to Dash

a. Objectives.

- Check pitch, heave, and yaw axis handling qualities for highly aggressive maneuvering.

- Check for undesirable coupling between the longitudinal and lateral-directional axes, and between the heave axis and longitudinal and lateral-directional axes, for maneuvers requiring large power changes.

- Check for harmony between the heave, pitch, and directional axis controllers.

- Check for adequate rotor response to aggressive collective inputs.

- Check for overly complex power management requirement.

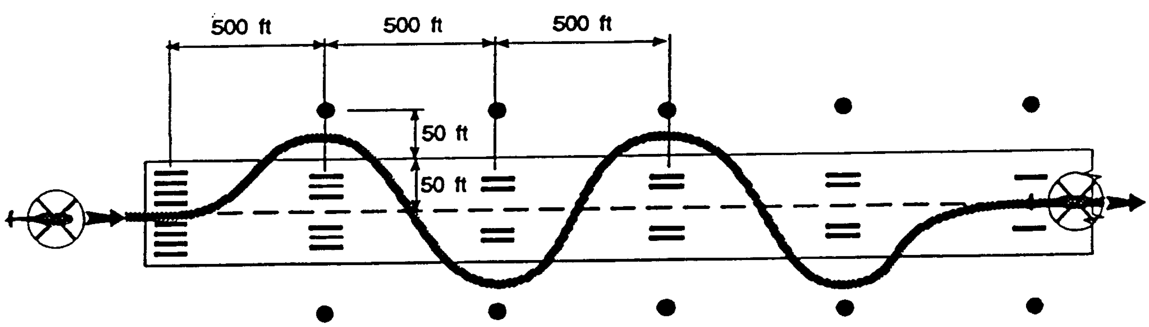


Figure 4(4.2). Suggested Course for Slalom Maneuver

b. Description of maneuver. From level unaccelerated flight at 120 knots, perform a level deceleration-acceleration. Adjust the pitch attitude to maintain altitude with a full down collective position. As the airspeed decreases to approximately 50 knots, aggressively assume the attitude for maximum acceleration and rapidly increase power to approximately the maximum, and maintain that power until the initial airspeed is reached. The entire maneuver shall be conducted below 61 m (200 ft).

c. Description of test course. Any reference line on the ground will serve as an adequate test course for this maneuver.

d. Desired performance.

- Achieve full down collective within 3 seconds from the initiation of the deceleration.

- Achieve either 95% of maximum continuous power or 95% of the transient limit within 2 seconds of initiating the acceleration.

- Maintain heading within ±5 degrees.

- Maintain altitude within ±15.2 m (*50 ft)

- During the acceleration, the power shall not exceed any rotorcraft limitation, and shall not change by more than 10%.

- No undesirable oscillations or coupling shall be present.

- Rotor RPM shall remain within the limits of the operational flight envelope without undue pilot compensation.

e. Adequate performance.

- Achieve full down collective within 5 seconds from the initiation of the deceleration.

- Achieve either 80% of maximum continuous power or 80% of the transient limit within 3 seconds of initiating the acceleration.

- Maintain heading within ±10 degrees.

- Maintain altitude below 61 m (200 ft).

- During the acceleration, the power shall not exceed any rotorcraft limitation, and shall remain between 80 and 100% of either maximum continuous power or the transient limit.

- No objectionable oscillations or coupling should be present.

- Rotor RPM shall remain within the limits of the service flight envelope.

4.2.8 Transient Turn

a. Objectives.

- Insure that handling qualities do not degrade during highly aggressive maneuvering in all axes.

- Check for undesirable coupling between the pitch, roll, and yaw axes during highly aggressive maneuvering.

b. Description of maneuver. Starting at 120 knots and an altitude at or below 61.0 m (200 ft), accomplish a 180-degree change in directional flightpath in as little time as possible. Use of pedals to induce a lateral acceleration in the direction of the turn is acceptable. Perform the maneuver both to the right and to the left. It is acceptable to reduce collective to increase the rate of speed bleed-off and thereby maximize the turn rate.

c. Description of test course. This maneuver does not require a test course that is marked out on the ground aside from a reference line such as a road or railroad track.

d. Desired performance.

- Achieve a peak normal load factor of at least; the limit of the operational flight envelope, n_L (+).

- Complete the 180-degree directional flightpath change within 10 seconds.

- Maintain altitude within ±15.2 m (±50 ft)

- Maintain the rotor RPM within the limit of the operational flight envelope.

e. Adequate performance.

- Achieve a peak normal load factor of at least 80% of the limit of the operational flight envelope, O.8n_L (+)

- Complete the 180-degree directional flightpath change within 15 seconds.

- Maintain altitude below 61 m (200 ft).

- Maintain the rotor RPM within the limit of the service flight envelope.

4.2.9 Pullup/Pushover

a. Objectives.

- Check handling qualities at elevated and reduced load factors and during transition between elevated and reduced load factors.

- Check for undesirable coupling between pitch, roll, and yaw for aggressive maneuvering in forward flight.

- Check for ability to avoid obstacles during high speed NOE operations.

b. Description of maneuver. From level unaccelerated flight at 120 knots, or with maximum continuous power, whichever results in the lowest power, attain a sustained positive load factor in a symmetrical pullup. Transition, via a symmetrical pushover, to a sustained negative load factor and recover to the initial airspeed as rapidly as possible.

c. Description of test course. This maneuver may be accomplished up and away, and no test course is required.

d. Desired performance.

- Attain a normal load factor of at least the positive limit of the OFE (n_L (+)) within 1 second from the initial control input. Maintain at least n_L (+) for at least 2 seconds.

- Accomplish transition from the positive n_L (+) pullup to a pushover of not greater than the negative normal load factor limit of the OFE (n_L (-)) within 2 seconds.
- Maintain a load factor of not greater than n_L (-) for at least 2 seconds.

- Maintain angular deviations in roll and yaw within $\pm$10 degrees from the initial unaccelerated level flight condition to completion of the maneuver.

e. Adequate performance.

- Attain at least n_L (+) within 2 seconds from the initial control input.

- Maintain at least n_L (+) for at least 1 second.

- Transition from the n_L (+) pullup to a pushover of not greater than n_L (-) within 4 seconds.

- Maintain a load factor of not greater than n_L(-) for at least 1 second.

- Maintain angular deviations in roll and yaw within $\pm$15 degrees from the initial unaccelerated level flight condition to completion of the maneuver.

4.2.10 Roll Reversal at Reduced and Elevated Load Factors

a. Objectives.

- Check handling qualities while maneuvering with load factors close to the OFE limits.
- Check the roll damping and roll authority during elevated and reduced load factor.
- Check for undesirable coupling between axes during aggressive maneuvering.
- Check the maneuvering stability of the rotorcraft close to the OFE limits.

b. Description of maneuver. Starting in a dive, conduct a series of pullups and pushovers to achieve normal accelerations within 0.l0g of the positive [n_L(+)] and negative (n_L(-)] boundaries of the operational flight envelope. The target normal acceleration should occur as the rotorcraft passes through the level attitude. At this time execute an aggressive roll to a minimum of 45 degrees of bank, and back to zero while maintaining the target load factor. The maneuvers should be conducted so that the airspeed during the rolling maneuvers is either 120 knots, or the maximum that can be achieved at maximum continuous power, whichever is less.

c. Desired performance.

- Achieve a peak roll rate of at least 50 percent of the maximum steady state roll rate achievable at one g.
- Maintain the target load factor within $\pm$0.30g.
- No undesirable oscillation in any axis.
- No sudden change in roll or pitch response.

d. Adequate performance.

- Achieve a peak roll rate of at least 30 percent of the maximum steady state roll rate achievable at one g.
- Maintain the target load factor within $\pm$0.50g.
- No uncontrollable or persistent oscillations in any axis.
- No objectionable changes or reversals in roll or pitch.

4.2.11 High Yo-Yo

a. Objectives.

- Check handling qualities during reduced and elevated load factors.
- Check the short term-response characteristics of the rotorcraft through aggressive pitch pointing tasks.
- Check for undesirable coupling between pitch, roll, and yaw during aggressive maneuvering.

b. Description of maneuver. Two aircraft are required to perform this air-combat maneuver. The maneuver is initiated from level unaccelerated flight with both aircraft at a constant airspeed equal to the V_H of the test aircraft (airspeed for maximum continuous power). The test rotorcraft is positioned at least 152 m (500 ft) in trail behind the target aircraft. The target aircraft then decelerates 20 knots, to (V_H - 20), causing the test rotorcraft to close on the target. When the range between the two aircraft decreases to approximately 91 m (300 ft), the target aircraft initiates a 60-degree banked turn at constant altitude. The test rotorcraft delays until the line-of-sight reaches 30 degrees, at which time the pilot initiates a climbing turn toward the target, with a nose-up pitch attitude of 15 to 30 degrees. The resulting deceleration causes a decrease in the rate of closure from above. When the closure rate is no longer apparent, and the range to the target is approximately 61 to 152 m (200 to 500 ft), the test rotorcraft rapidly lowers the nose to achieve a firing solution within missile launch constraints.

c Desired performance.

- No undesirable interaxis coupling.
- Maintain the missile launch constraints for 7 seconds.
- Acquire the target with no tendency for pitch overshoots.

d. Adequate performance.

- Interaxis coupling shall not be objectionable.
- Maintain the missile launch constraints for 4 seconds.
- Acquire the target with no tendency for pitch overshoots.

4.2.12 Low Yo-Yo

a. Objectives.

- Check handling qualities during reduced and elevated load factors.
- Check the short-term response characteristics of the rotorcraft through aggressive pitch pointing tasks.
- Check for undesirable coupling between pitch, roll, and yaw during aggressive maneuvering.

b. Description of maneuver. Two aircraft are required to perform this air-combat maneuver, and the target aircraft must be capable of achieving airspeeds of at least 20 knots greater than the V_H of the test aircraft (airspeed for maximum continuous power). It may be necessary to use a fixed-wing aircraft as the target. The maneuver is initiated from level unaccelerated flight, with both aircraft at an airspeed equal to the V_H of the test rotorcraft. The test rotorcraft is positioned approximately 61 m (200 ft) in trail behind the target aircraft. The target aircraft then accelerates 20 knots to V_H + 20, resulting in a steady increase in range between the two aircraft. When the range between the two aircraft increases to approximately 91 m (300 ft), the target aircraft executes a 60-degree banked turn at constant altitude. The test rotorcraft delays until the line-of-sight reaches 30 degrees, at which time the pilot initiates a diving turn in the direction of the target with a nose-down pitch attitude of 15 to 30 degrees. The resulting acceleration causes the test rotorcraft to begin to close on the target from below. When a rate of closure on the target is apparent, and the range to the target is within 152 m (500 ft), the test rotorcraft rapidly raises the nose and tracks the target to achieve a firing solution within missile launch constraints.

c. Desired performance.

- No undesirable interaxis coupling.
- Maintain the missile launch constraints for 7 seconds.
- Acquire the target with no tendency for pitch overshoots.

- Maintain power within the transient range for as long as possible, without exceeding the time limit specified for the rotorcraft, or until simulated missile launch. Maintain at least 95% of maximum continuous power when rotorcraft limitations prohibit operation in the transient range.

d. Adequate performance.

- Interaxis coupling shall not be objectionable.
- Maintain the missile launch constraints for 4 seconds.
- Acquire the target with no tendency for pitch overshoots.
- Maintain power within $\pm$10% of maximum continuous. If +10% exceeds a limit, do not exceed that limit.

4.3 DECELERATING APPROACH IN IMC CONDITIONS

a. Objectives.

- Check ability to perform precision glideslope and localizer tracking to very low decision height and groundspeed with a reasonable pilot workload.
- Check ability to precisely control airspeed and to perform a deceleration while descending on the glideslope.

b. Description of maneuver. Starting on a 4 degree glideslope at 100 knots, perform a manual deceleration to an airspeed of 25 knots at an altitude of 15.2 m (50 ft). Guidance commands may be generated using onboard sensors, or from ground-based transmitters.

c. Desired performance.

- Maintain glideslope within $\pm$3.81 m ($\pm$12.5 ft)
- Maintain localizer within $\pm$15.2 m ($\pm$50 ft).
- Maintain airspeed within $\pm$5 knots of reference speed.

d. Adequate performance.

- Maintain glideslope within $\pm$7.63 m ($\pm$25 ft.
- Maintain localizer within $\pm$22.9 m ($\pm$75 ft).
- Maintain airspeed within $\pm$10 knots of reference speed.

4.4 PRECISION TASKS IN THE DEGRADED VISUAL ENVIRONMENT

The following precision maneuvers shall be flown in the degraded visual environment (DVE) specified in 3.1.1, using the displays and vision aids that will normally be available to the pilot. The wind conditions may be calm, but it is desirable to demonstrate the maneuvers in stronger winds.

4.4.1 Hover

a. Objectives.

- Check ability to transition from translating flight to a stabilized hover with precision and a reasonable amount of aggressiveness in the DVE.

- Check ability to maintain precise position, heading, and altitude in the DVE.

b. Description of maneuver. Initiate the maneuver at a ground-speed of between 6 and 10 knots with the target hover point oriented approximately 45 degrees relative to the heading of the rotorcraft. The target hover point is a repeatable, unchanging ground-referenced point from which rotorcraft deviations are measured. The ground track should be such that the rotorcraft will arrive over the target hover point (see illustration in “description of test course”).

c. Description of test course. The suggested test course for this maneuver is shown in Figure 1(4.1). Note that the hover altitude depends on the height of the hover sight, and the distance between that symbol, the hover target, and the helicopter. These dimensions may be adjusted to achieve a desired hover altitude. The hover target will have to be modified from Figure 1(4.1) to reflect the increased altitude tolerances allowed for the DVE.

d. Desired performance.

- Accomplish the transition to hover in one smooth maneuver. It is not acceptable to accomplish most of the deceleration well before the hover point and then to creep up to the final position. Attain a stabilized hover within 10 seconds of the initiation of deceleration.

- Maintain a stabilized hover for at least 30 seconds.

- Maintain the longitudinal and lateral position within $\pm$0.91 m ($\pm$3 ft) of a point on the ground and altitude within $\pm$0.61 m ($\pm$2 ft). Keeping the hover sight within the desired box on the modified hover target (Figure 1(4.1)) will insure desired lateral and vertical performance.

- Maintain heading within $\pm$5 degrees.

- There shall be no objectionable oscillations in any axis either during the stabilized hover, or the transition to hover.

e. Adequate performance.

- Accomplish the transition to hover in one smooth maneuver. It is not acceptable to accomplish most of the deceleration well before the hover point and then to creep up to the final position. Attain a stabilized hover within 20 seconds of the initiation of deceleration.

- Maintain a stabilized hover for at least 30 seconds.

- Maintain the longitudinal and lateral position within $\pm$2.44 m ($\pm$8 ft) of a point on the ground and altitude within $\pm$1.22 m ($\pm$4 ft). Keeping the hover sight within the adequate box on the modified hover target (Figure 1(4.1)) will insure adequate lateral and vertical performance.

- Maintain heading within $\pm$10 degrees.

4.4.2 Hovering Turn

a. Objectives.

- Check for undesirable handling qualities in a hovering turn in the DVE.
- Check ability to recover from a hovering turn with reasonable precision in the DVE.
- Check for undesirable interaxis coupling in the DVE.
- Check for undesirable display symbology and dynamics for hover in the DVE.

b. Description of maneuver. From a stabilized hover at an altitude of less than 6.1 m (20 ft) complete a 180 degree turn. Perform the maneuver in both directions.

c. Description of test course. It is suggested that this maneuver use the test course described for the pirouette (4.1.4, Figure 2(4.1)) with the rotorcraft located at the center of the pirouette circle.

d. Desired performance.

- Maintain the longitudinal and lateral position within ±1.83 m (±6 ft) of a reference point on the ground.
- Maintain altitude within ±0.91 m (±3 ft)
- Stabilize the final rotorcraft heading at 180 degrees from the initial heading within ±5 degrees.
- Complete the turn to a stabilized hover (within the ±5 degree window) within 15 seconds from initiation of the maneuver.

e. Adequate performance.

- Maintain the longitudinal and lateral position within *3.66 m (*12 ft) of a reference point on the ground. Maintain altitude within *1.83 m (*6 ft)
- Stabilize the final rotorcraft heading at 180 degrees from the initial heading within ±10 degrees.
- Complete the turn to a stabilized hover (within the *10 degree window) within 15 seconds from initiation of the maneuver.

4.4.3 Landing

a. Objectives.

- Check ability to precisely control the rotorcraft position during the final descent to a precision landing point.
- Check pilot-vehicle dynamics when pilot is forced into tight compensatory tracking behavior.

b. Description of maneuver. Starting from an altitude of greater than 3.05 m (10 ft), maintain an essentially steady descent to the designated landing area. It is acceptable to arrest sink rate momentarily to make last-minute corrections before touchdown.

c. Description of test course. The landing area shall be a rectangular shape that exceeds the dimensions of the rotorcraft landing gear by 1.83 m (6 ft) in width and 3.66 m (12 ft) in length.

d. Desired performance.

- Accomplish the landing with a smooth continuous descent, without evidence of objectionable oscillations.
- Touch down with all elements of the landing gear within the landing area.
- Once height is below 3.05 m (10 ft) altitude complete the landing within 15 seconds.
- Attain a rotorcraft heading at touchdown that is aligned with the longitudinal axis of the landing area within ±10 degrees.
- The final position of the rotorcraft shall be the position that existed at touchdown. It is not acceptable to adjust the rotorcraft position and heading after all elements of the landing gear have made contact with the pad.

e. Adequate performance.

- Touch down within and remain within the landing area
- Attain a rotorcraft heading at touchdown that is aligned with the longitudinal axis of the landing area. within ±15 degrees.

4.4.4 Pirouette

a. Objectives.

- Check ability to accomplish precision control of the rotorcraft simultaneously in the pitch, roll, yaw, and heave axes in the DVE.
- Check for degraded display symbology and dynamics during multiple axis maneuvering.

b. Description of maneuver. Initiate the maneuver from a stabilized hover over a point on the circumference of a 30.5 m (100 ft) radius circle with the nose of the rotorcraft pointed at a reference point at the center of the circle, and at a hover altitude of approximately 3.05 m (10 ft). Accomplish a lateral translation around the circle, keeping the nose of the rotor-craft pointed at the center of the circle, and the circumference of the circle under a selected point on the helicopter. Terminate the maneuver with a stabilized hover over the starting point. Perform the maneuver in both directions.

c. Description of test course. The test course shall consist of markings on the ground that clearly denote the circular pathways that define desired and adequate performance. The suggested course shown in Figure 2(4.1) is considered adequate for the evaluation. It may also be useful to add objects to assist the pilot with vertical cueing, such a post at the center of the circle.

d. Desired performance.

- Maintain a selected reference point on the rotorcraft within ±3.05 m (±10 ft) of the circumference of the circle.
- Maintain altitude within ±1.22 m (±4 ft)
- Maintain heading so that the nose of the rotorcraft points at the center of the circle within 10 degrees.
- Complete the circle and arrive back over the starting point within 60 seconds. Maintain essentially

constant lateral groundspeed throughout the maneuver. Note: the nominal lateral velocity will be approximately 6 knots.

- Achieve a stabilized hover (within ±3.05 m (±10 ft)) within 10 seconds after returning to the starting point.

e. Adequate performance.

- Maintain a selected reference point on the rotorcraft within ±4.57 m (±15 ft) of the circumference of the circle.

- Maintain altitude within ±3.05 m (±10 ft)

- Maintain heading so that the nose of the rotorcraft points at the center of the circle within ±15 degrees.

- Complete the circle and arrive back over the starting point within 75 seconds.

- Achieve a stabilized hover (within ±4.57 m (±15 ft)) within 20 seconds after returning to the starting point.

4.5 MODERATELY AGGRESSIVE TASKS IN THE DEGRADED VISUAL ENVIRONMENT (DVE)

4.5.1 Bob-up and Bob-down

a. Objectives.

- Check for adequate heave damping, i.e., the ability to precisely start and stop a vertical rate in the DVE.

- Check for adequate height control power for vertical axis maneuvering in the DVE.

- Check the characteristics of the heave axis controller in the DVE, especially if a non-conventional controller is used, e.g., a four- axis sidestick.

- Check for undesirable coupling between collective and the pitch, yaw, and roll axes in the DVE.

b. Description of maneuver. From a stabilized hover at 3.05 m (10 ft), bob-up to a defined reference altitude between 12.2 and 15.2 m (40 and 50 ft). The defined reference altitude, and associated outside cues, shall be established by the evaluation pilot prior to initiating the maneuver. Stabilize at the reference altitude for at least 2 seconds, simulating an attack with fixed guns. Bob-down to re-establish the 3.05-rn (10-ft) stabilized hover.

c. Description of test course. It is intended that the cue used to define the reference altitude be some vertical object in the field-of-view as opposed to using the radar altimeter. Experience has shown that aligning some object in the near field, such as a tree-top or street lamp, with an object in the far field works well. Some markers should be placed on the ground to allow the pilot to ascertain the horizontal position of the rotorcraft with respect to the desired and adequate performance requirements. A suggested test course is shown in Figure 4(4.2).

d. Desired performance.

- Complete the maneuver within 20 seconds.

- Maintain the longitudinal and lateral position of the rotorcraft within ±3.05 m (±10 ft) of a reference point on the ground.

- Maintain heading within ±3 degrees.

- Capture and maintain the final stabilized hover altitude within ±0.91 m (±3 ft).

e. Adequate performance.

- Complete the maneuver within 30 seconds.
- Maintain the longitudinal and lateral position of the rotorcraft within ±6.1 m (±20 ft) of a reference point on the ground.
- Maintain heading within ±6 degrees.
- Capture and maintain the final stabilized hover altitude within ±1.83 m (±6 ft)

4.5.2 Acceleration and Deceleration

a. Objectives.

- Check pitch axis and heave axis handling qualities for reasonably aggressive maneuvering in the DVE.
- Check for undesirable coupling between the longitudinal and lateral-directional axes while performing reasonably aggressive longitudinal axis maneuvers in the DVE.
- Check for harmony between the heave axis and pitch axis controllers while maneuvering in the DVE.
- Check for adequate rotor response to moderately aggressive collective inputs.
- Check for overly complex power management requirements while maneuvering in the DVE.

b. Description of maneuver. Starting from a stabilized hover, accelerate to a groundspeed of at least 50 knots, and immediately decelerate to hover over a defined point. The maximum nose-down attitude should occur immediately after initiating the maneuver, and the peak nose-up pitch attitude should occur just before reaching the final stabilized hover.

c. Description of test course. The test course shall consist of a reference line on the ground indicating the desired track during the acceleration and deceleration, and markers to denote the starting point and endpoint of the maneuver. The distance from the starting point to the final stabilized hover position is a function of the performance of the rotorcraft, and shall be determined based on trial runs consisting of accelerations to the target airspeed, and decelerations to hover as described above. The course should also include reference lines or markers parallel to the course centerline to allow the pilot and observers to perceive desired and adequate lateral tracking performance. A suggested test course for this maneuver is shown in Figure 3(4.2).

d. Desired performance.

- Complete the maneuver over the reference point at the end of the course. The longitudinal tolerance on the final hover position is plus zero and minus a distance equal to one half of the overall length of the helicopter (positive forward).
- Maintain altitude below 15.2 m (50 ft).
- Maintain lateral track within ±3.05 m (±10 ft).
- Maintain heading within ±10 degrees.
- Achieve pitch attitude changes from the hover attitude of at least 12 degrees nose-down for the acceleration and at least 15 degrees nose-up for the deceleration. Significant increases in power are not al-

lowable until just before the final stabilized hover.

- Rotor RPM shall remain within the limits of the operational flight envelope without undue pilot compensation.

e. Adequate performance.

- Complete the maneuver over the reference point at the end of the course. The longitudinal tolerance on the final hover p0sition is plus zero and minus a distance equal to the overall length of the rotorcraft (positive forward).

- Maintain altitude below 21.3 m (70 ft) and clear of the ground.

- Maintain lateral track within $\pm$6.1 m ($\pm$20 ft).

- Maintain heading within $\pm$20 degrees.

- Achieve a nose-down pitch attitude of at least 7 degrees below the hover attitude during the acceleration and a nose-up attitude of at least 10 degrees above the hover attitude for the deceleration. Significant increases in power are not allowable until just before the final stabilized hover.

- Rotor RPM shall remain within the limits of the service flight envelope.

4.5.3 <u>Sidestep</u>

a. Objectives.

- Check lateral-directional handling qualities for reasonably aggressive lateral maneuvering in the DVE.

- Check for objectionable interaxis coupling while maneuvering in the DVE.

- Check ability to coordinate bank angle and collective to hold constant altitude while performing moderately aggressive lateral maneuvering in the DVE.

b. Description of maneuver. Starting from a stabilized hover with the longitudinal axis of the rotorcraft oriented 90 degrees to a reference line marked on the ground, initiate a lateral translation, holding altitude constant with power. When the rotorcraft has achieved a lateral velocity of at least 17 knots, immediately initiate a deceleration to hover at constant altitude. The peak bank angle during deceleration should occur just before the rotorcraft comes to a stop. Establish and maintain a stabilized hover for 5 seconds. Immediately repeat the maneuver in the opposite direction.

c. Description of test course. The test course consists of any reference line on the ground that is readily visible to the pilot. This may consist of a solid line or a series of markers, or any other method deemed acceptable by the testing activity. A suggested course using traffic cones and flat markers is shown in Figure 2(4.2).

d. Desired performance.

- Maintain the selected reference point on the rotorcraft within $\pm$3.05m ($\pm$10 ft) of the ground reference line.

- Maintain altitude within $\pm$3.05 m ($\pm$10 ft) at a selected altitude below 9.14 m (30 ft).

- Maintain heading within $\pm$10 degrees.

- Achieve at least 20 degrees of bank angle during the acceleration and deceleration.

- Achieve a stabilized hover within 10 seconds after reaching the hover point.

e. Adequate performance.

- Maintain the selected reference point on the rotorcraft within ±4.57m (±15 ft) of the ground reference line.
- Maintain altitude within *4.57 m (*15 ft) at a selected altitude below 9.14 m (30 ft)
- Maintain heading within *15 degrees.
- Achieve at least 10 degrees of bank angle during the acceleration and deceleration.
- Achieve a stabilized hover within 20 seconds after reaching the hover point.

4.5.4 Slalom

a. Objectives.

- Check ability to maneuver with respect to objects on the ground for NOE forward flight in the DVE.
- Check turn coordination for forward flight maneuvering in the DVE.
- Check for objectionable interaxis coupling during forward flight maneuvering in the DVE.

b. Description of maneuver. Initiate the maneuver in level unaccelerated flight and lined up with the centerline of the test course. Perform a series of smooth turns at 152-m (500-ft) intervals. The turns shall be at least 15.2 m (50 ft) from the centerline, with a maximum lateral error of 15.2 m (50 ft). The maneuver is to be accomplished at a reference altitude below 30.5 m (100 ft). Complete the maneuver on the centerline.

c. Description of test course. The suggested test course for this maneuver is shown in Figure 4(4.2). Most runways have touchdown stripes at 152-rn (500-ft) intervals that can be conveniently used instead of the pylons. However, if the runway is not 30.5 m (100 ft) wide, it will be necessary to use two cones to define each gate (as opposed to one cone and the runway edge as shown in Figure 4(4.2)).

d. Desired performance.

- Maintain an airspeed of at least 30 knots throughout the course.

e. Adequate performance.

- Maintain an airspeed of at least 15 knots throughout the course.

5. SUMMARY OF REVISIONS TO ADS-33C

Based on the results of considerable flight testing, it has become apparent that some of the criteria in ADS-33C should be revised. This "D" version of ADS-33 includes only those revisions that are felt to be essential to insure good flying qualities or to make clarifications. The most extensive changes in this specification from ADS-33C are in the flight test maneuvers in Section 4. Changes have also been made to several of the quantitative requirements in Section 3. In cases where criterion boundaries have changed, a short description of the rationale for the change is given along with references that contain the supporting data. The following summary is provided to allow the user to identify these changes. Paragraph numbers refer to paragraphs in ADS-33C.

3.2.3 Combinations of Degraded Response-Tvpe and UCE

A new row has been added to Table 3(3.2). This change is incorporated to correct a publications error.

3.2.6 Character of Attitude Hold and Heading Hold Response-Tvpes

The wording of the first sentence has been edited for clarity. In ADS-33C this sentence stated "If Attitude or Heading (Direction) Hold is specified..., the attitude, or heading, shall...." The new sentence is "If Attitude Hold or Heading (Direction) Hold is specified..., the *pitch* attitude shall...."

3.3.2.1 Short-Term Response to Control Inputs (Bandwidth)

Based on recent data (discussed under Paragraph 3.4.5.1 below), the roll bandwidth requirement has been relaxed from 3.5 rad/sec to 2.5 rad/sec for target acquisition and tracking MTEs. The phase delay limit has been made more stringent in roll for these MTEs, and is 0.12 sec for level 1 and 0.20 sec for level 2. The ADS-33C roll bandwidth boundaries are identical for air combat (forward flight) and target acquisition and tracking (hover and low speed). Therefore, the revised forward flight boundaries have been incorporated into this hover and low speed requirement.

3.3.6 Moderate-Amplitude Heading Chanaes (Attitude Ouickness)

The level 1 and 2 limits in Figure 6a(3.3) have been relaxed to reflect motion-based simulation data obtained in the vertical motion simulator (VMS) at NASA Ames (Reference 1).
The flying qualities tasks used to develop these relaxed boundaries were as follows.

- Hovering Acquisition Task. While in a 10 foot hover, a target helicopter appeared at an angle of between 10 and 60 degrees from the rotorcraft heading. The task was to rapidly change heading and hold a fixed pipper on the target within tl degree for a period of 2 seconds. A total of 6 targets appeared that required heading changes of 10, 20, 30, 40, 50, and 60 degrees, in random order.

- Hovering 180 Task: From an initial 10 foot hover, the evaluation pilot was given a signal that he was being attacked by an enemy tank from the 180 degree position. The task required that the pilot make a 180 degree turn, and hold the pipper within ±2 degrees of the target, which was on a collision course with the helicopter. Desired performance was to accomplish this within 7 seconds, and adequate performance allowed 14 seconds, at which time the tank passed below the helicopter.

The data for each of these tasks indicated essentially identical attitude quickness boundaries. Such good agreement indicates that the data are generally applicable to the aggressive heading task for Hover and Low Speed.

Reference
Whalley, Matthew S., *A Piloted Simulation Investigation of Yaw Attitude Quickness in Hover and Yaw Bandwidth in Forward Flight,* NASA 'IM-103948, USAAVSCOM TR-92-A-002, Sept. 1992.

3.3.9.2 Pitch-to-Roll and Roll-to-Pitch Coupling During Aggressive Maneuvering

Attitude responses are now defined to be changes in attitude from trim, as opposed to absolute attitudes. It has been rewritten to be the ratio of peak off-axis response in the first four seconds to on-axis response occurring at four seconds. After four seconds, the primary response to a step control input should have reached a significant value. If, during those four seconds, the off-axis response is above some threshold value, the pilot will be required to apply countering controls to minimize the coupling. The requirement in ADS-33D now states this interpretation explicitly.

3.3.10.1 Height Response Characteristics

The equation in Figure 8(3.3) for computing $h_{est}(t)$ has been retyped for clarity. In addition, the method defined in Figure 8(3.3) now specifically allows for use of more than 101 data points.

3.4.3 Flight Path Control

This requirement in ADS-33C was identical to the hover and low speed requirement. It has been replaced by a qualitative statement that allows use of either collective or cyclic for flight path control. This qualitative requirement was implemented because flight testing has shown that the vertical response in forward flight can be much more sensitive to pitch attitude than collective. A requirement is needed that accounts for the natural tendency to transition from collective to pitch attitude for height control as air speed increases beyond the speed for minimum power-required.

3.3.9.2 Pitch-to-Roll and Roll-to-Pitch Coupling During Aggressive Maneuvering

Changes for this requirement are as described for 3.3.9.2 above.

3.4.5.1 Small-Amplitude Roll Attitude Response to Control Inputs (Bandwidth)

The Bandwidth boundaries for air combat (forward flight) and target acquisition and tracking (hover and low speed) have been revised to reflect data obtained since the original boundaries were formulated in 1987. The primary sources of supporting data are: 1) an in-flight simulation using the German Aerospace Laboratory (DLR) variable stability BO-lO5 (Reference 1), and 2) an air combat simulation on the NASA Ames vertical motion simulator (VMS) (Reference 2).

The task for the DLR flight experiment was an aggressive slalom course that involved tracking through a set of unevenly spaced gates. Uneven spacing of the gates was used to eliminate any tendency for the pilots to develop a precognitive "rhythm" instead of the desired closed loop tracking behavior. An inverse modeling technique was used to set the final course geometry so that the peak bank angles and time between gates were reasonable. Since the goal of the experiment was to investigate small amplitude precision tracking, the course was designed so that the peak bank angles did not exceed approximately 15 degrees. The data from these tests (see Reference 1) indicate that the current roll bandwidth limits are too stringent, and that the current limits on phase delay are too lenient for the target acquisition and tracking (hover and low speed) and air combat (forward flight) MTEs. Specifically, the data suggest a reduction in the level 1 roll bandwidth limit from 3.5 to 2.5 rad/sec, and reduction in the level 2 limit from 2.0 to 1.5 rad/sec. The sensitivity of pilot rating to phase delay (τ_ρ) was significantly higher for this experiment than for previous flight tests. This is attributed to the aggressive and precise nature of the task compared to previous tests. Specifically, the data suggests an upper limit on between 0.10 and 0.12 sec for level 1, and 0.20 sec for level 2. The most relaxed limit that could be justified from the data was $\tau_\rho = 0.12$ sec. This value was used to avoid the possibility of an overly stringent requirement that might result in complications in the design of a flight control system without a significant payoff in terms of pilot workload. The level 2 limit was set at 0.20 sec based on only a few data points, and is consistent with results obtained from fixed-wing aircraft. The new limits on phase delay are consistent with previous results, for example the ADOCS demonstrator was rated as HQR=5/6 for the slope landing (Reference 3). Reference 3 notes that this is probably a result of excessive phase delay ($\tau_\rho = .19$ sec), because the deficiency was a 1 Hz PlO tendency. The ADOCS roll Bandwidth was 2.1 rad/sec.

A ground-based simulation was run by the U.S. Army Aeroflightdynamics Directorate to investigate the handling qualities requirements for air combat (Reference 2). Two tasks involving an automated adversary rotorcraft were accomplished. Numerous results were obtained regarding helicopter dynamics and control power required for air combat maneuvering. The pitch and roll bandwidth data indicated a noticeable improvement in pilot ratings with increasing values of Bandwidth up to 2 rad/sec. Little additional improvement was noted beyond a Bandwidth of 2 rad/sec. This is consistent with the ADS-33C pitch Bandwidth requirement ($\omega_{BW\theta}$, $\geq$2.0 rad/sec for Level 1), and the relaxed roll bandwidth requirement (2.5 rad/sec) obtained from the above flight tests.

In summary, the roll Bandwidth requirement has been relaxed from 3.5 rad/sec to 2.5 rad/sec for Target Acquisition and Tracking (Paragraph 3.3.2.1) and for Air Combat (Paragraph 3.4.5.1). The phase delay limit has been made more stringent in roll for these MTEs, and is 0.12 sec for Level 1 and 0.20 sec for Level 2.

References

a. Pausder, Heinz-Jurgen, and Chris L. Blanken, "Investigation of the Effects of Bandwidth and Time Delay on Helicopter Roll-Axis Handling Qualities," Piloting Vertical Flight Aircraft: A Conference on Flying Qualities and Human Factors, NASA CP-3220$_1$ July 1993, pp. 91-110.

b. Whalley, Matthew S., and Carpenter, William R., A Piloted Simulation Investigation of Forward Flight Handling Qualities Requirements for Helicopter Air-to-Air Combat, USAAVSCOM Th 91-A-009, May 1992.

c. Tischler, M.B., J.W. Fletcher, P.M. Morris, and G.E. Tucker, "Flying Quality Analysis and Flight Evaluation of a Highly Augmented Combat Rotorcraft," Journal of Guidance, Control, and Dynamics, September 1991.

4. FLIGHT TEST MANEUVERS

The most significant changes in the flight test maneuvers are as follows:

- The introductory statement has been modified to provide more information on the conduct of tests and assignment of pilot ratings.
- The maneuvers have been rearranged to reflect a logical transition from hover to low speed to forward flight.
- Adequate performance requirements have been added to all maneuvers based on flight tests by the U.S. Army Airworthiness Qualification Test Directorate (AQTD)
- New maneuvers have been added based on flight tests by AQTD. These maneuvers are considered to be essential elements (i.e., mission-task-elements) of the Army rotorcraft missions for scout-attack rotorcraft, and hence conform to the fundamental goal of the specification to be "mission-oriented."
- For several of the ADS-33C maneuvers, the task definitions or desired performance limits have been changed based on flight tests by AQTD.
- The general structure of the maneuver statements has been streamlined. For each maneuver, there are subheadings defining objectives, description of maneuver, description of test course (if applicable), and desired and adequate performance limits. For the near-earth maneuvers illustrative figures have been provided showing suggested test course layouts.

The following paragraphs outline the significant changes that have been made to each of the Section 4 maneuvers. Paragraph numbers refer to the listings in ADS-33D.

4.1 PRECISION TASKS IN THE GOOD VISUAL ENVIRONMENT

4.1.1 Hover

Maneuver description has changed. The maneuver now emphasizes both the ability to hover and the ability to transition from low-speed flight to a hover.

4.1.2 Hovering Turn

The aggressiveness of the ADS-33C hovering turn has been reduced. Longitudinal and lateral position Requirements for desired performance are tighter ($\pm$3 ft as opposed to $\pm$6 ft in ADS-33C), and time to complete the turn is doubled to 10 sec. The more aggressive limits of the ADS-33C maneuver have been adopted for a new turn to target maneuver (see 4.2.1 below)

4.1.3 Landing

The task description has changed considerably, from a vertical landing starting at 26 ft in ADS-33C, to a landing Onto a raised platform from an initial altitude of greater than 10 ft. AFDD and NASA flight tests have shown that the vertical descent is unrealistic, and that pilots tend to slowly drift forward during the descent to keep the pad in sight. They also noted that the vertical descent did not add anything to the maneuver. Changes have been made to the performance standards to reflect this revised maneuver. Most importantly, the maneuver is no longer a rapid landing (ADS33C required completion of the maneuver in 6 sec or less) but a more precise maneuver, with desired performance time of 10 sec.

4.1.4 Pirouette

Performance requirements for stabilizing at the end of the pirouette are now included. This is based on experience that showed that the stabilization at the end of the maneuver is as important to good handling as the maneuver itself. After the pirouette is completed, the stabilized hover must be achieved within 5 sec and within $\pm$10 ft of the endpoint for desired performance.

4.1.5 Slope Landing

This task is defined in much greater detail. Touchdown position limits are defined in terms of landing gear dimensions, rather than a reference position on the rotorcraft. There is an additional requirement to maintain ground contact with one part of the landing gear for a specified time before touching down or lifting off.

4.2 AGGRESSIVE TASKS IN THE GOOD VISUAL ENVIRONMENT

4.2.1 Turn to Target

This is a revised version of the ADS-33C hovering turn maneuver. The new hovering turn (discussed above) has tighter performance limits and a longer time to complete the maneuver, but this task specifically relates to a targeting sight on the rotorcraft. The turn must be completed within 5 sec, including time to achieve a firing solution, for desired performance. All position limits for desired performance are identical to those for the ADS-33C hovering turn.

4.2.2 Bob-up and Bob-down

This is 4.2.3 in ADS-33C. Required distance achieved on the bob-up has been increased from clearing an obstacle approximately 25 ft high to attaining an altitude of between 40 and 50 ft. Time to perform the maneuver (for desired performance) has increased from 8 sec to 10 sec, with slightly more stringent position limits ($\pm$6 ft compared to $\pm$8 ft) and a heading limit of $\pm$3 degrees throughout the maneuver. In addition, there is an added requirement to capture and maintain the final stabilized hover altitude after the bob-down.

4.2.3 Vertical Remask

This is a new maneuver for ADS-33D. It combines the elements of a bob-down with the elements of a sidestep. The AQTD pilots felt that this MTE was necessary because it is a common tactical evasive maneuver if observed during a bob-up. It is a good test of the capability to rapidly change thrust with precision and without exceeding torque limits.

4.2.4 Acceleration and Deceleration

This is 4.2.1 in ADS~33C. The details of the task description have been clarified and the top speed is now 50 knots instead of 60 knots. Tolerance on longitudinal position for the final hover point is defined as a fraction of the length of the rotorcraft, rather than as an absolute distance. Altitude limits are stated differently (stay below 50 ft for desired performance; ADS-33C required 40 $\pm$15 ft), as are requirements on power and pitch attitudes used to perform the acceleration and deceleration.

4.2.5 Sidestep

This is 4.2.2 of ADS-33C with a much more detailed task description. The expected level of aggressiveness is now explicitly stated in terms of bank angles achieved to initiate and stop the sidestep. Top sideward speed to be achieved has been specified based on maximum achievable speed, up to 45 knots. Most of the desired performance limits are unchanged. Altitude requirements now appear as performance limits, rather than as a part of the maneuver definition, as they did in ADS-33C.

4.2.6 Slalom

ADS-33C paragraph 4.2.5 has been rewritten to include flight over specific objects on the ground (pylons) that are 500 feet apart. The ADS-33C slalom did not have such pylons in an attempt to keep the maneuver simple and low-cost. Experience has shown that ground reference objects are essential to make the slalom a meaningful mission-task-element. The altitude limit for desired performance was relaxed from $\pm$10 ft to simply remain below 100 ft. This is consistent with tactical maneuvering at low altitude where the pilot's primary objective is to remain masked, not to control altitude precisely. The only performance limits are minimum airspeeds during the maneuver.

4.2.7 Deceleration to Dash

This is a new maneuver for ADS-33D, and was added as a result of lessons learned with the AH-64A Apache, related to control of rotor RPM. It is also an excellent maneuver to test for adverse coupling between pitch, yaw, and heave. Tactically, the maneuver is used when approaching a ridgeline at high speed. The aircraft is slowed to inspect the terrain past the ridge, and then rapidly accelerated, to avoid excessive exposure at low speed.

4.2.8 Transient Turn

The maximum altitude for performing this maneuver is defined to be 200 ft (it was specified as a minimum, 100 ft, in 4.2.6 of ADS33C). It is also now a 180-deg change in “directional flightpath” (where the rotorcraft is going) as opposed to a change in heading (where it is pointing). In addition, use of collective is explicitly permitted to increase speed bleed-off and hence increase turn rate.

4.2.9 Pullup/Pushover

This is a slight revision to 4.2.4 of ADS-33C. The initial flight condition must be either speed for maximum continuous power or 120 knots, whichever requires less power. Load factor performance limits are based on the limits of the operational flight envelope (e.g., achieve $n_L(+)$ in ADS-33C, as opposed to 2g in ADS-33C, for desired performance in the pullup).

4.2.10 Roll Reversal at Reduced and Elevated Load Factors

Several changes have been made to this maneuver from 4.2.7 of ADS33C. The most significant is the entry point of the task: a dive instead of level flight. Other changes make the maneuver itself more specific. In terms of desired performance the only change is a requirement to maintain the target load factor within $\pm$0.30g.

4.2.11 High Yo-Yo

4.2.12 Low Yo-Yo

These are classical air combat energy management maneuvers and have been included to quantify the Air Combat MTEs used in Section 3.

4.3 DECELERATING APPROACH IN IMC CONDITIONS

With the exception of the title (in ADS-33C 4.3 was "Decelerating Approach to Hover"), there is no change to this task.

4.4 PRECISION TASKS IN THE DEGRADED VISUAL ENVIRONMENT

4.4.1 Hover

This maneuver has been modified to reflect the new transition-to-hover portion, discussed for 4.1.1 above. Altitude deviations for desired performance have been tightened from $\pm$3 ft in ADS-33C to $\pm$2 ft here.

4.4.2 Hovering Turn

This is basically the ADS-33C maneuver, with a relaxation in desired time to complete the maneuver from 10 to 15 sec.

4.4.3 Landing

In ADS-33C the task required only to "Perform a vertical landing from a stabilized hover." In ADS-33D the initial altitude is specified and the only touchdown position requirement is to land within an area six ft wider and 12 ft longer than the landing gear. In ADS-33C, the position requirement was within 3 ft of a reference point on the ground. In addition, the landing must now take 15 Sec, as opposed to 10 sec in ADS-33C.

4.4.4 Pirouette

Maneuver description and desired performance limits are basically unchanged. Any differences are as described for the pirouette in the good visual environment (see 4.1.4 above).

4.5 MODERATELY AGGRESSIVE TASKS IN THE DEGRADED VISUAL ENVIRONMENT

4.5.1 Bob-up and Bob-down

This was 4.5.3 of ADS-33C. The changes here are similar to those for the task in the good visual environment (see 4.2.2 above).

4.5.2 Acceleration and Deceleration

This is a revision to 4.5.1 of ADS-33C, and the changes are similar to those for the task in the Good Visual Environment (see 4.2.4 above)

4.5.3 Sidestep

There is little difference between this task and 4.5.2 of ADS-33C. The only difference is an addition in the performance requirements; a stabilized hover must be achieved within a specified time after reaching the hover point at the end of the sidestep.

4.5.4 Slalom

The differences between this maneuver and the slalom in 4.5.4 of ADS-33C are as described for 4.2.6 above.

Appendix C. Aircraft Description and Instrumentation

The UH-60A Black Hawk is a utility twin-turbine, single main rotor helicopter capable of transporting cargo, 11 combat troops, and weapons during day, night, visual and instrument meteorological conditions. The aircraft has conventional wheel-type landing gear and a maximum gross weight of 20,250 pounds. The main and tail rotors are both four-bladed. A moveable horizontal stabilator is located on the lower aft portion of the tail rotor pylon. The helicopter is powered by two T700-GE-700 turboshaft engines each having an uninstalled rating of 1,553 shaft horsepower at sea level, standard day static conditions. Installed dual engine power is transmission limited to 2,828 shp.

A cargo hook is mounted in the floor of the aircraft, and is gimbaled in roll. A hatch provides crew chief access to the hook, and the load can be released by a button on the pilots' cyclic sticks, and manually by the crew chief.

The test aircraft, U.S. Army S/N 82-23748 (ARMY 748), is a sixth-year production Black Hawk which incorporates the External Stores Support System fixed provisions and fairings, the reoriented production airspeed probes, and the modified production stabilator schedule.

Modifications made to the aircraft under the airloads program and retained in the current aircraft test configuration includes the Aircraft Data Acquisition System (ADAS) comprised of 1) an instrumentation rack ("c.g. rack") mounted on the center rear cabin deck; 2) a flight data tape recorder mounted on the right rear cabin deck; 3) an instrumentation power distribution panel mounted above the tape recorder; 4) the "ADAS rack" containing telemetry equipment mounted on the left rear cabin deck; and 5) the "engineering rack" mounted behind the right pilot seat.

The ADAS also includes air data sensors mounted on a boom extending ahead of the aircraft, a low airspeed data system mounted externally on the right rear window frame behind the right seat, and a total temperature sensor mounted under the aircraft below the left seat. Laser reflector assemblies are mounted on the landing gear stub wings.

Instrumentation and Data Acquisition

<u>System Overview:</u> The helicopter sensor signals (the c.g. rack sensors including accelerometers, rate and attitude gyros, plus control position sensors, air data, and hook load cell) are passed through filters and encoded in a PCM stream, which is then recorded on a tape recorder and also transmitted to the ground telemetry station. A time code generator receives the broadcast IRIG A time and supplies this to the recorders. A flow diagram of the instrumentation and data acquisition system on the helicopter is shown in Figure C-1.

The recorded signals are listed in Table C-1. The recorded helicopter sensors are a subset of those recorded by the ADAS system in the airloads program, with sensors for the engine-transmission, fuel, and airframe accelerometers omitted. The listed signals measure most (but not all) of the helicopter and load rigid body states and the control positions at several points in the control system.

<u>ADAS Sensors:</u> These are mounted on the ADAS instrumentation rack (c.g. rack) in the rear cabin and include accelerometers, angular accelerometers, angular rates, and attitude gyros.

<u>Air Data:</u> This group is comprised of the boom sensors (the yaw-alpha vanes and static and dynamic pressure sensors), a low airspeed pressure head mounted externally behind the right pilot seat and close under the rotor (LASSIE or HADS Helicopter Air Data System), and a total temperature sensor mounted

on the airframe. The boom sensors are used to derive airspeed at speeds above 25 knots and the LASSIE is used below 20 knots.

Control Position Sensors: The locations for the various control position sensors, along with the nomenclature for the signals and related and several derived parameters, are shown in schematic form in the upper part of Figure C-2. As shown in the lower part of Figure C-2, the actual control position sensors are installed at four different locations in the control linkages. First, the pilot inputs are measured on the control pushrods behind the right seat. There are four string potentiometers (string pots) connected to the lower arm of the bellcranks that connect the vertical pushrods to the overhead pushrods, one for each input channel; lateral cyclic, longitudinal cyclic, directional pedals, and collective. Second, the SAS actuator outputs for roll, pitch, and yaw are measured by sensors mounted directly on the actuators. The pushrods for the sensors are attached to the bolt that holds the SAS actuator shaft to the output link. Third, the mixing unit inputs are measured by three linear displacement transducers mounted underneath the pilot assist servo assemblies. These sensors measure the combined output of pilot control and the SAS actuators. Finally, the primary servo outputs are measured by three string pots connected to the primary servo output rod ends for the forward, lateral, and aft servos.

Laser Tracking: The aircraft is equipped with reflector assemblies consisting of banks of corner mirrors mounted externally on the landing gear stub wings (Figure C-3). Laser tracking is done from a van at a surveyed location, and data is transmitted to the TM station for real-time displays and digital recording

Recorders and Time Code: The tape recorder for the data is mounted on the cabin floor next to the c.g. rack. Recording is controlled by the left seat pilot using buttons on the pedestal to increment record numbers, to start and end a recorded flight segment (record), and to startup/stop the recorder. The time code generator is mounted in the ADAS c.g. rack.

Telemetry Antennas: The aircraft is equipped with 4 research antennas; the load TM receiver, the video transmitter, the ADAS PCM transmitter, and the time code receiver. Their locations on the bottom of the aircraft are shown in Figure C-4.

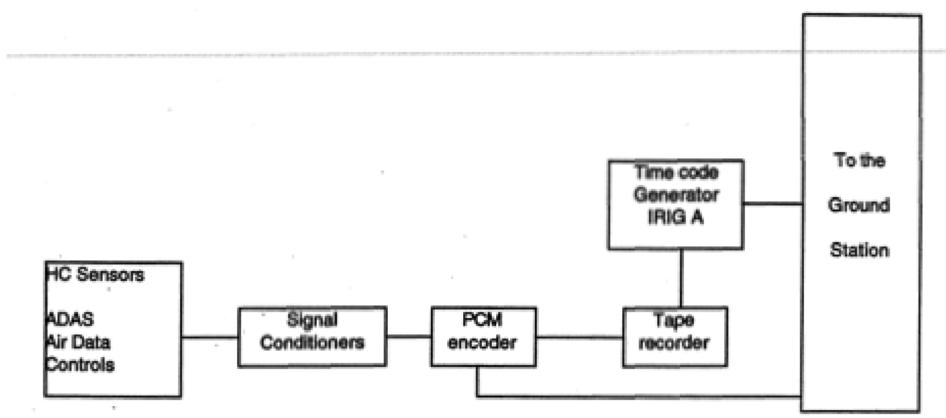


Figure C-1. Aircraft instrumentation and data acquisition system

Table C-1. Helicopter PCM Measurements (37)

Item Code	Mnemonic	Description	Positive Direction	Units	Range MIN	Range MAX	Sample Rate
D100	LONGSTK	Longitudinal Control Position	AFT	%	0	100	209
D101	LATSTK	Lateral Control Position	RIGHT	%	0	100	209
D102	PEDAL	Directional Control Position	RT PEDAL	%	0	100	209
D103	COLLSTK	Collective Control Position	UP	%	0	100	209
D003	STABLR	Stabilator Angle	TE DOWN	deg	-10	40	209
DM00	DMIXE	Longitudinal Mixer Input Position	AFT	%	0	100	209
DM01	DMIXA	Lateral Mixer Input Position	RIGHT	%	0	100	209
DM02	DMIXR	Directional Mixer Input Position	RT PEDAL	%	0	100	209
DP00	PSFWD	Primary Servo, Forward	UP	%	0	100	209
DP01	PSLAT	Primary Servo, Lateral	UP	%	0	100	209
DP02	PSAFT	Primary Servo, Aft	UP	%	0	100	209
R021	TRIP	Tail Rotor Impressed Pitch	LT PEDAL	deg	0	100	209
DS00	SASE	Longitudinal SAS Output	AFT	%	0	100	209
DS01	SASA	Lateral SAS Output	RIGHT	%	0	100	209
DS02	SASR	Directional SAS Output	RIGHT	%	0	100	209
DA00	PITCHATT	Pitch Attitude	NOSE UP	deg	-50	50	209
DA01	ROLLATT	Roll Attitude	RIGHT	deg	-100	100	209
DA02	HEADING	Heading	NOSE RT	deg	0	360	209
DAA0	ALPHA	Angle of Attack	NOSE UP	deg	-100	100	209
DSS0	BETA	Sideslip Angle	NOSE LT	deg	-100	100	209
DR00	PTCHRATE	Pitch Rate	NOSE UP	deg/s	-50	50	209
DR01	ROLLRATE	Roll Rate	RIGHT	deg/s	-50	50	209
DR02	YAWRATE	Yaw Rate	NOSE RT	deg/s	-50	50	209
DAC0	PTCHACC	Pitch Angular Acceleration	NOSE UP	deg/s^2	-600	600	209
DAC1	ROLLACC	Roll Angular Acceleration	RIGHT	deg/s^2	-200	200	209
DAC2	YAWACC	Yaw Angular Acceleration	NOSE RT	deg/s^2	-100	100	209
DL00	AXCG	X-Axis Linear Acceleration	FORWARD	g’s	-2	2	209
DL01	AYCG	Y-Axis Linear Acceleration	RIGHT	g’s	-2	2	209
DL02	AZCG	Z-Axis Linear Acceleration	UP	g’s	-2	4	209
V001	V001	Airspeed, Boom		in Hg	0	2	209
H001	H001	Static Pressure, Boom		in Hg	20	32	209
VX03	LSSX	LASSIE Forward Airspeed	FORWARD	kts	-35	165	209
VY03	LSSY	LASSIE Lateral Airspeed	RIGHT	kts	-50	50	209
VZ03	LSSZ	LASSIE Vertical Airspeed	UP	ft/min	-300	2000	209
T100	T100	Stagnation Temperature		°C	-20	50	209
H003	RALT	Radar Altimeter		ft	0	1500	209
HKLD	HKLD	Hook Load		lbs	0		

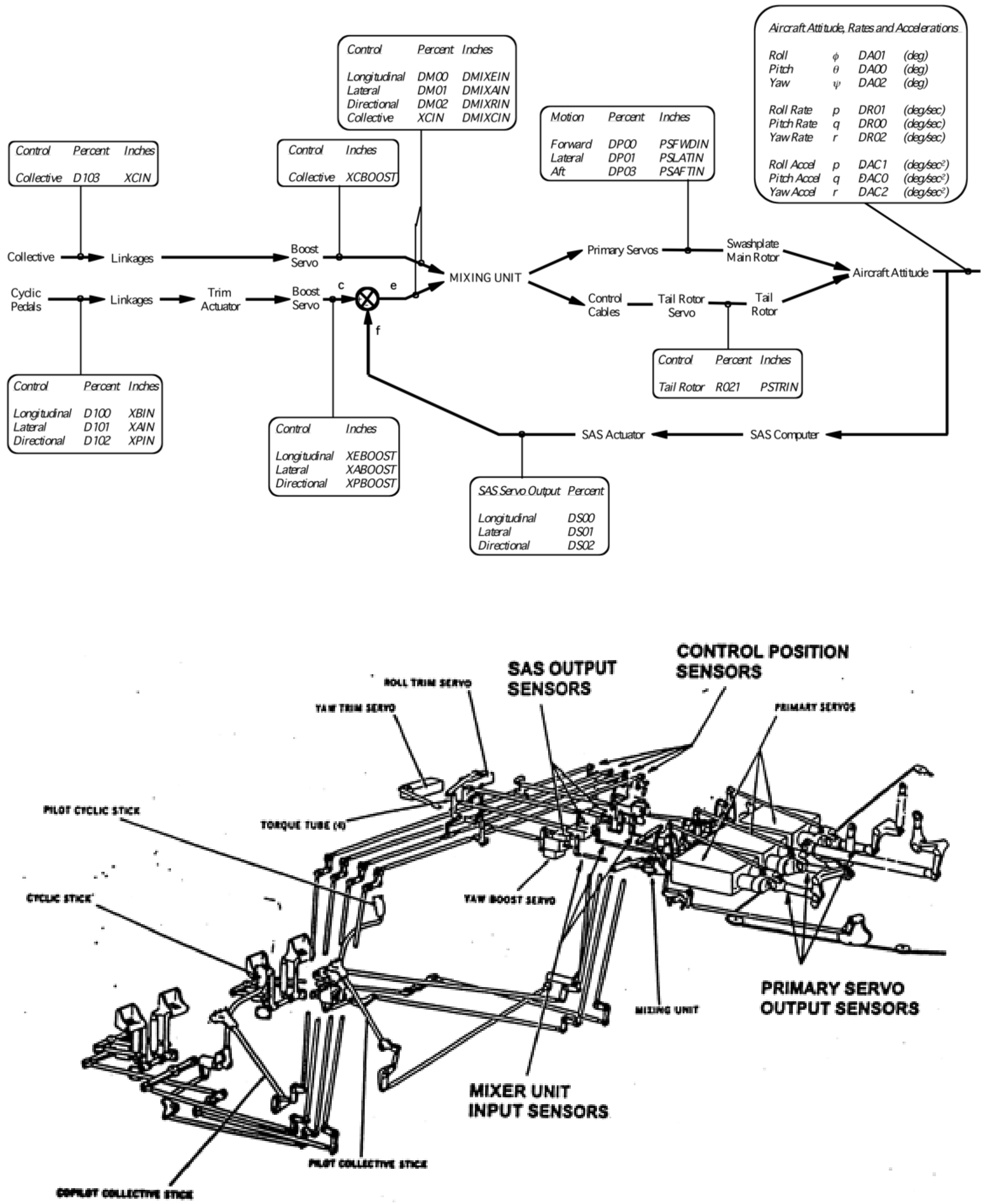


Figure C-2. Control System and Position Sensors.

Figure C-3. Laser reflector

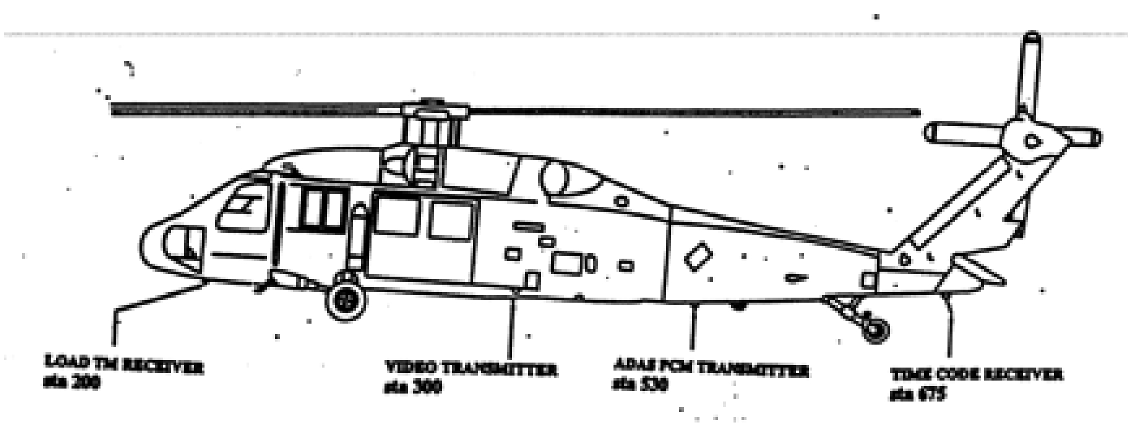


Figure C-4. Helicopter antenna locations

Appendix D. Test Techniques, MTE Course Cueing, and Test Conditions

This Appendix describes the setting of MTE task standards used in Phase 1 of this assessment and provides an overview of the MTE courses.

Setting Task Standards. During the initial maneuver evaluation phase, questions arose from the evaluation pilots on the rationale for setting maneuver standards. Mr. David Key, the former Army project manager for ADS-33, composed the following guidelines:

The Mission Task Elements (MTEs) may not be recognizable as mission tasks. Rather they are contrived maneuvers at least part of which should be an ingredient of some mission task. All of the MTEs are simple enough to be precisely defined, and to help with problem detection and diagnosis some MTEs are just single axis tasks.

To provide a meaningful benchmark across helicopters, and to get consistent ratings within helicopters, not only the task, but also the performance standards of precision and aggressiveness have to be precisely defined. This is a critical step. Increased precision and aggressiveness requires more pilot compensation, and hence the Handling Qualities Rating (HQR) will degrade. The benefit of setting high standards of precision and aggressiveness levels is that poor characteristics will be exposed, whereas they can be overlooked in more modest maneuvers. The downside is that high standards may be difficult to achieve without extensive development efforts, or may not even be possible with certain configurations. Thus we must devise standards that are a realistic compromise; they must be demanding enough to expose meaningful deficiencies, but not require more than is really necessary.

The process of flying candidate maneuvers in a familiar helicopter with known virtues and faults provides great insight for setting MTE standards. However, just because the test helicopter is well suited for a particular task does not mean that the standards should be set as high as its capabilities; it may be appropriate to ask for less. Conversely, if the test helicopter is particularly weak in a certain axis, it may be appropriate to ask for more.

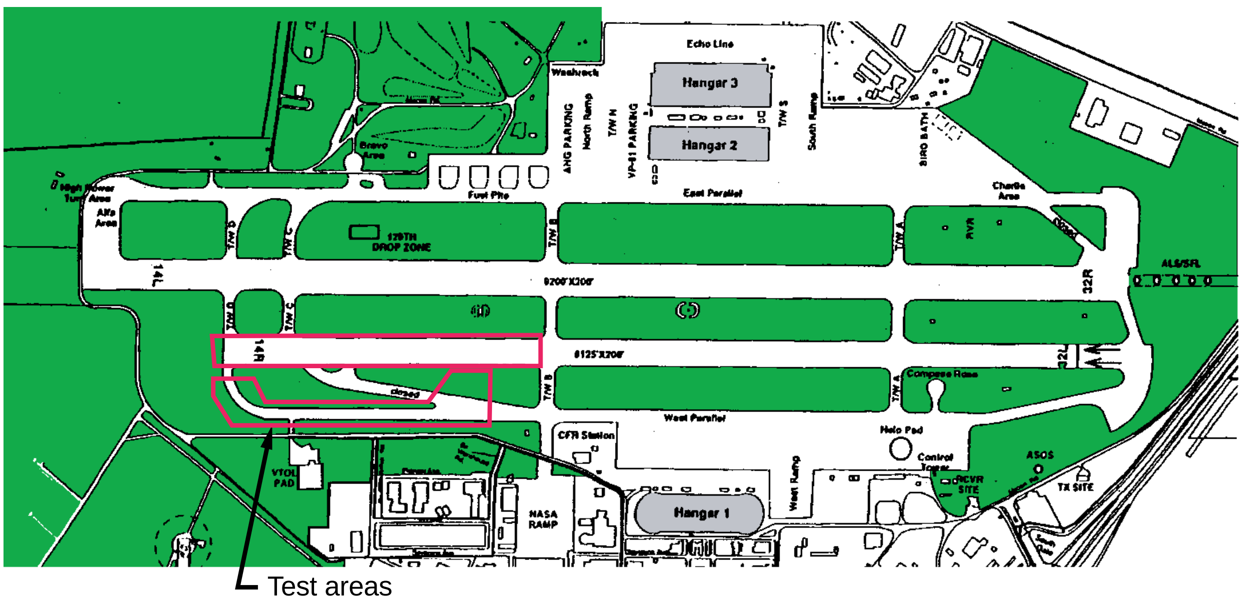
Clearly the standards must be related to what will be needed in the helicopter's designated role. It is not reasonable to require a cargo type to be as agile and maneuverable as a scout/attack. Though less aggressive, a cargo or utility type may need more spatial precision and less pointing accuracy than the scout/attack.

To some extent the levels of aggressiveness and precision interact. For example, in the hover task it would seem to be more aggressive, and take more pilot compensation, to enter and stabilize in a ±3 ft cube in 5 sec than to enter and stabilize in a ±6 ft cube in 5 sec. However, once stabilized, the task precision does become the sole guideline. Allowable track and altitude errors in the translating tasks are also primarily precision related. Such steady state precision standards should be somewhat relatable to mission needs. Is the hover precision adequate for a sling load pick-up and drop off, or a fast rope deployment?

The standards for neither precision nor aggressiveness should be set at routine mission levels. They need to be set at a level that provides some margin from routine levels to allow for unusual situations such as distractions, and the need to hustle when flying in harm's way. The evaluators are highly trained test pilots performing evaluations in a pristine environment, so they may be expected to do better than the operational pilot in the field. Exercising tight limits can ensure that there are no sudden changes in HQ (cliffs) close to the operational limits. The inherent delays in rotor response means that all helicopters have a limit beyond which one can expect bad things to happen such as loss of control or exceeding some dynamic limitations. The important thing is to ensure that such limitations do not intrude into the mission, that they occur gradually with warnings, or are sufficiently removed that they will not be encountered.

The following paragraphs provide an overview of the flight test courses that were set-up and used for the ADS-33 qualitative assessments. The dominant course cues were orange traffic cones. For the Hover, Hovering Turn, and Vertical Maneuver MTEs (with and without and external slung load), hover target reference symbols and hover boards were used to provide position cueing. For the Pirouette MTE, four concentric circles were painted on the taxi to provide cueing for “Desired” and “Adequate” position while traversing around the circle. A center-pole provided heading and altitude cueing.

The ADS-33 MTE courses were set up using the northwest taxi and the end of runway 32L, Moffett Field Federal Airfield. The illustration below shows the location of the flight test assessment.



The following figures provide pictures and illustrations of course cueing for the MTEs.

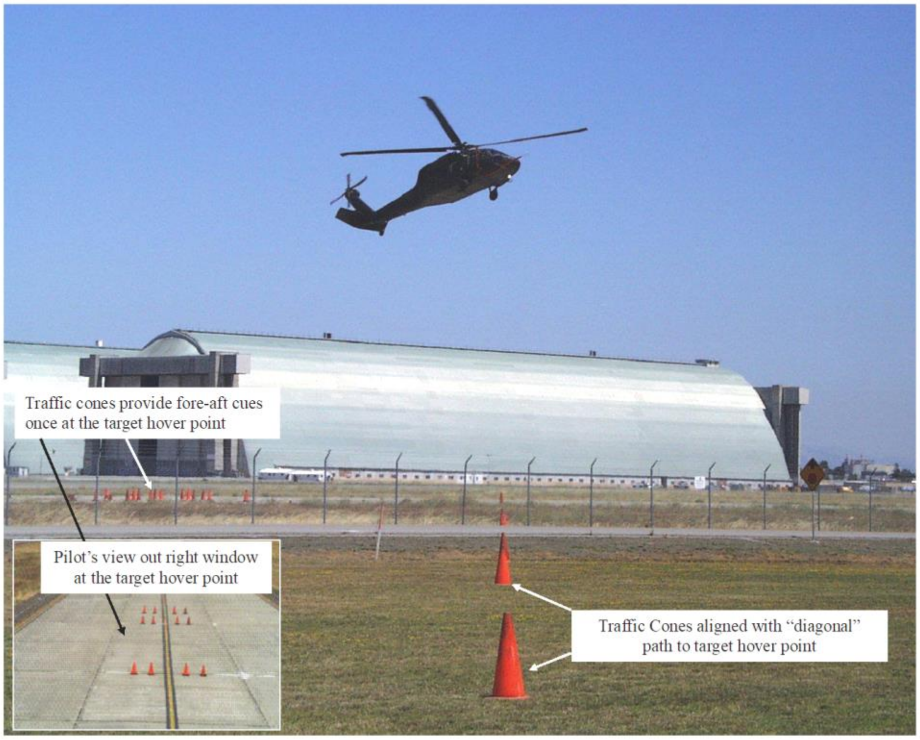


Figure D-1. Hover MTE traffic cones course layout.

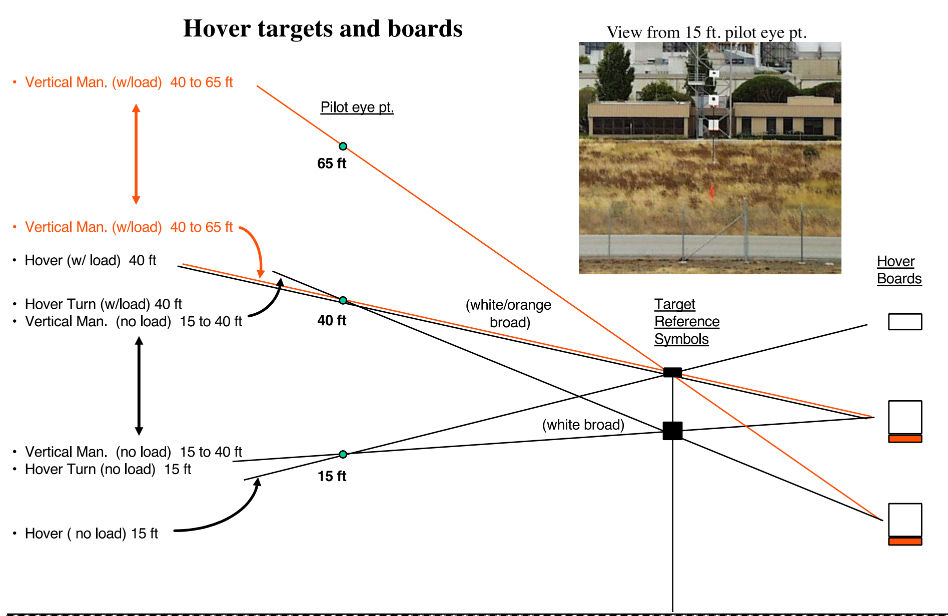


Figure D-2. Illustration of Target Reference Symbols and Hover Boards used for pilot cueing while performing the: Hover MTE; Hovering Turn MTE; and the Vertical Maneuver MTE.

Figure D-3. Lateral Reposition MTE traffic-cone layout for start/stop cueing.

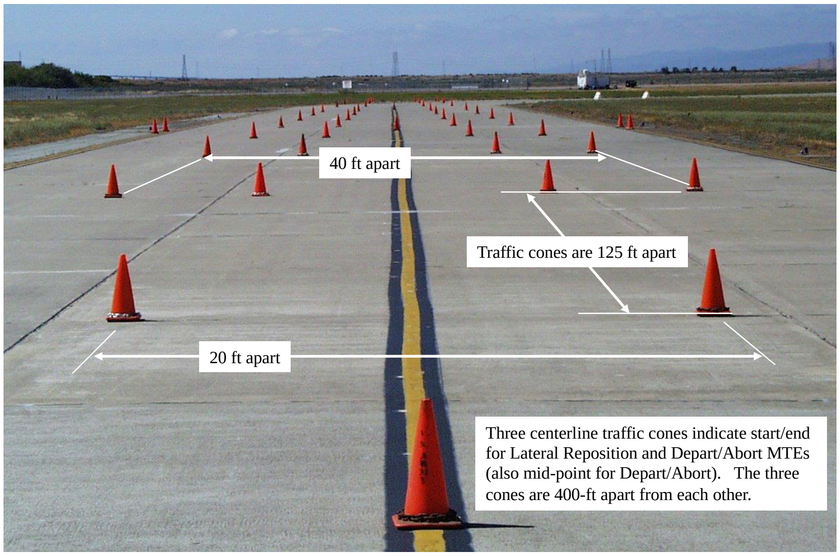


Figure D-4. Traffic-cone layout for: fore-aft cueing for Lateral Reposition MTE; and lateral limits while performing the Depart/Abort MTE.

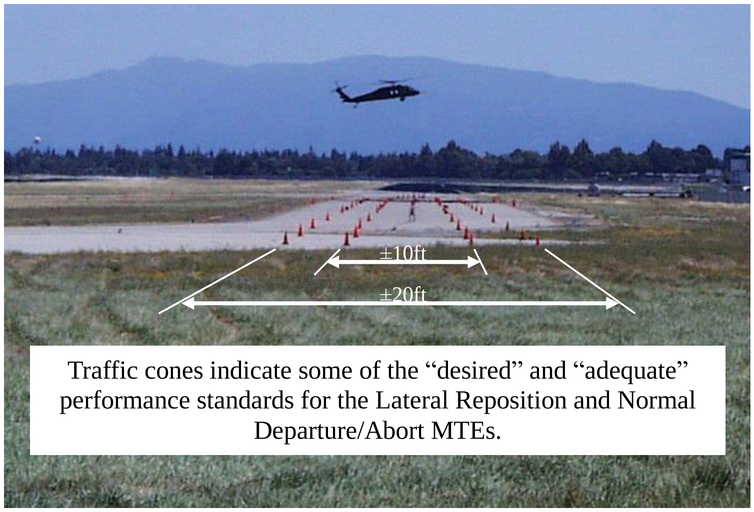


Figure D-5. Photo of the aircraft performing the Lateral Reposition MTE.

Four concentric circles painted onto the ramp. Flight within the two inner circles (yellow) indicates “desired” performance. Flight between the yellow and red circles are “adequate” performance. Flight inside/outside red circles are not adequate. Radii of yellow circles are 90 and 110 ft; red circles are 85 and 115 ft. Much appreciation is given to the constructors (Messrs. Fallon and Weakley) of circle cueing.   Note, the Moffett Airfield management required the circles be painted with ‘finger-paint’ – such that on-the-first rain, the circles would wash away.

A pole with an orange bucket on top located in the center of the circle provides altitude cues. That is, bucket height is half the aircraft target altitude. With the aircraft at the desired height, the bucket aligns with the painted circles on the opposite side. Also, not shown (but used) was a traffic cone on the opposite side of the circle aligned with the start/stop position. The “hold-line” bisected the circle and provided a reasonable cue for the start/stop line and the half-way point.

Figure D-6. Concentric circles and a center-pole (with an orange bucket on top) provide cueing for the Pirouette MTE.

Figure D-7. Photos from the aircraft (clockwise from upper left): the Hover MTE target and boards; the taxiway traffic cones rows for the Lateral Reposition and Depart/Abort MTEs; and right and left end-points for the Lateral Reposition MTE.

Figure D-8. Slope Landing MTE photos. Clockwise from upper left: Approach to sloped landing zone, with traffic cones at the “12-o’clock” and “3-o’clock” position; “12-o’clock” traffic cones; cockpit-view while landed on the slope; landed on the slope, with one of the “3-o’clock” traffic cones visible.

Table D-1 Test Conditions

<table>
<tr><th>Maneuver</th><th>Configurations[2]</th><th>Winds[3]/Conditions[4]</th><th>ADS-33D Paragraph</th><th>Test Plan Paragraph</th><th>Remarks[6]</th></tr>
<tr><td>Precision Hover</td><td rowspan="12">A, B</td><td rowspan="4">**Calm/Moderate**</td><td>4.1.1</td><td>------</td><td></td></tr>
<tr><td>Hovering Turn</td><td>4.1.2</td><td>------</td><td></td></tr>
<tr><td>Bob-up and Bob-down</td><td>4.2.2</td><td>------</td><td>Tailwind/ critical azimuth</td></tr>
<tr><td>Pirouette</td><td>4.1.4</td><td>------</td><td></td></tr>
<tr><td>Slope Landing</td><td rowspan="9">**Calm**</td><td>4.1.5</td><td>------</td><td></td></tr>
<tr><td>Landing</td><td>4.1.3</td><td>-------</td><td></td></tr>
<tr><td>Acceleration/Deceleration</td><td>4.2.4</td><td>35</td><td></td></tr>
<tr><td>Sidestep</td><td>4.2.5</td><td>------</td><td></td></tr>
<tr><td>Slalom</td><td>4.2.6</td><td>36</td><td></td></tr>
<tr><td>Deceleration to Dash</td><td>4.2.7</td><td>------</td><td></td></tr>
<tr><td>Decelerating Approach in IMC</td><td>4.3</td><td>------</td><td></td></tr>
<tr><td>Precision Landing[5]</td><td rowspan="9">N/A</td><td>38</td><td></td></tr>
<tr><td>Hover with Load[5]</td><td rowspan="4">A, B, C, D</td><td>39</td><td></td></tr>
<tr><td>Bob-up and Bob-down with Load[5]</td><td rowspan="3">**Calm/ Moderate**</td><td>40</td><td>Tailwind/ critical azimuth</td></tr>
<tr><td>Forward Flight Maneuvering with Load[5]</td><td>41</td><td>No more than Light Turbulence; 1000' MSL</td></tr>
<tr><td>Formation Flights[5]</td><td>42</td><td>No more than Light Turbulence; 1000' MSL</td></tr>
<tr><td>Normal Departure/Abort with Internal Load[5]</td><td>A, B</td><td rowspan="4">**Calm**</td><td>43</td><td rowspan="4">**Performance Standards developed during Phase 1. See appropriate paragraphs.**</td></tr>
<tr><td>Normal Departure /Abort with External Load[5]</td><td>C, D</td><td>44</td></tr>
<tr><td>Lateral Reposition with Internal Load[5]</td><td>A, B</td><td>45</td></tr>
<tr><td>Lateral Reposition with External Load[5]</td><td>C, D</td><td>46</td></tr>
</table>

Notes:

[1]Automatic Flight Control System (AFCS) will be configured as follows unless otherwise noted: SAS1, SAS2, TRIM, FPS, Boost: ON STAB: ON

[2]Configurations: A = no ballast, 13,500 lb gross weight (approximate average)
B = internal ballast, 18,000 lb gross weight (approximate average)
C = 4,000 lb external load, 18,000 lb gross weight (approximate average)
D = no ballast, 6,000 lb external load, 19,000 lb gross weight (approximate average)
center of gravity _______ - ________ inch (   )

[3]Winds: Calm < 5 knots, moderate 10-20 knots

[4]Conditions: Good visual environment only (Day, VFR)

[5]Additional maneuvers developed for the utility missions; descriptions presented in paragraphs 37-46.

[6]Performance standards and descriptions IAW ADS-33D except as modified during Phase 1; minimum safe altitude: 700 feet AGL for all forward flight maneuvers

Table D-2 Hover Test and Test Conditions

Test	Axis	Requirement	ADS-33D Paragraph	Configurations[2]	Test Techniques/ Control Inputs	Remarks
Attitude Bandwidth	Pitch Roll Yaw	Bandwidth Phase Delay	3.3.2.1 3.3.5.1	A, B	Frequency Sweeps	Input frequency range approximately 0.1-2 Hz; control amplitude approximately ± 1 inch about trim
Attitude Response		Damping Ratio	3.3.2.2 3.3.5.2		Pulse Inputs	Pulse amplitude approximately 1 inch about trim
		Peak rate to Peak attitude	3.3.3 3.3.6		Pulse/Step Inputs	Inputs increased in 1/2 inch increments
		Achievable Rate	3.3.4 3.3.8		Step Inputs	Step inputs increased in increments of 1/4 inch. Maximum input when steady rate achieved or attitude limit reached. Attitude limits: ±20˚ pitch/±30˚ roll. Control fixtures used for step inputs.
Inner-Axis Coupling	Pitch Roll	Pitch/Roll Roll/Pitch Coupling	3.3.9.2			
	Collective	Collective to yaw coupling	3.3.9.1			
Response to Controller		Height Response	3.3.10.1			
		Torque Response	3.3.10.2			
Vertical Axis Control Power		Achievable Rate	3.3.10.3			
Engine-Governing Response Characteristics	– –	Rotor Governing	3.3.10.4		Rotor speed Control inputs	Rotor speed increased and decreased using collective mounted rotor trim control.

Notes:
[1]Automatic Flight Control System (AFCS) will be configured as follows unless otherwise noted: SAS1, SAS2, TRIM, Boost: ON; STAB: ON; FPS: ON or OFF
[2]Configurations: A = no ballast, 13,500 lb gross weight (approximate average)
B = internal ballast, 17,000 lb gross weight (approximate average)
C = 4,000 lb external load, 17,000 lb gross weight (approximate average
D = no ballast, 6,000 lb external load, 19,000 lb gross weight (approximate average)
center of gravity 348-360 inches (mid to aft)

Table D-3 Forward Flight Tests and Test Conditions

Test	Axis	Requirement	Airspeed (KIAS)	ADS-33D Paragraph	Configurations[2]	Test Techniques	Remarks[4]
Attitude Bandwidth	Pitch Roll Yaw	Bandwidth phase delay		3.4.1.1 3.4.5.1 3.4.7.1		Frequency Sweeps	Sweep range 0.1 - 2.0 Hz, amplitude approximately ±1/2 inch
Pitch Attitude Response	Pitch	Damping Ratio	60,120	3.4.1.2		Pulse inputs	Pulse amplitude=1 inch
Lateral-Directional Dynamic Stability	Yaw	Damping ratio and frequency		3.4.1.2		Doublet inputs	Doublet amplitude ± 1 inch
Maneuvering Stability		Achieve "g" limit		3.4.1.3(a)		Steady turns, pull-ups, and pushovers	0 - 2 "g" limit; angle of bank limit: 60 degrees
Pitch Control Power	**Pitch**	Steady load factor maintain altitude	45-V_H[3]	3.4.2		MCP acceleration from 45 knots - minimum power deceleration from V_H[3]	Power limited to 95% of maximum continuous power; Level 2 handling quality
Lateral-Directional Static Stability	Roll Yaw	Pedal force and pedal position/sideslip		3.4.9.1		Steady heading sideslip	**Maximum sideslip: ±30 ˚ at 60 KIAS,** ±15˚ at 120 KIAS
		Bank angle/sideslip		3.4.9.2			
		Lateral cyclic force pedal position/sideslip		3.4.9.3	A, B		
Roll Attitude Response	**Roll**	Peak rate to peak attitude change		3.4.5.2		**Step inputs**	**Step inputs increased in increments of 1/2 inch, maximum input attained when steady rate achieved or attitude limit reached.** **Attitude limits:** **60 KIAS 120 KIAS** **Pitch ±30° ±30°** **Roll ±60° ±60°** **Sideslip ±30° ±15°** **Control fixture will be used for step inputs.**
		Achievable rate		3.4.5.3			
Roll Sideslip Coupling	Roll Yaw	Roll/sideslip coupling	60,120	3.4.6.1/ 3.4.6.2		Pulse inputs	
Spiral Stability	Roll	Controls free		3.4.8.2			
Inter-Axis Coupling	Pitch Roll	Pitch/Roll Roll/Pitch coupling		3.4.4.2		**Step inputs**	
	Collective	Collective /Pitch Coupling		3.4.4.1.1 3.4.4.1.2			
Yaw Response	Yaw	Large Amplitude Heading Changes		3.4.7.2			Do not exceed sideslip limit. 1/4 inch increments using a fixture.
Yaw Response	Yaw	Yaw Control with Speed Change		3.4.7.4		Speed change with constant power/altitude	Pedal forces determined via displacements

Notes:

[1]Automatic Flight Control System (AFCS) will be configured as follows unless otherwise noted: SAS1, SAS2, TRIM, Boost: ON; STAB: ON; FPS: ON or OFF

[2]Configurations: A = no ballast, 13,500 lb gross weight (approximate average)
B = internal ballast, 18,000 lb gross weight (approximate average)
C = 4,000 lb external load, 18,000 lb gross weight (approximate average)
D = no ballast, 6,000 lb external load, 19,000 lb gross weight (approximate average)
center of gravity _______ - ________ inches. (   )

[3]V_H: Maximum airspeed in level flight

[4]Flights conducted between 1000 and 3000 feet PA; chase aircraft required; minimum safe altitude: 700 feet AGL.

Appendix E. Test Data

This Appendix provides a sample of test data collected during the assessment of ADS-33D-PRF using a UH-60A Black Hawk. The data presented covers both the quantitative and the qualitative assessments.

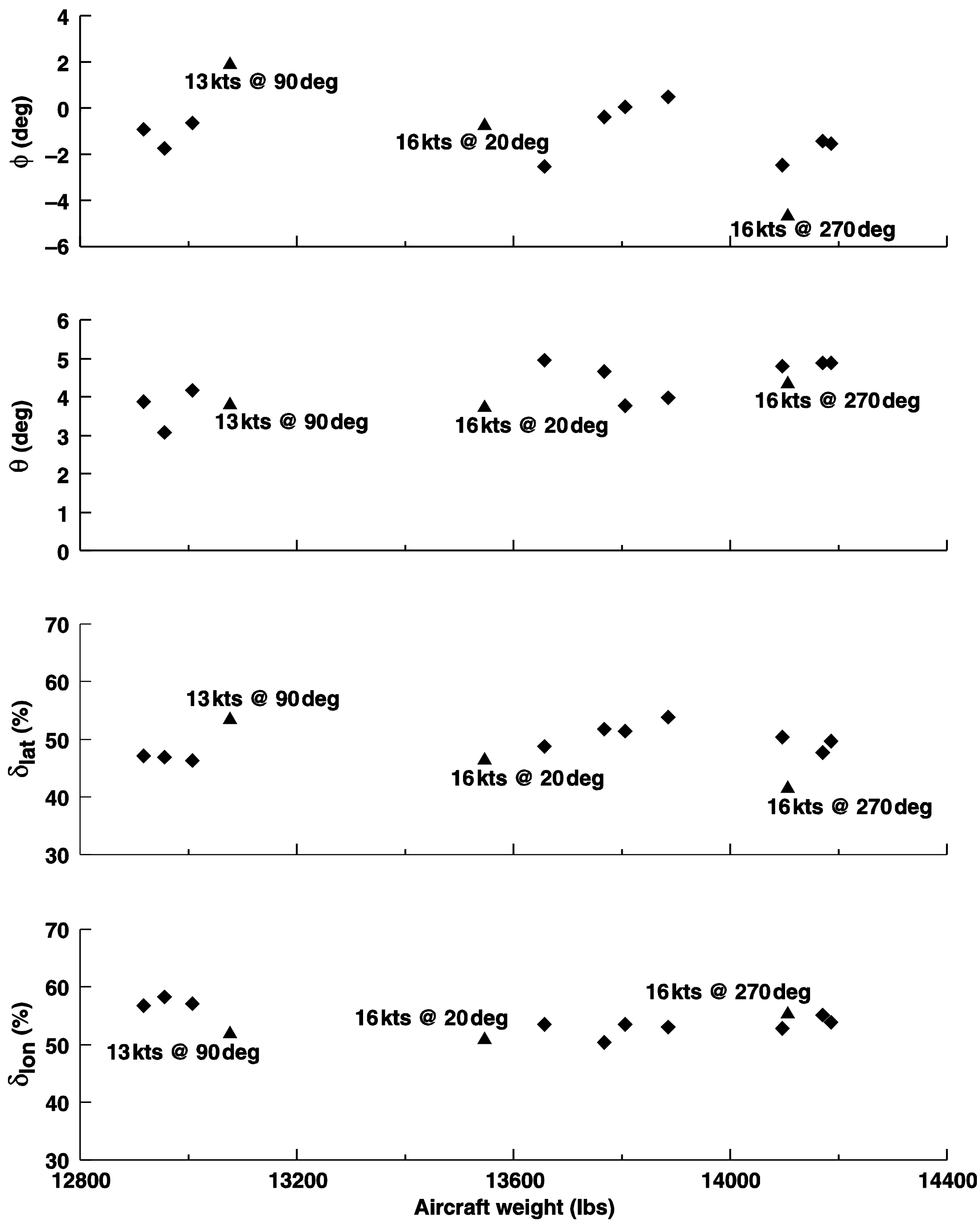


Figure E-1 Trim Attitude and Cyclic Stick Position, Configuration A, Hover

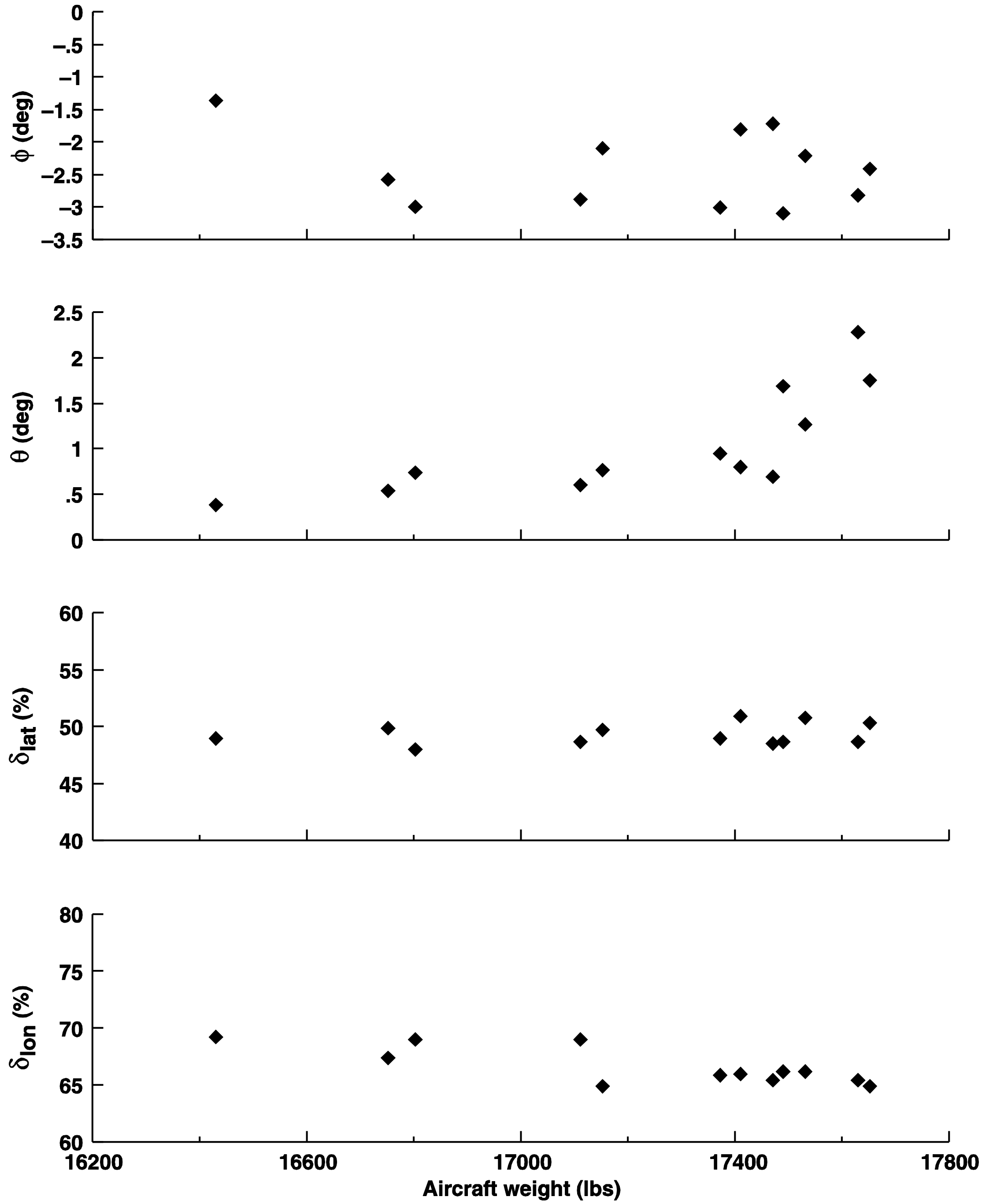


Figure E-2 Trim Attitude and Cyclic Stick Position, Configuration B, Hover

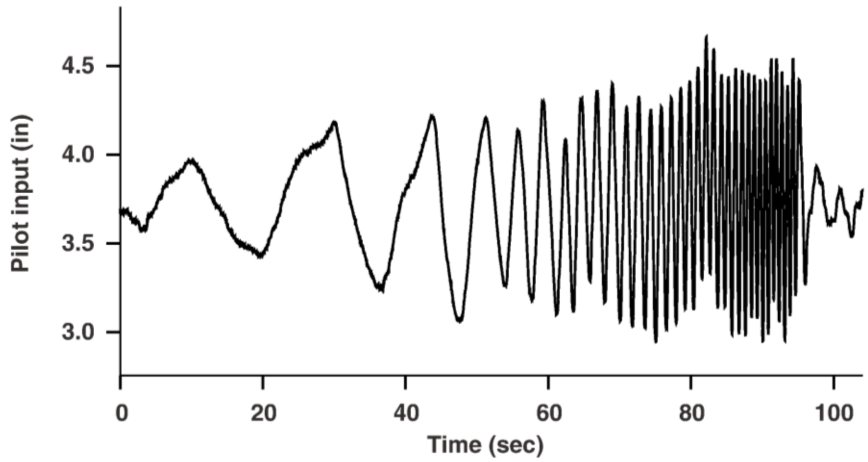


Figure E-3 Time History of Typical Frequency Sweep

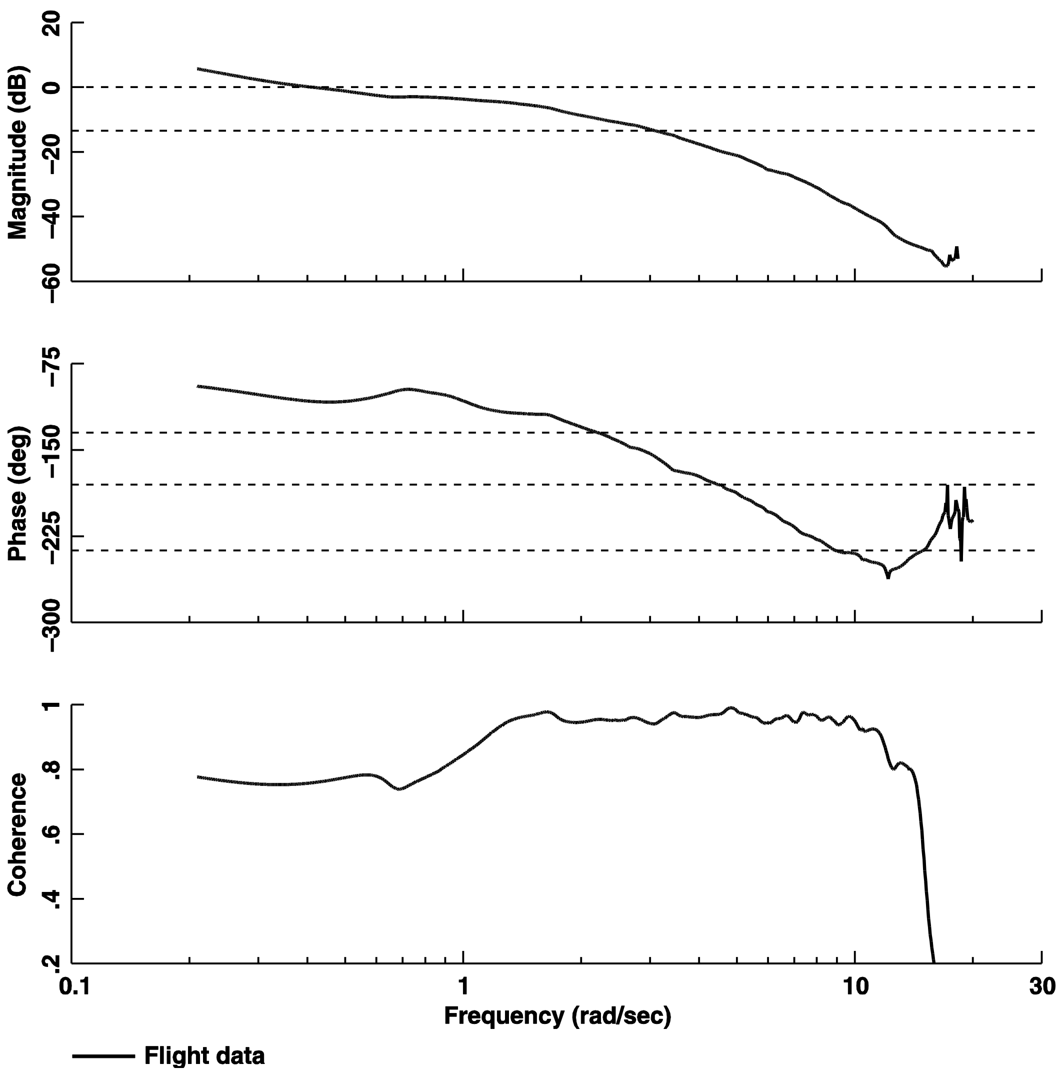


Figure E-4 3.3.2 Pitch Bode

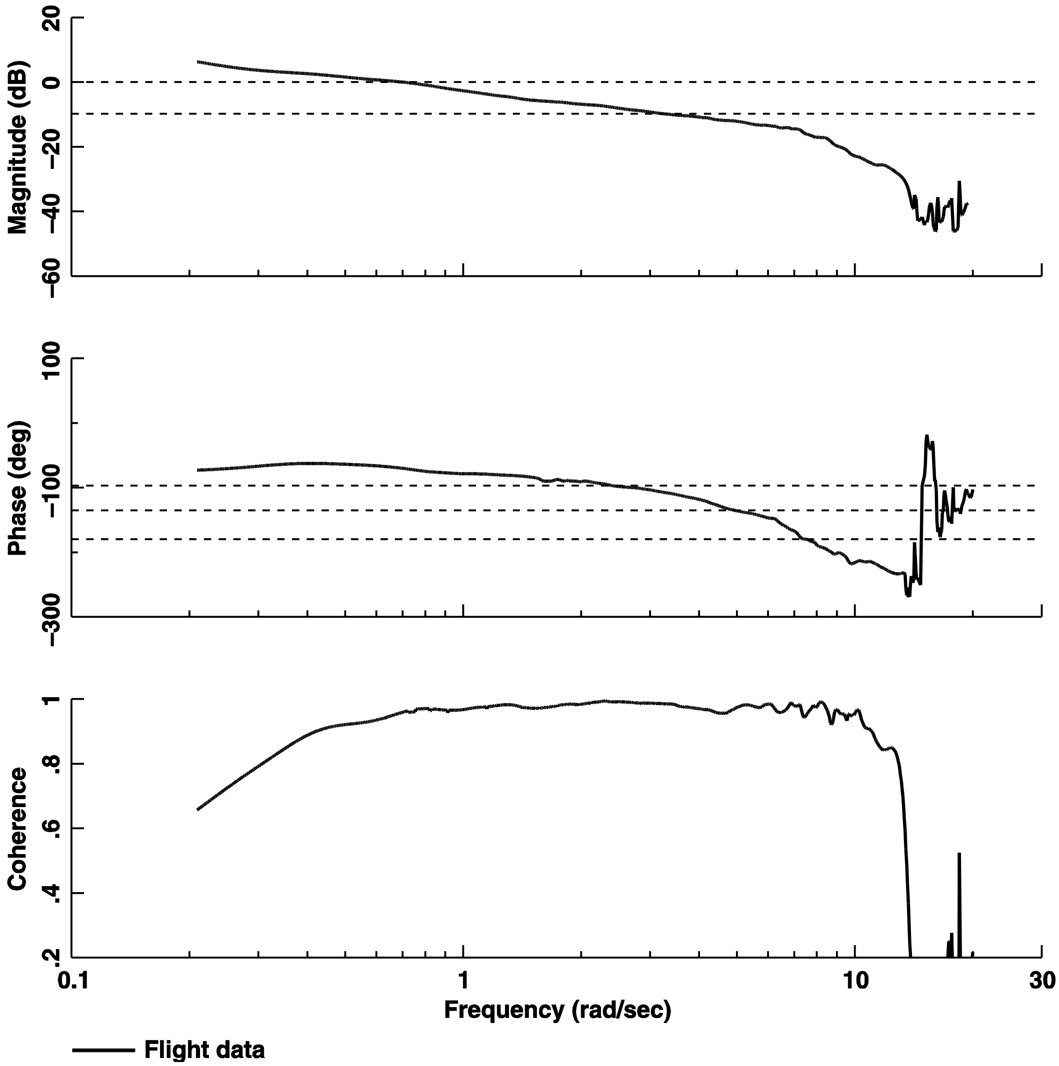


Figure E-5 3.3.2 Roll Bode

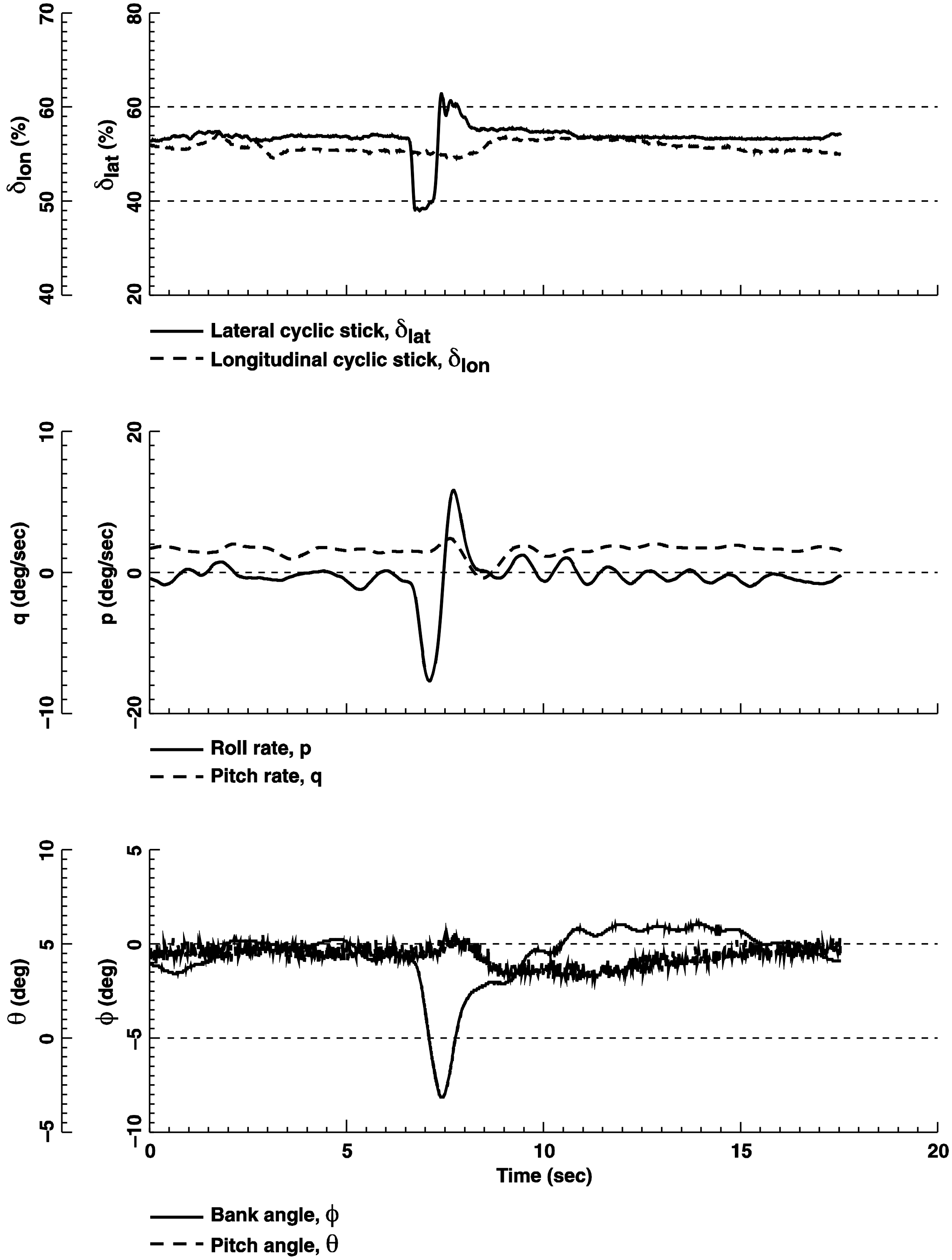


Figure E-6 Lat Pulse, Left, Hover, Flt 189 Rec 31, 3.3.2.3

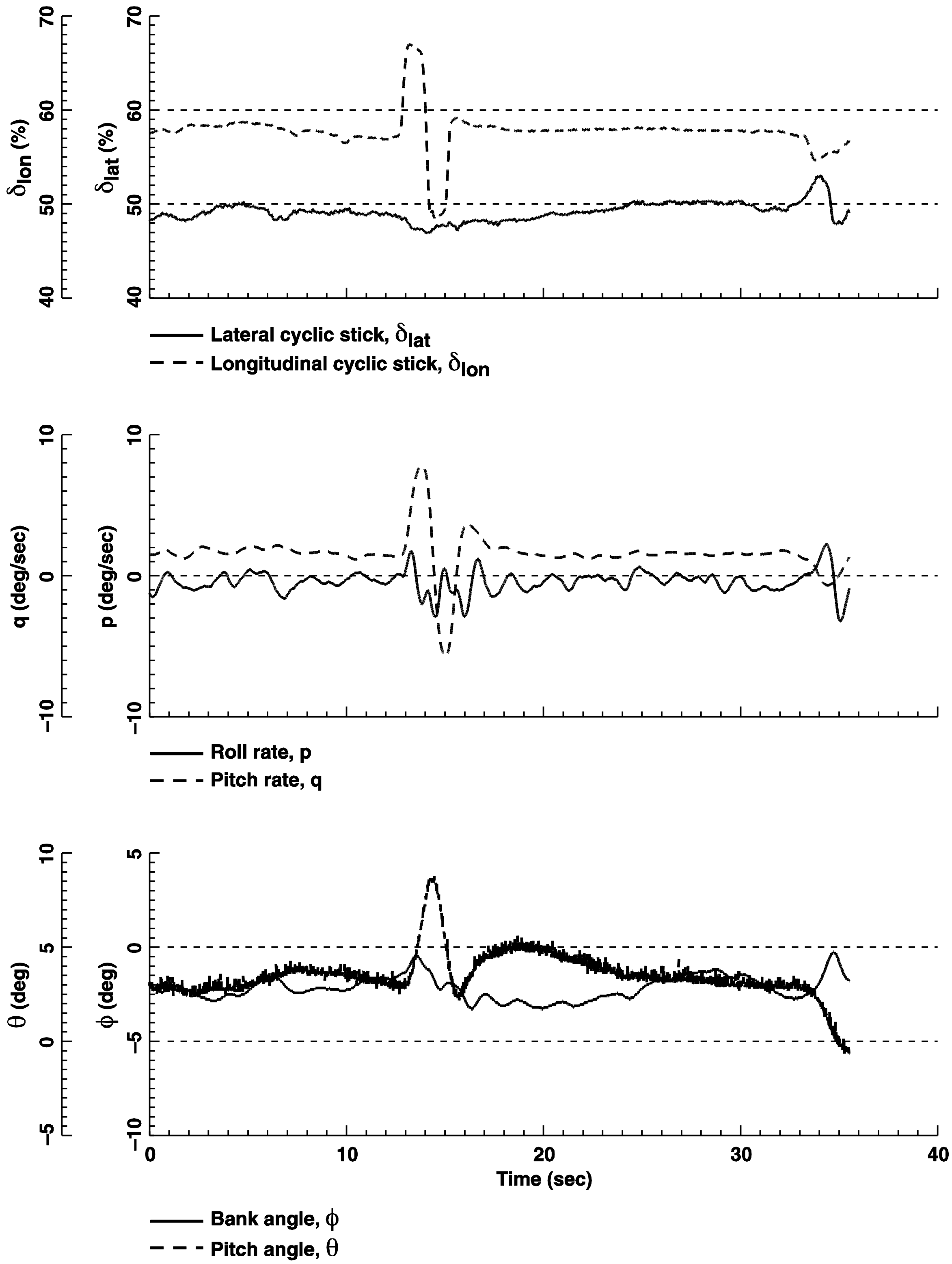


Figure E-7 Lon Doublet, Aft, Hover, Flt 189 Rec 36, 3.3.2.3

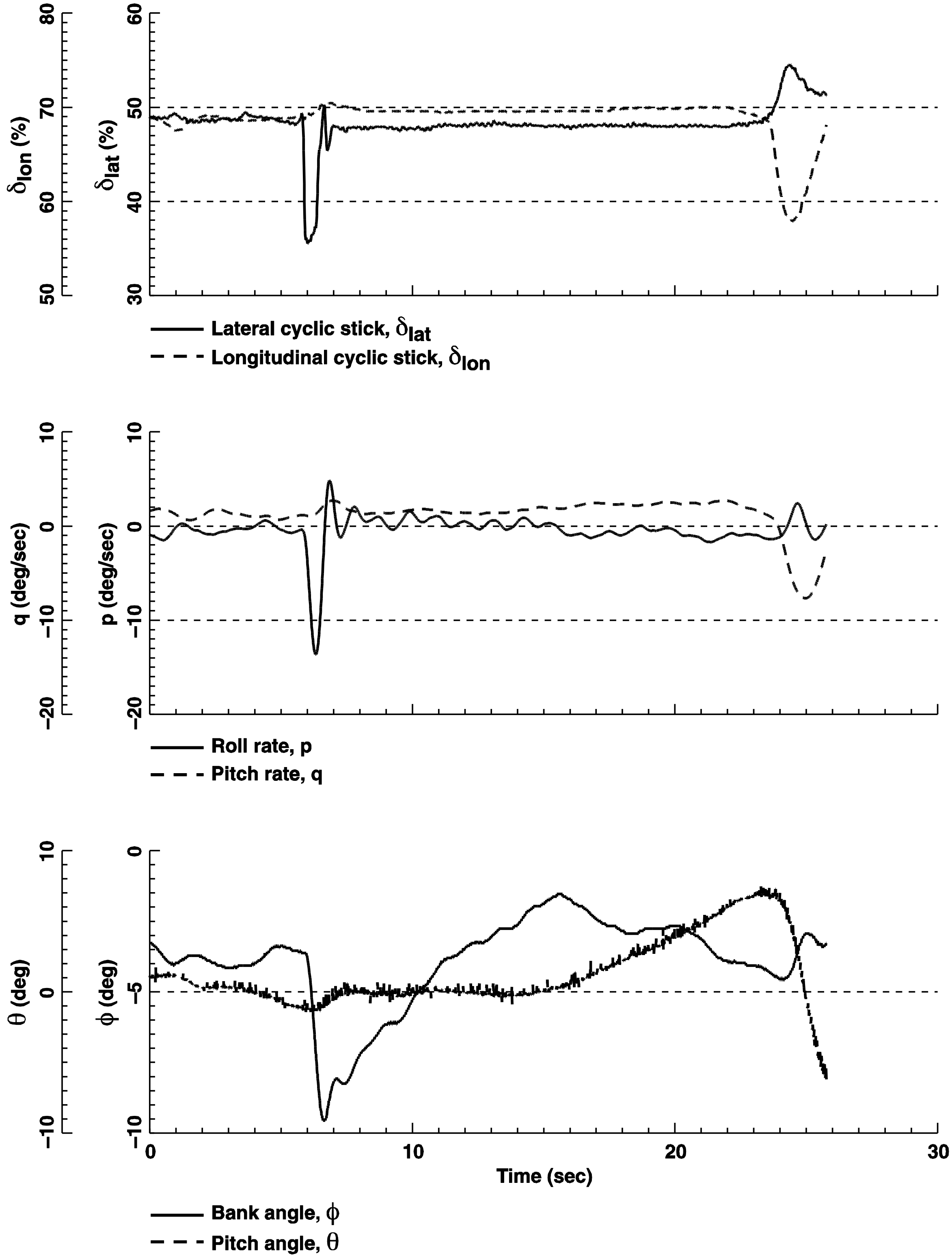


Figure E-8 Lat Pulse, Left, Hover, Flt 211 Rec 37, 3.3.2.3

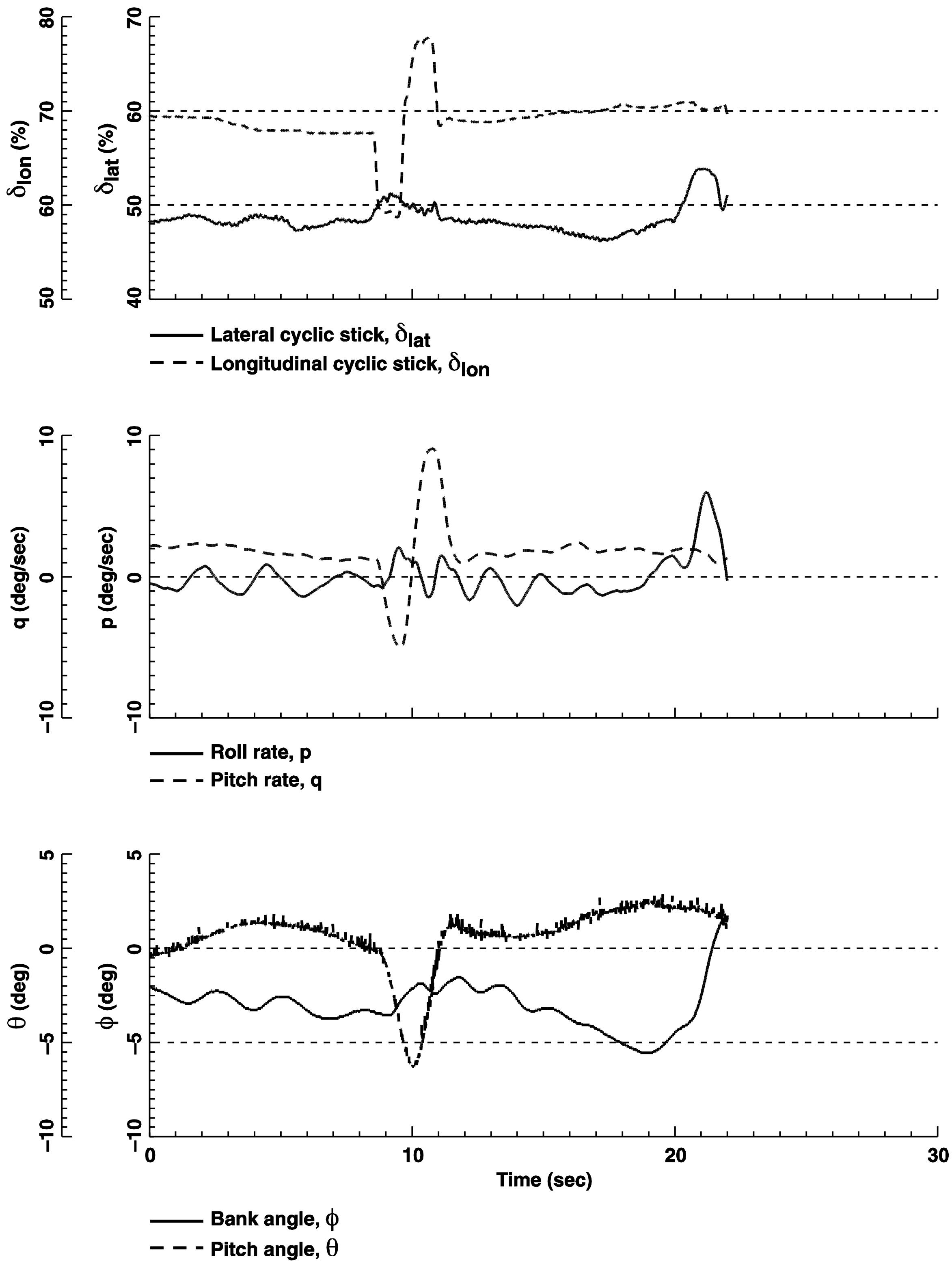
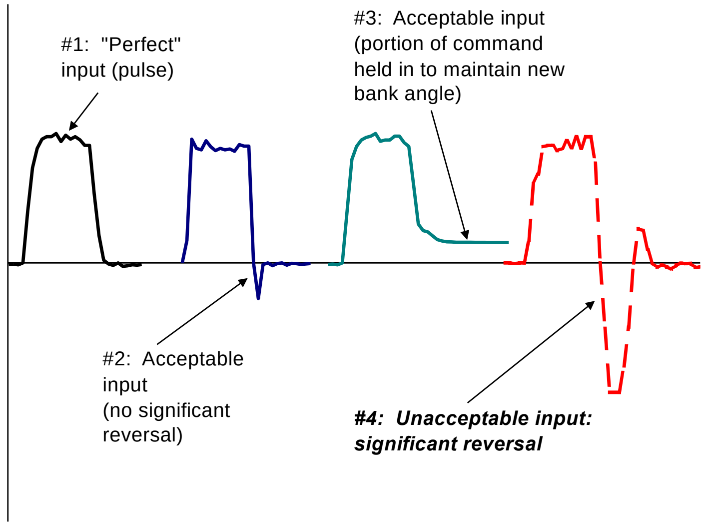
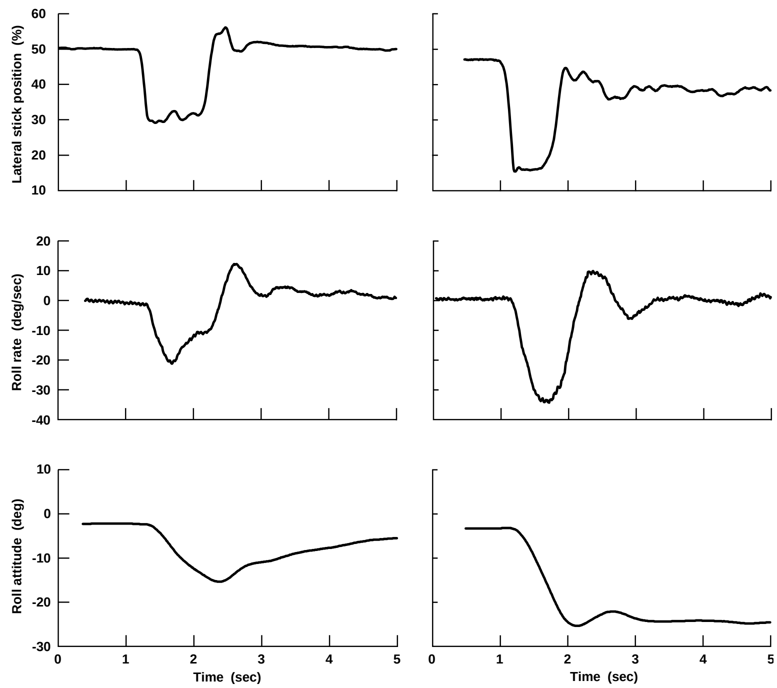


Figure E-9 Lon Doublet, Fwd, Hover, Flt 211 Rec 45, 3.3.2.3



a) Examples of lateral cyclic inputs for roll attitude quickness data. Input #3 was necessary for the UH-60A test to obtain good quickness data.



b) Time history example of initial control input and modified control input for attitude quickness data collection.

Figure E-10 3.3.3 AQ w/ initial and modified control inputs

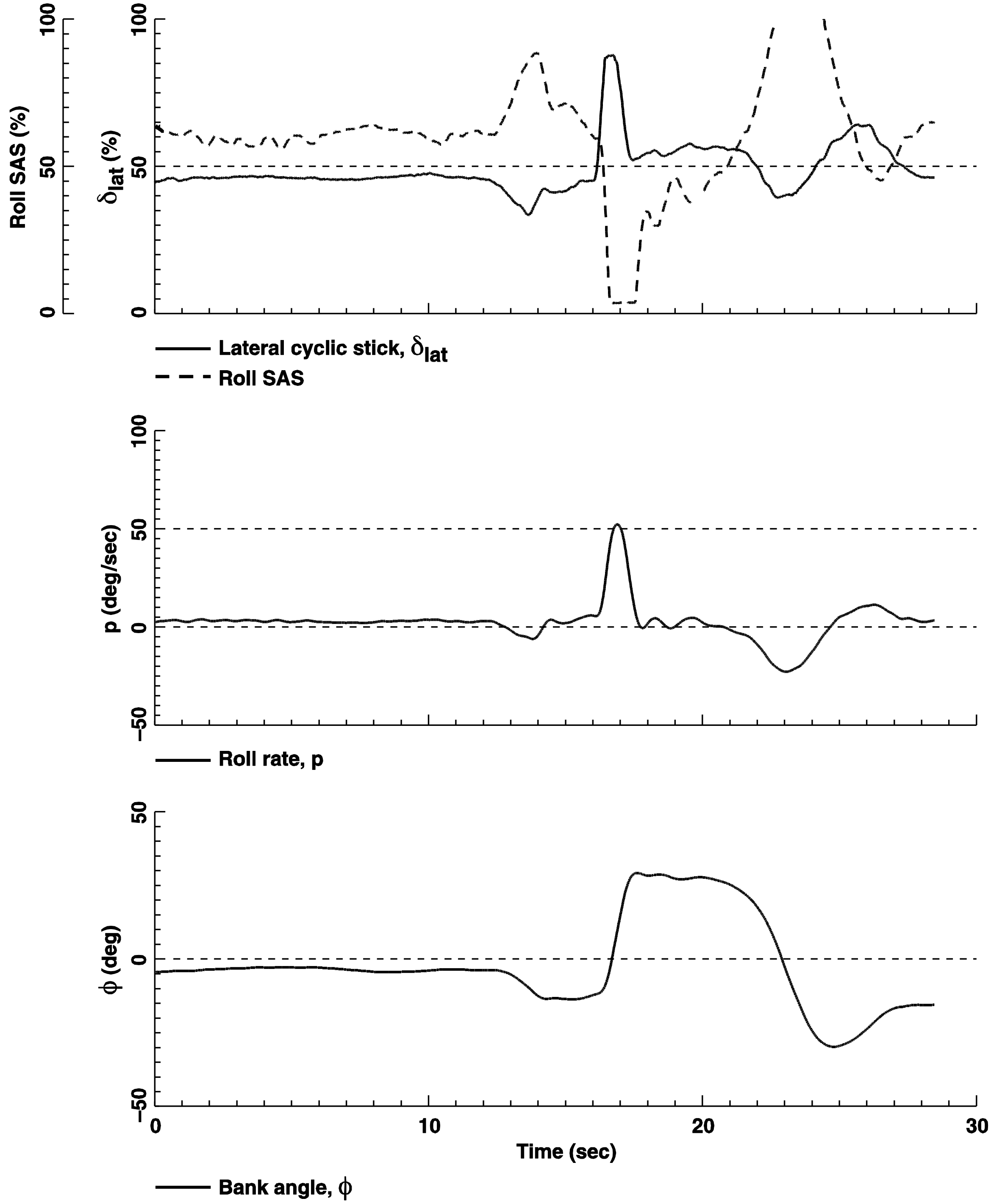


Figure E-11 Lat Pulse, Right, Hover, Flt 215 Rec 5, 3.3.3

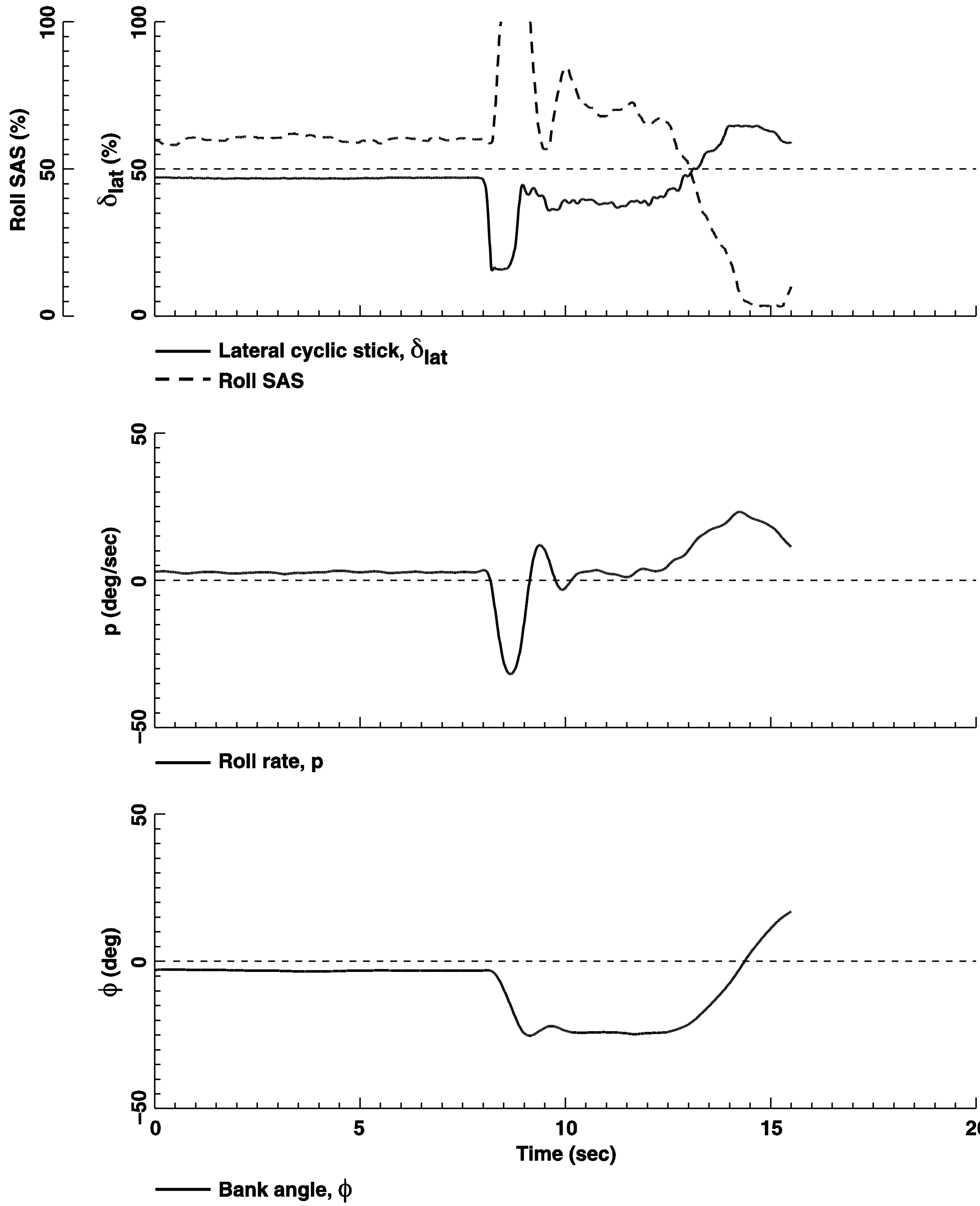


Figure E-12 Lat Pulse, Left, Hover, Flt 215 Rec 10, 3.3.3

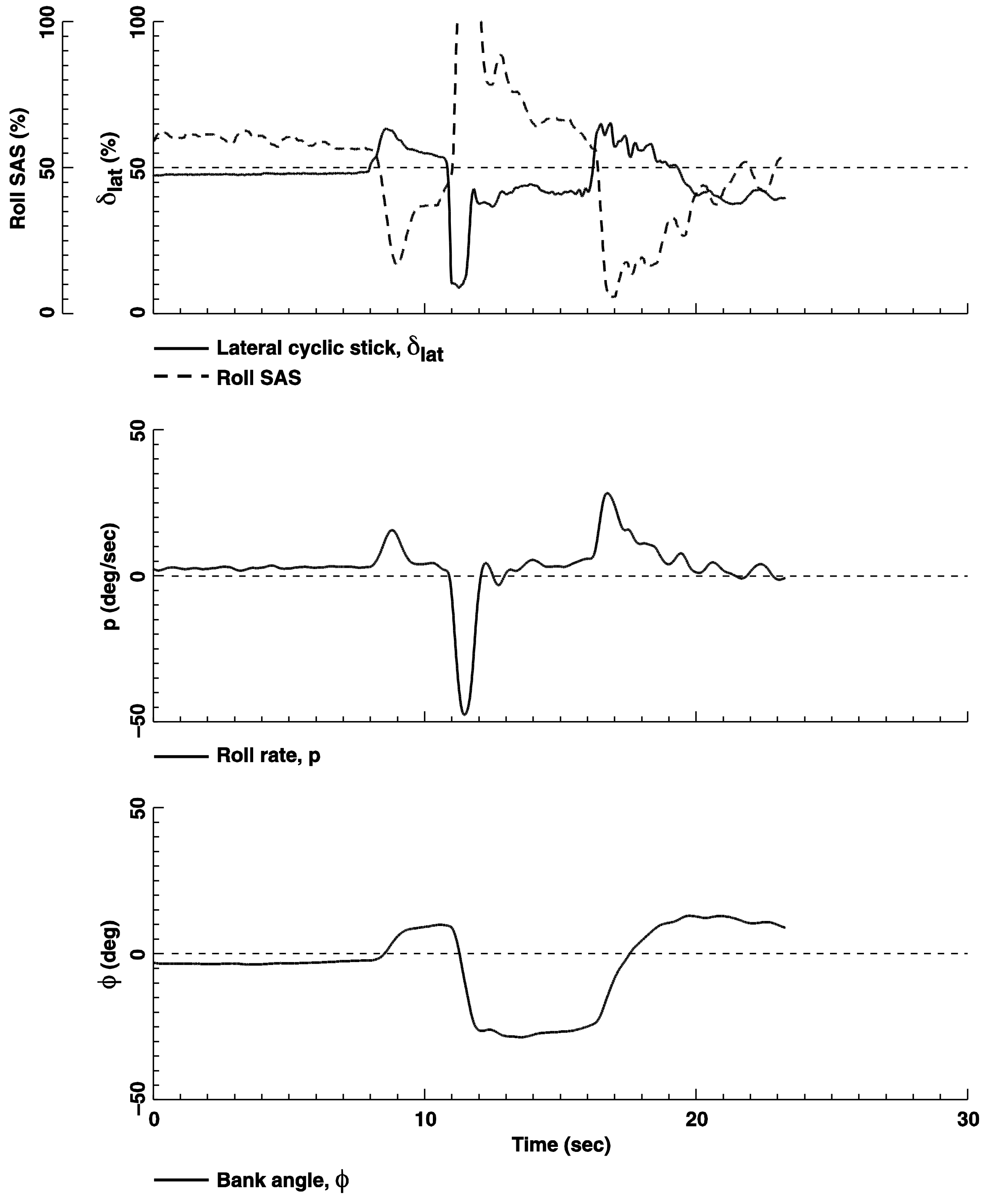


Figure E-13 Lat Pulse, Left, Hover, Flt 215 Rec 13, 3.3.3

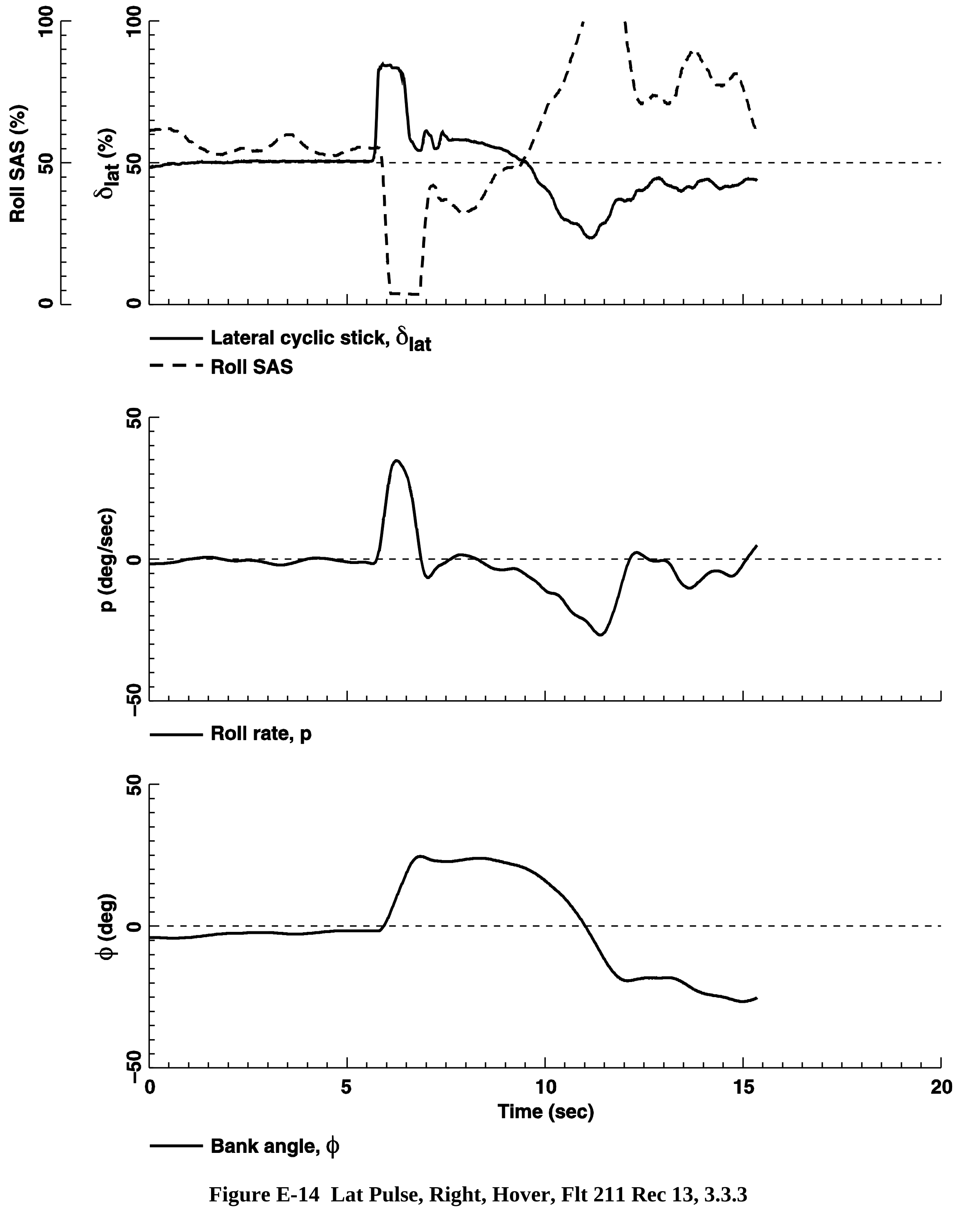


Figure E-14 Lat Pulse, Right, Hover, Flt 211 Rec 13, 3.3.3

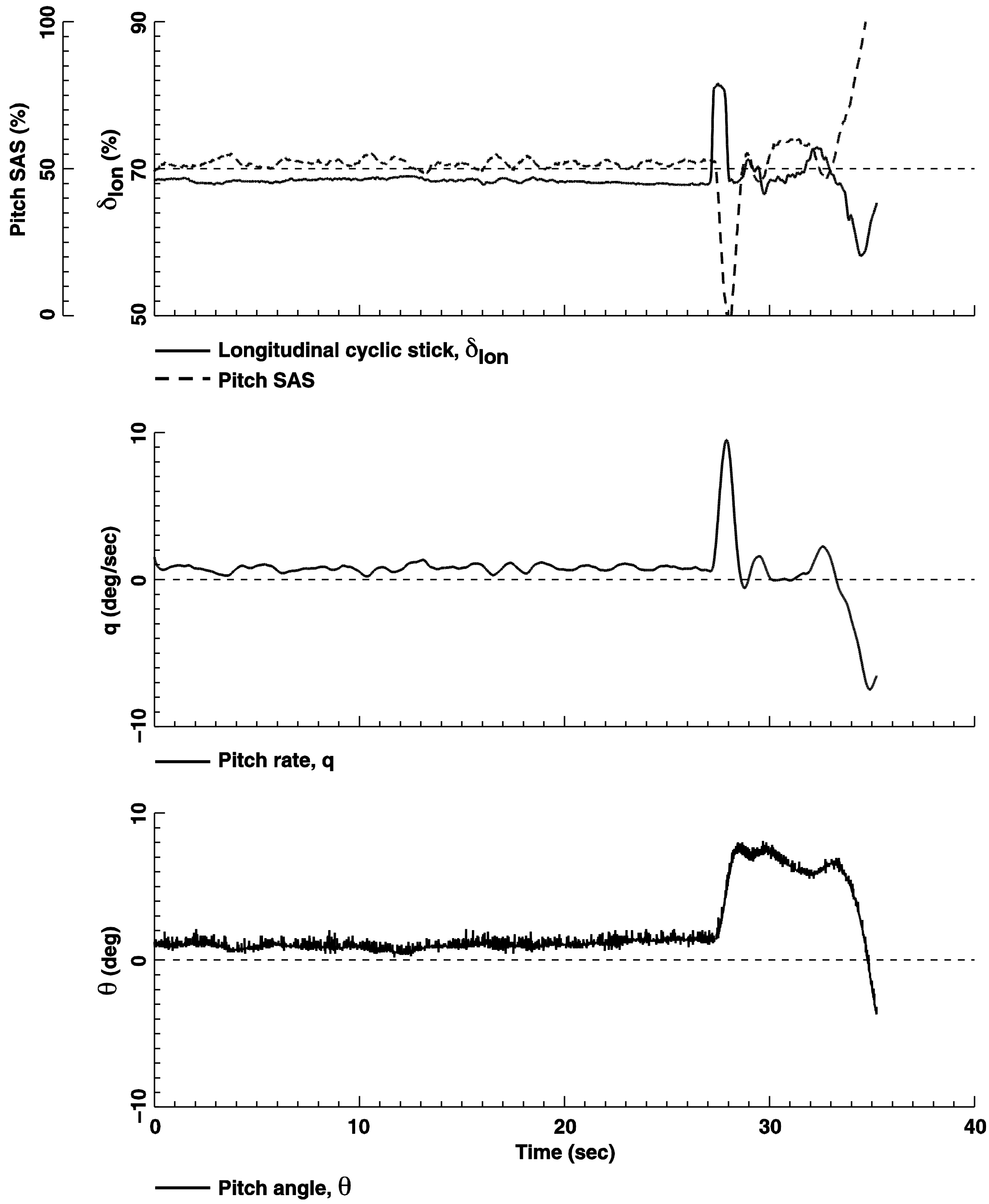


Figure E-15 Lon Pulse, Aft, Hover, Flt 215 Rec 15, 3.3.3

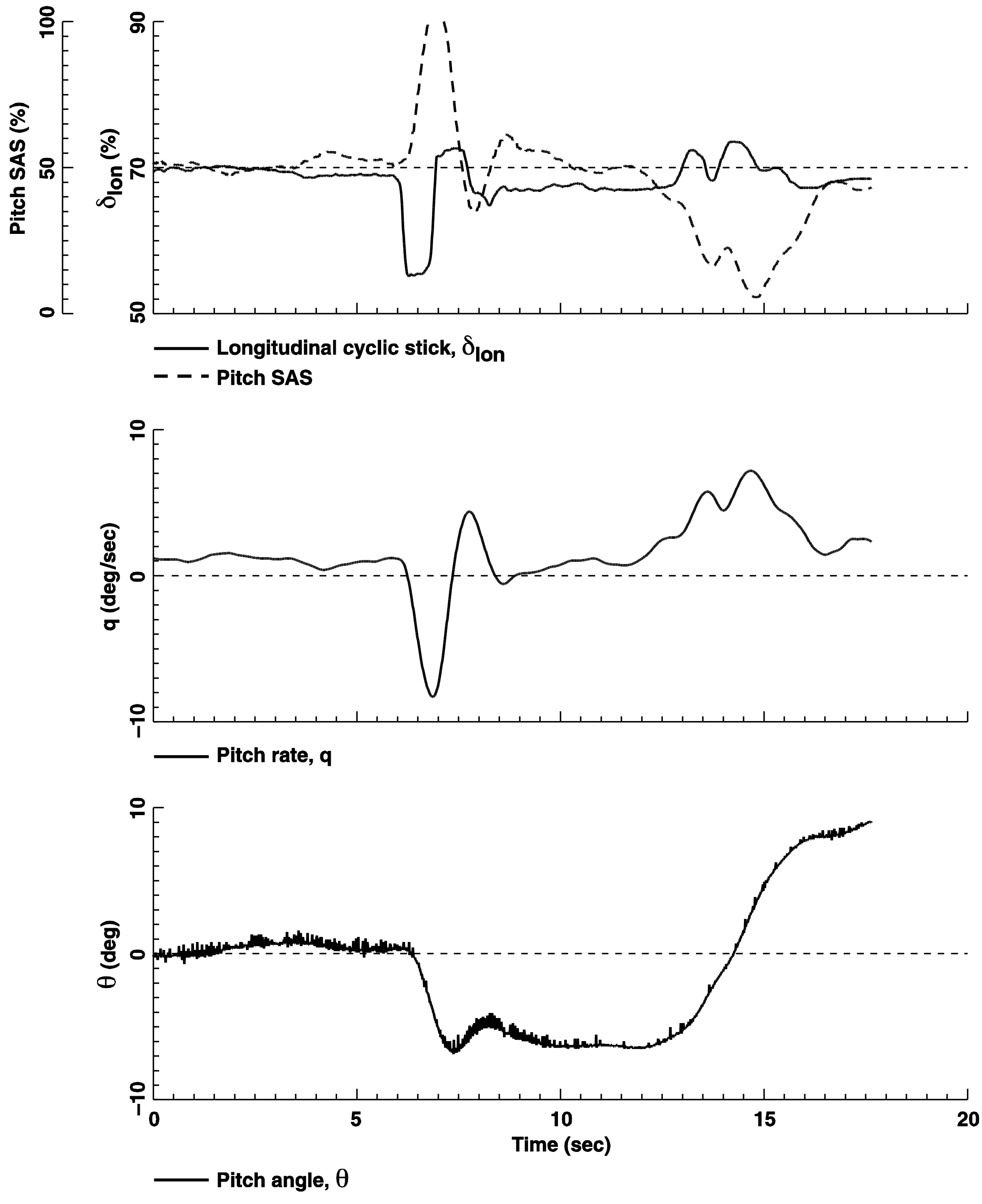


Figure E-16 Lon Pulse, Fwd, Hover, Flt 215 Rec 22, 3.3.3

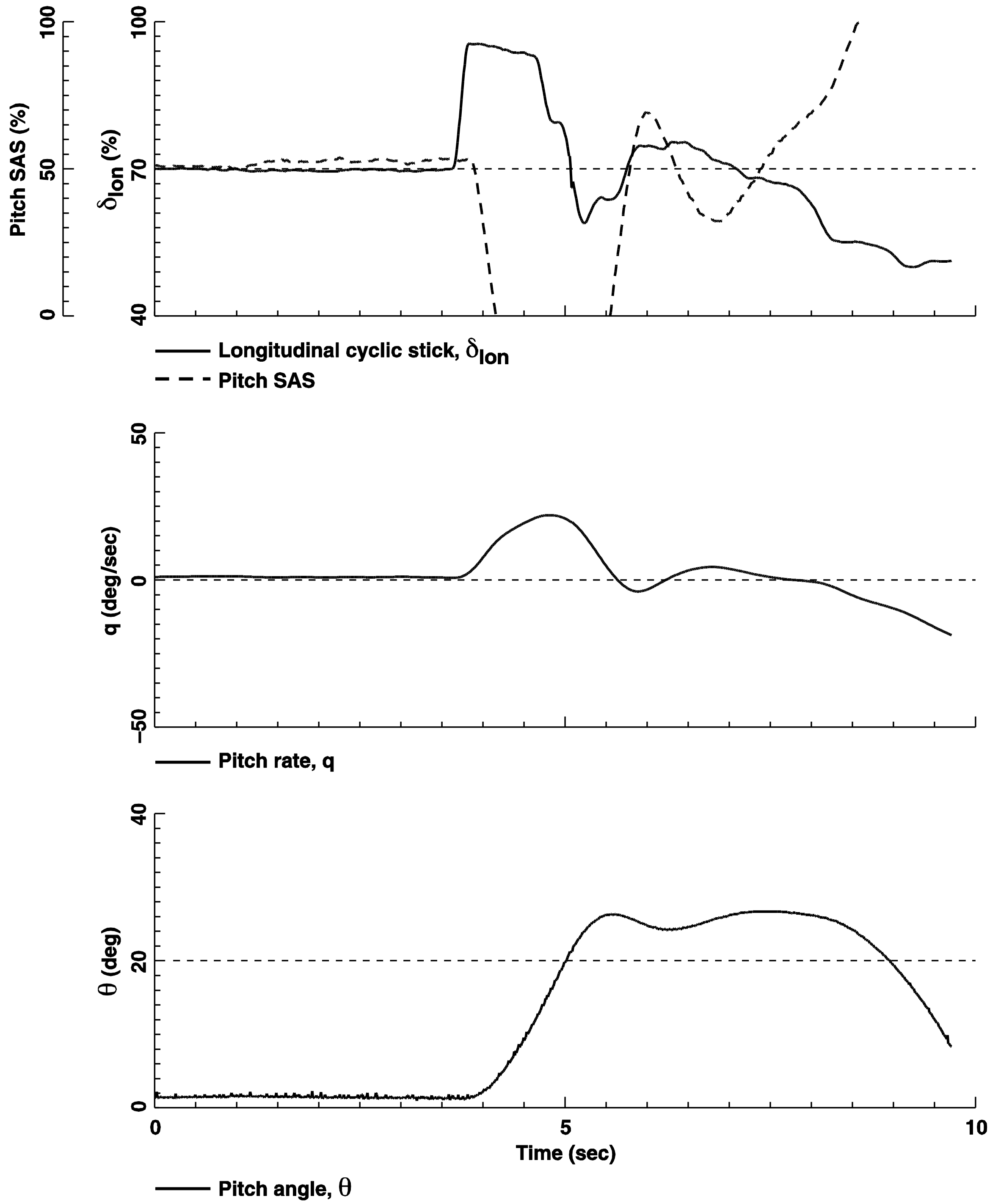


Figure E-17 Lon Pulse, Aft, Hover, Flt 215 Rec 21, 3.3.3

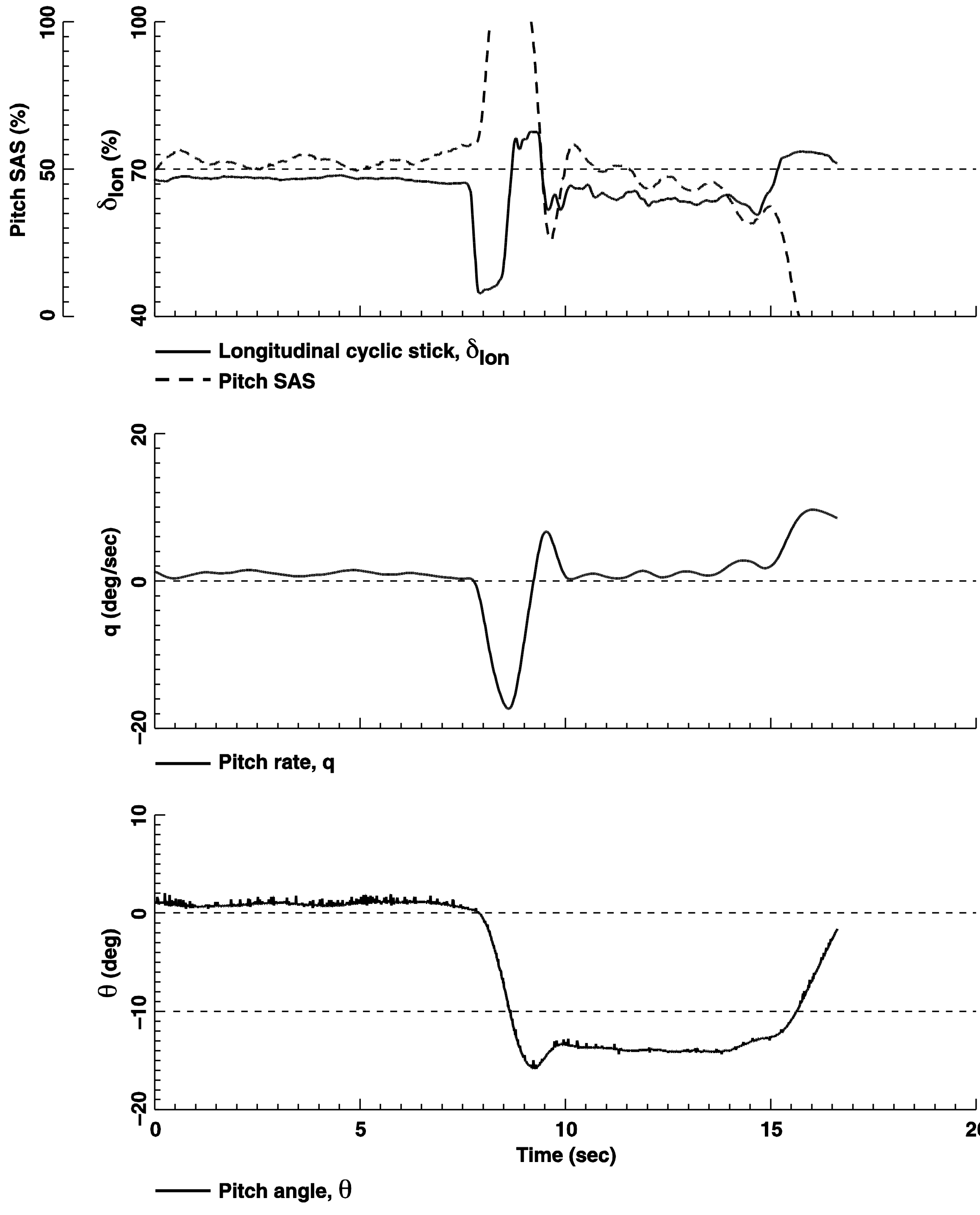


Figure E-18 Lon Pulse, Fwd, Hover, Flt 215 Rec 23, 3.3.3

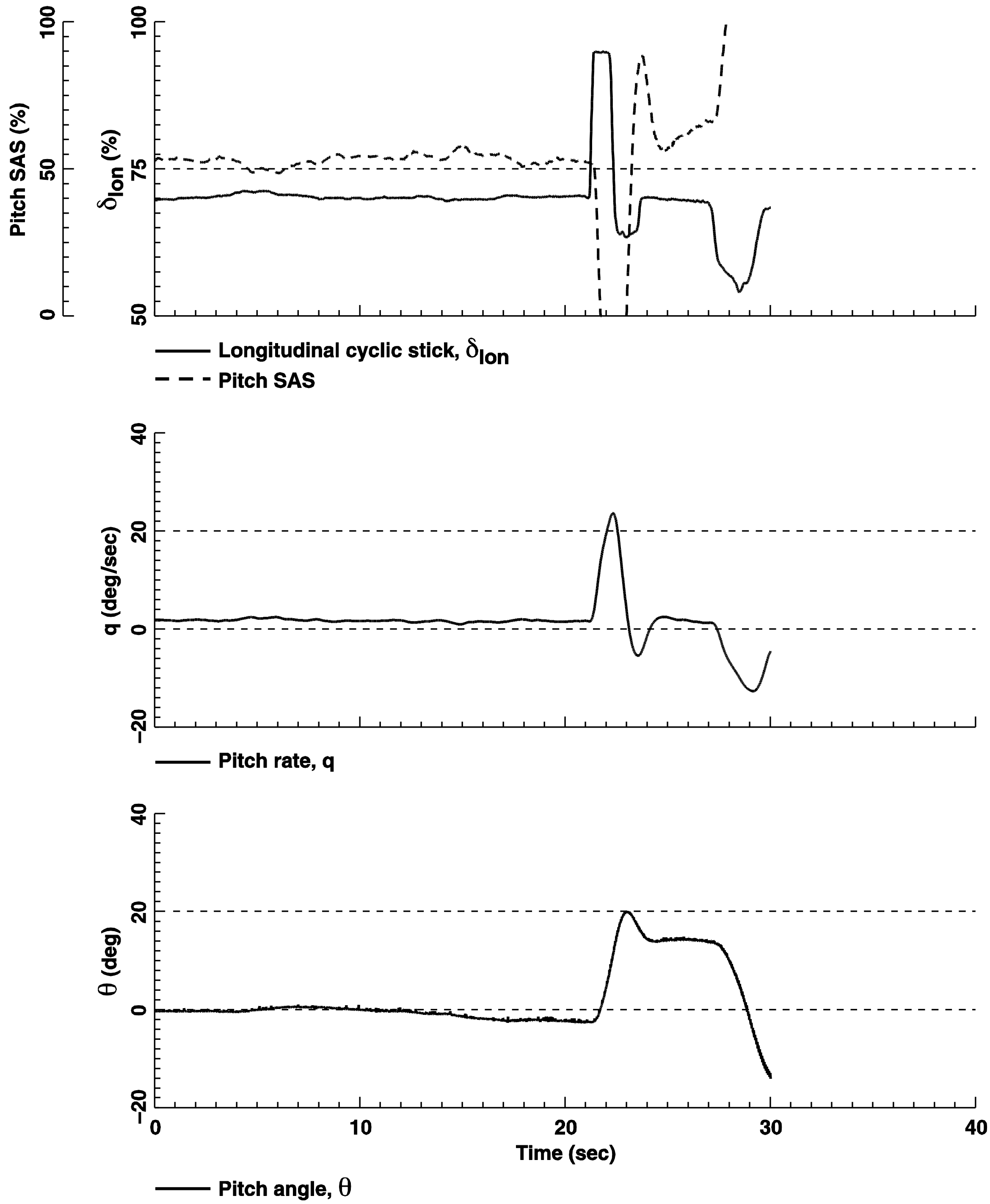


Figure E-19 Lon Pulse, Aft, Hover, Flt 211 Rec 54, 3.3.4 large amplitude

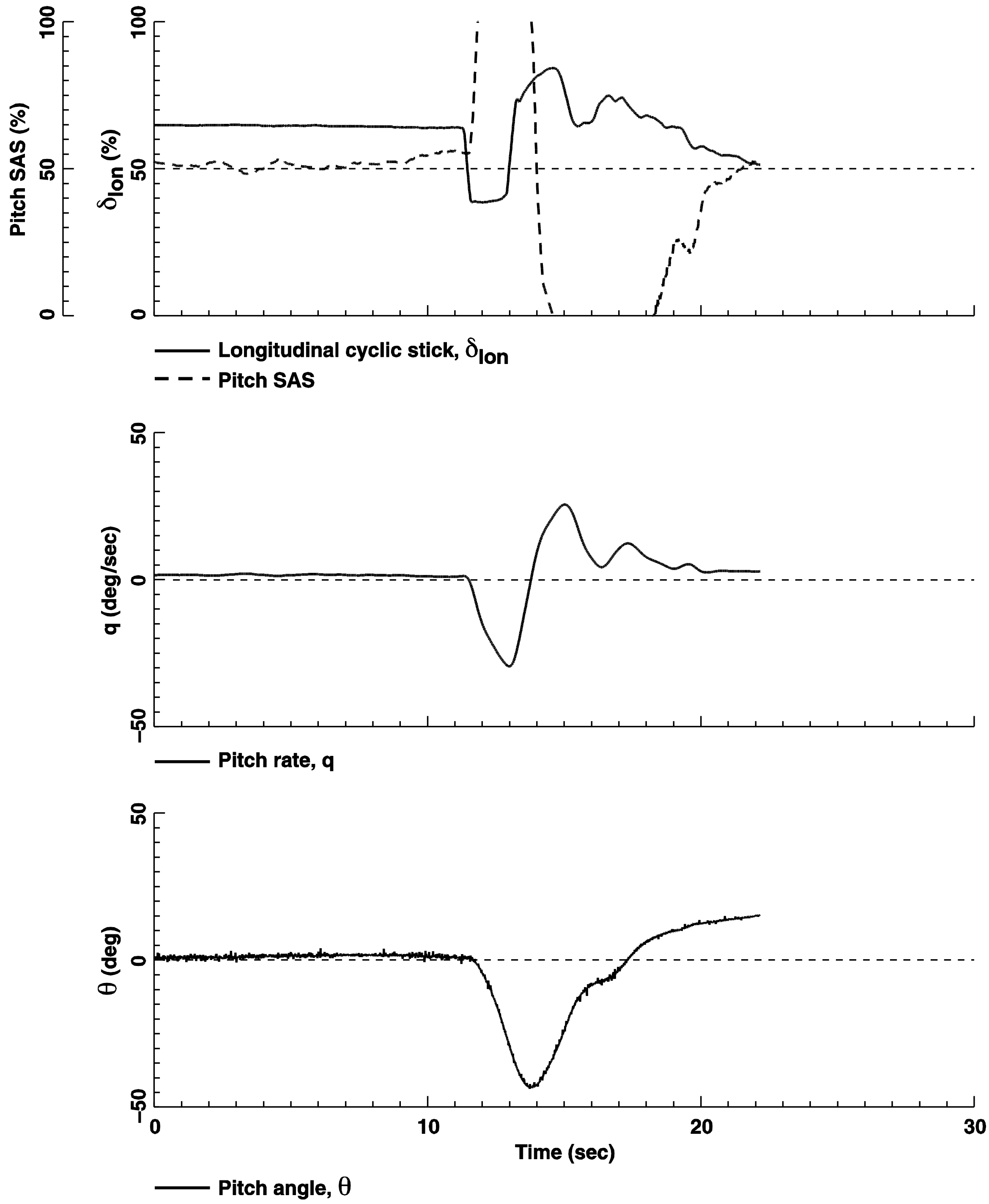


Figure E-20 Lon Step, Fwd, Hover, Flt 212 Rec 15, 3.3.4 large amplitude

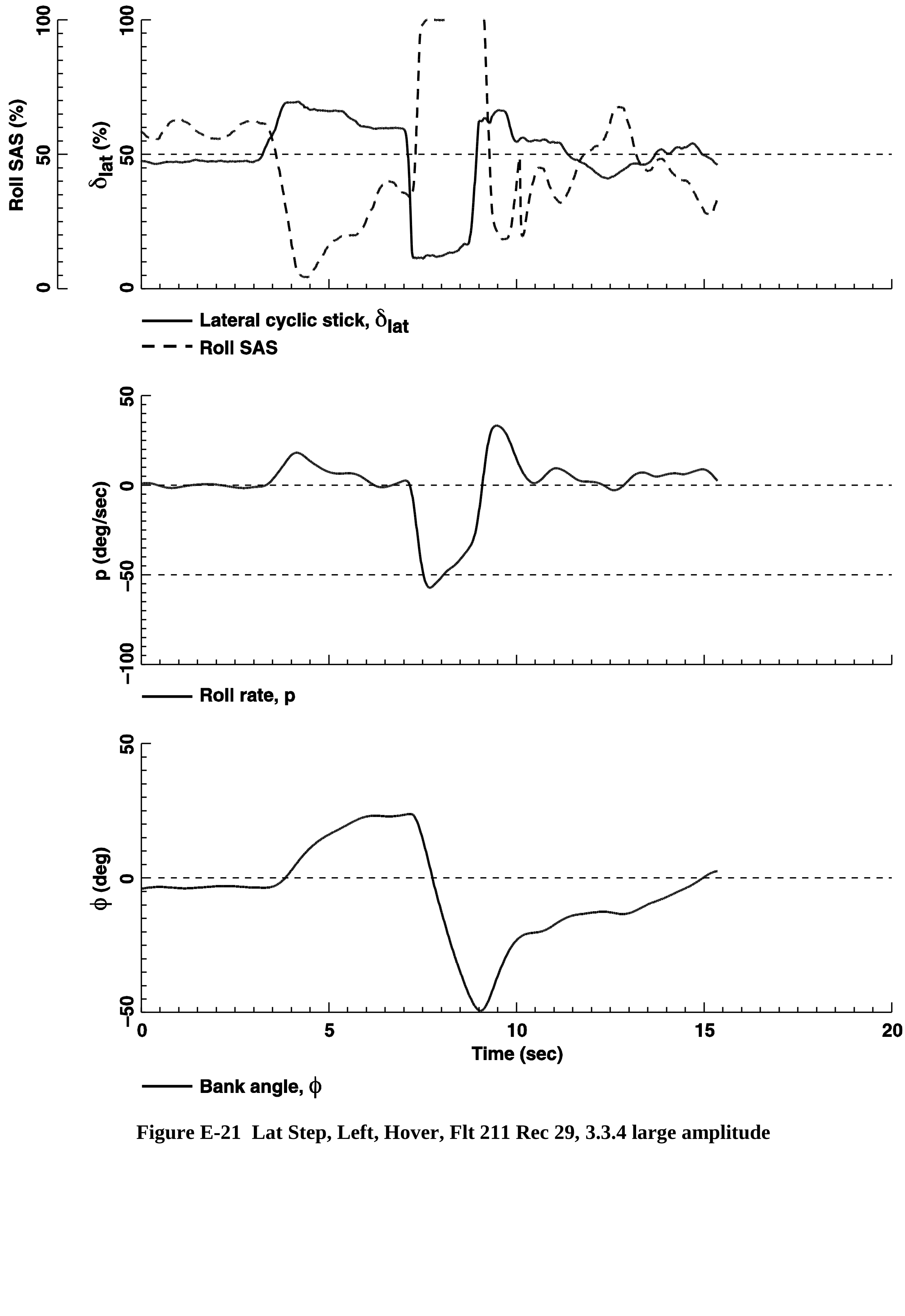


Figure E-21 Lat Step, Left, Hover, Flt 211 Rec 29, 3.3.4 large amplitude

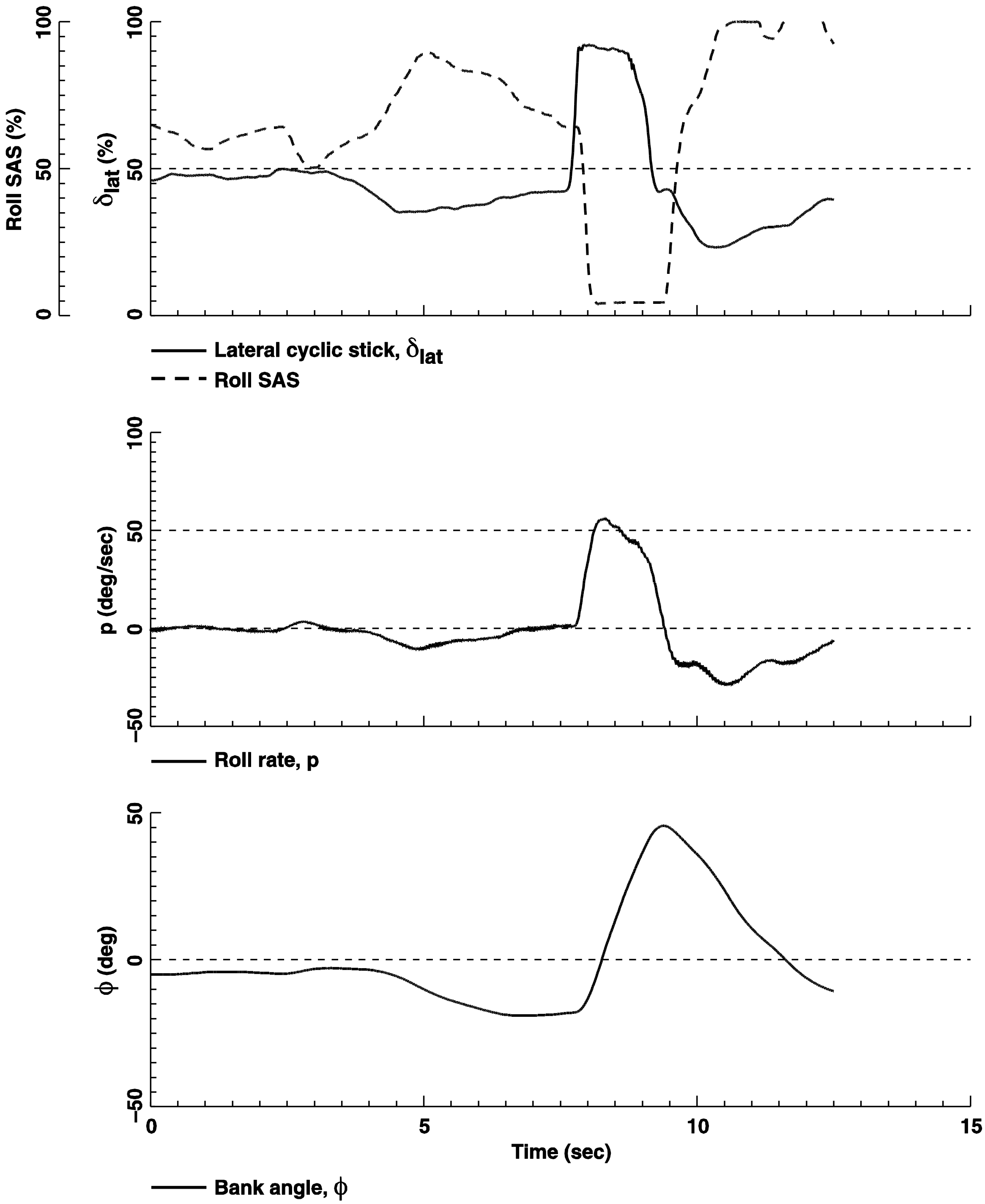


Figure E-22 Lat Step, Right, Hover, Flt 211 Rec 35, 3.3.4 large amplitude

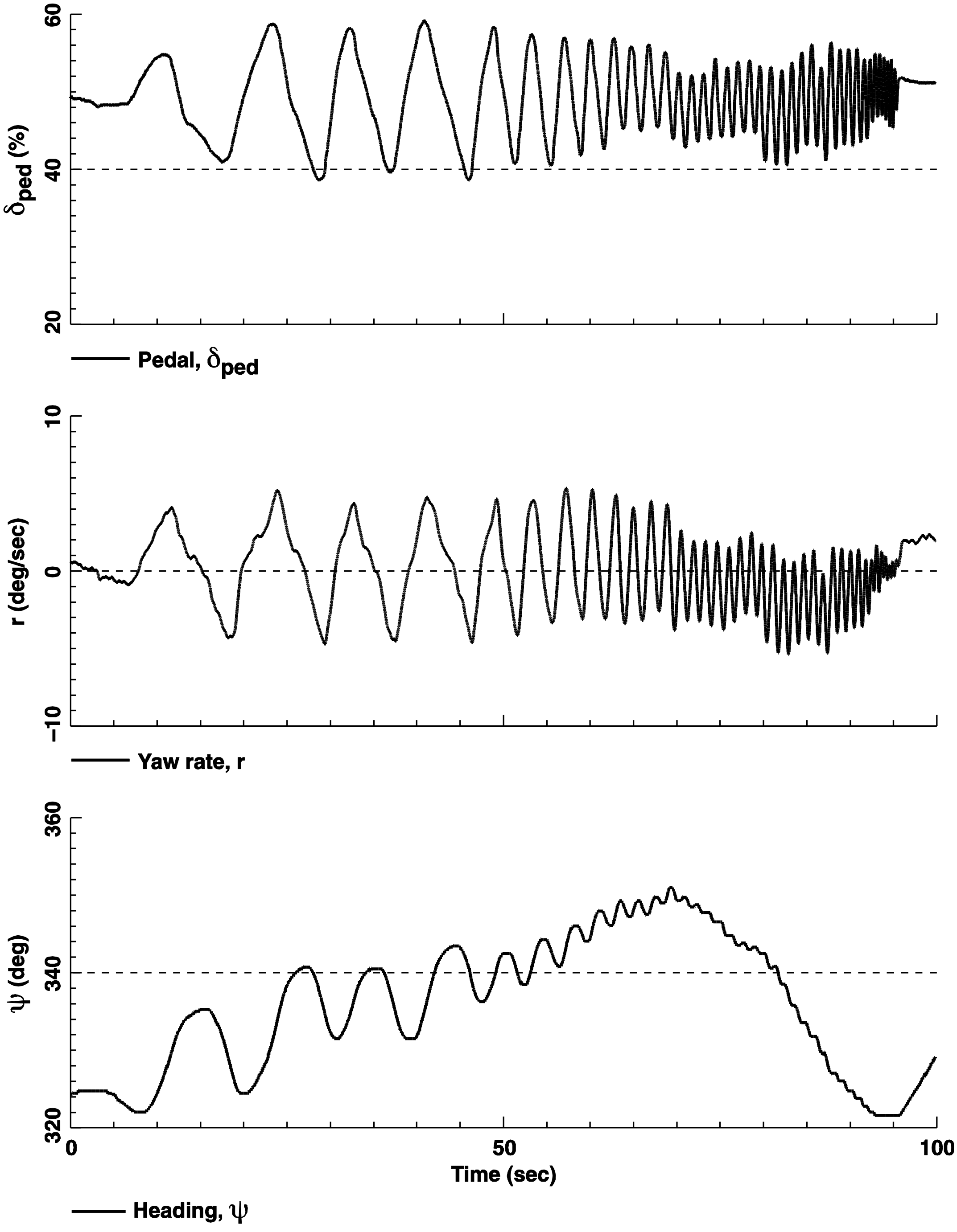


Figure E-23 Typical Pedal Frequency Sweep, Hover, Flt 212 Rec 24, 3.3.5.1

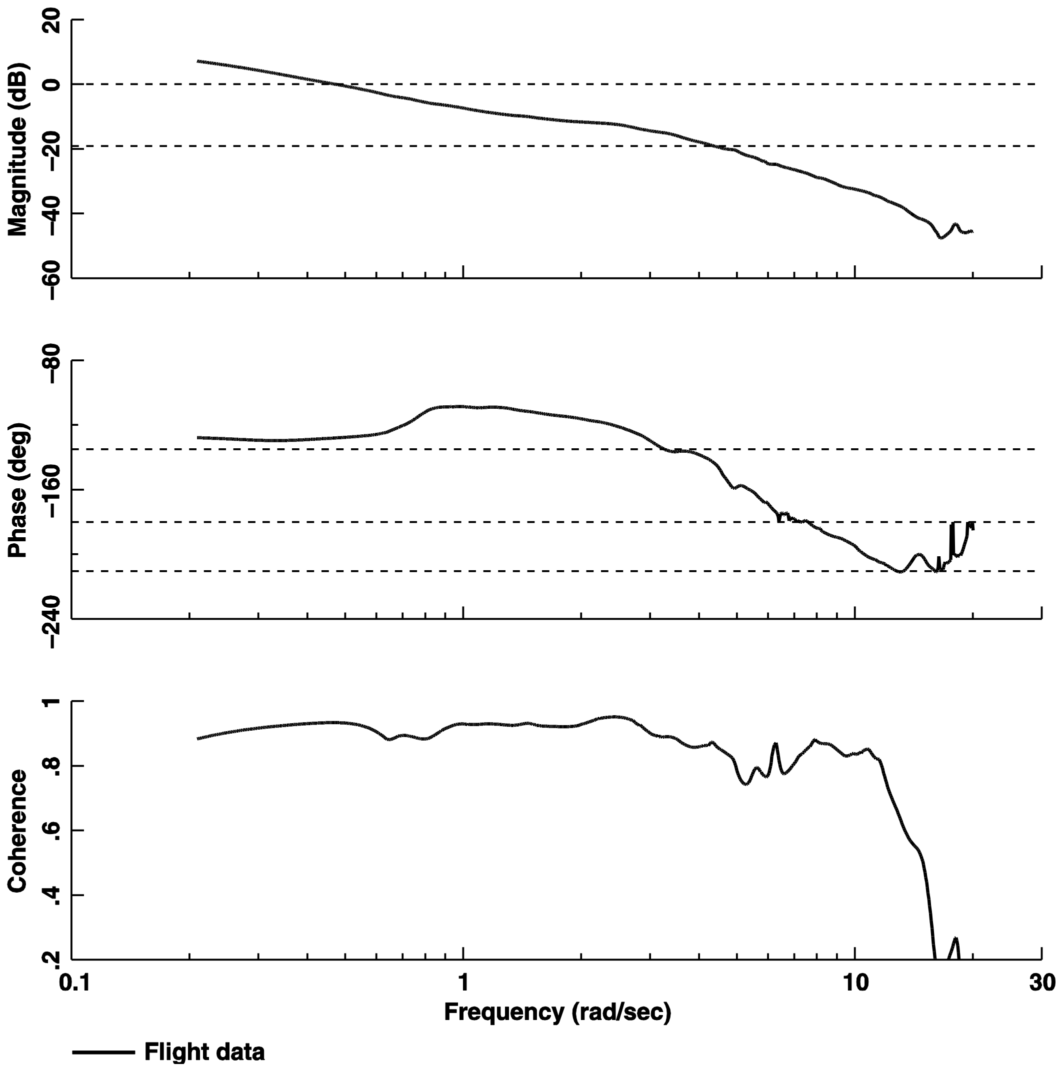


Figure E-24 3.3.5.1 bode

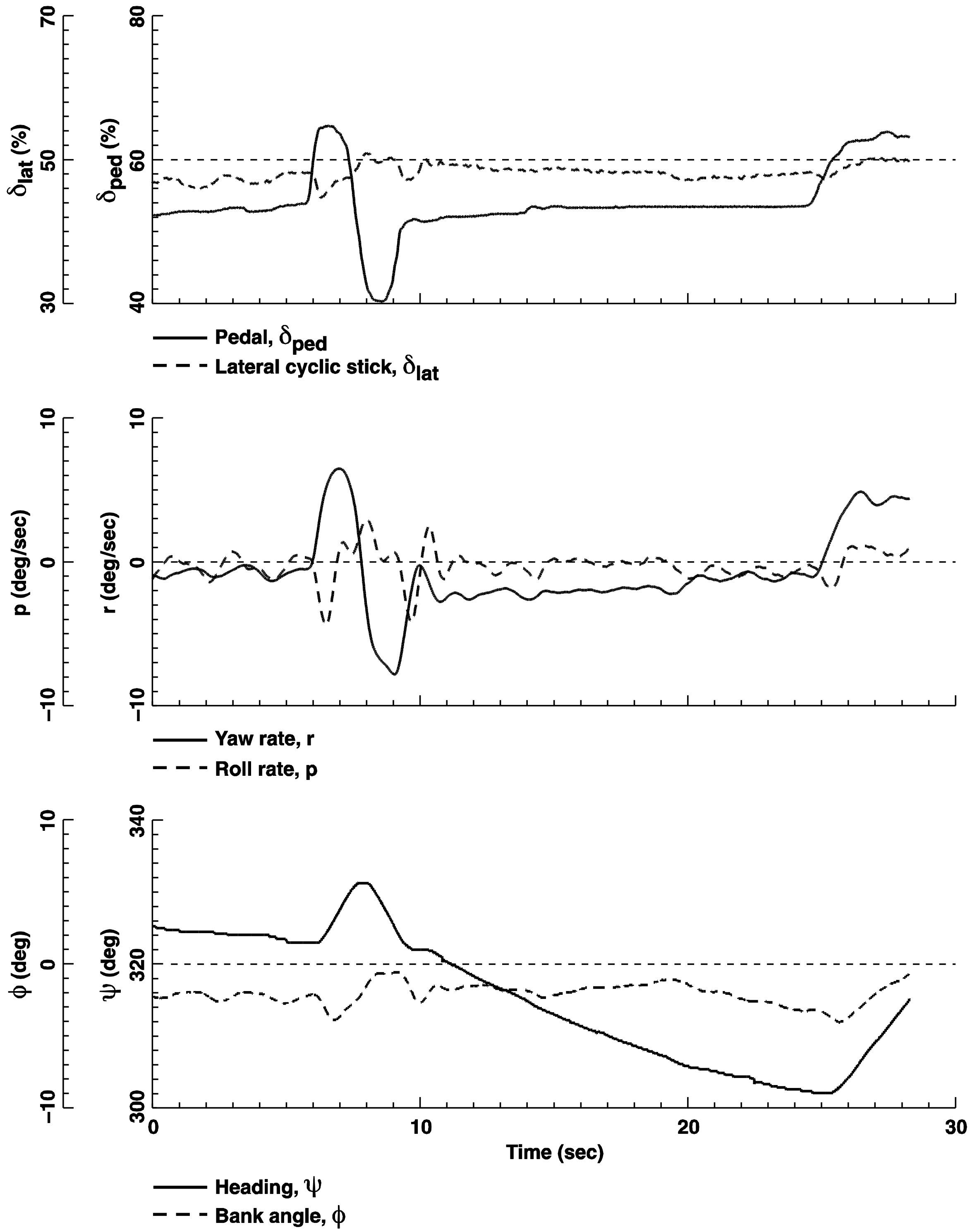


Figure E-25 Pedal Doublet, Right, Hover, Flt 189 Rec 65, 3.3.5.2

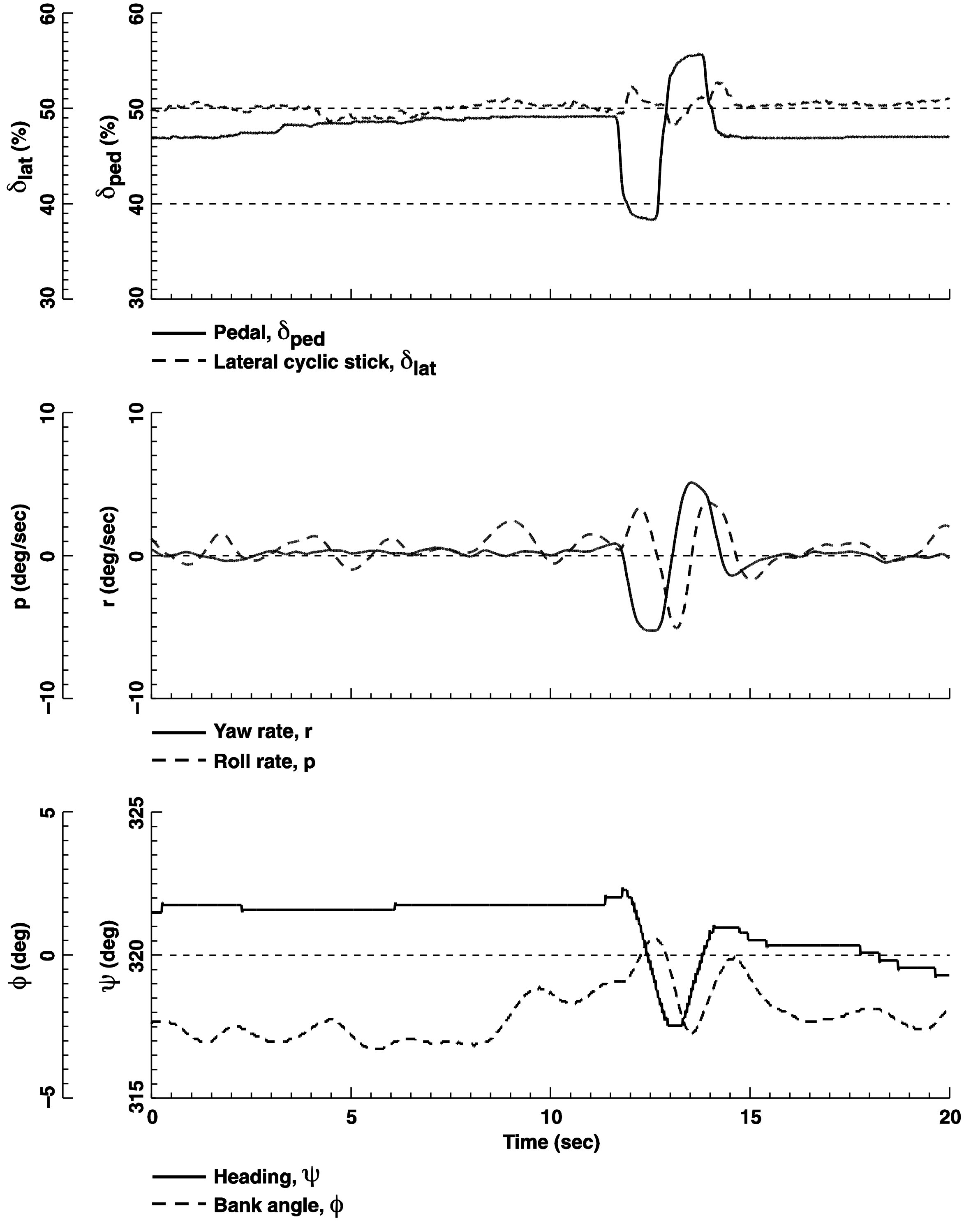


Figure E-26 Pedal Doublet, Left, Hover, Flt 212 Rec 21, 3.3.5.2

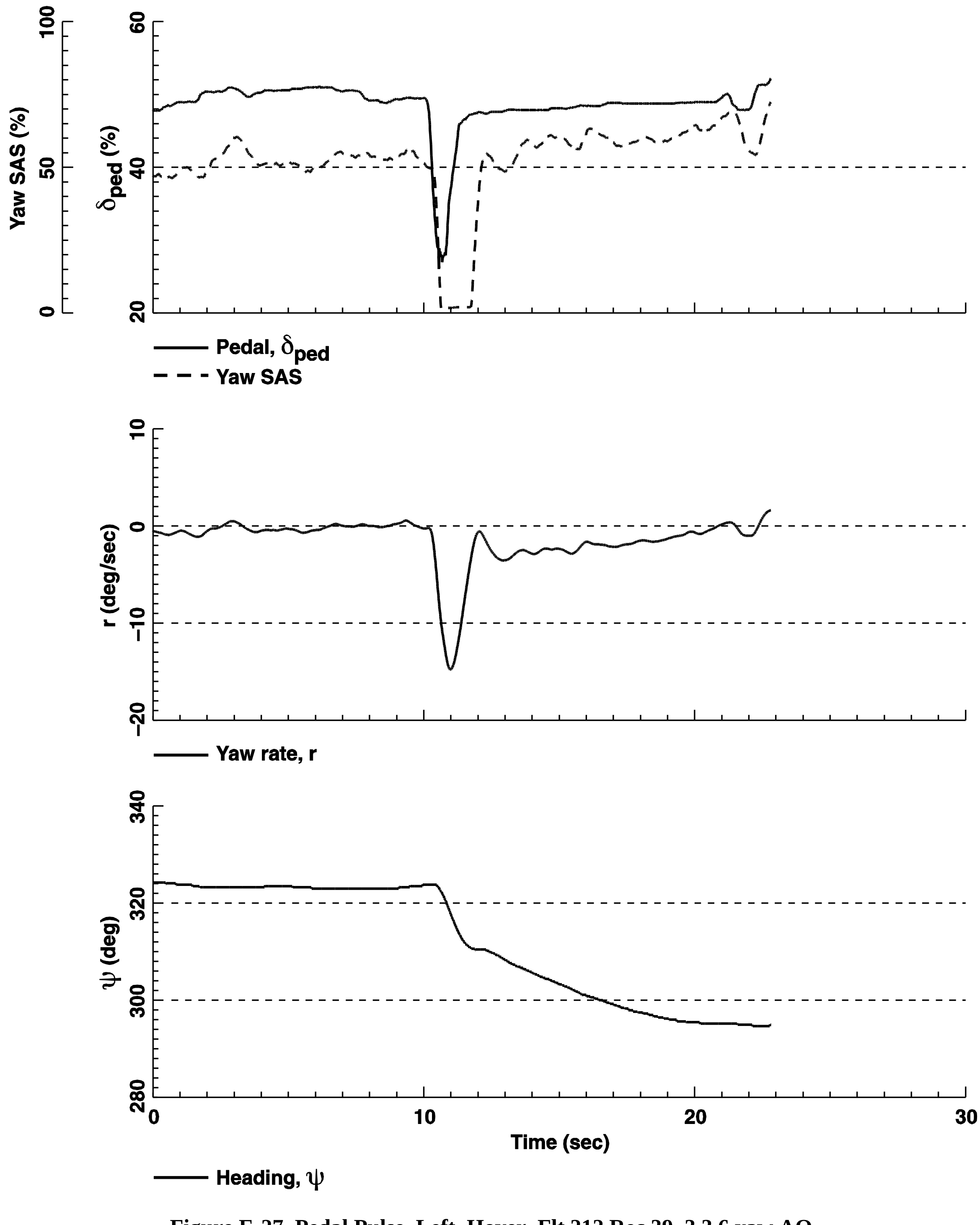


Figure E-27 Pedal Pulse, Left, Hover, Flt 212 Rec 39, 3.3.6 yaw AQ

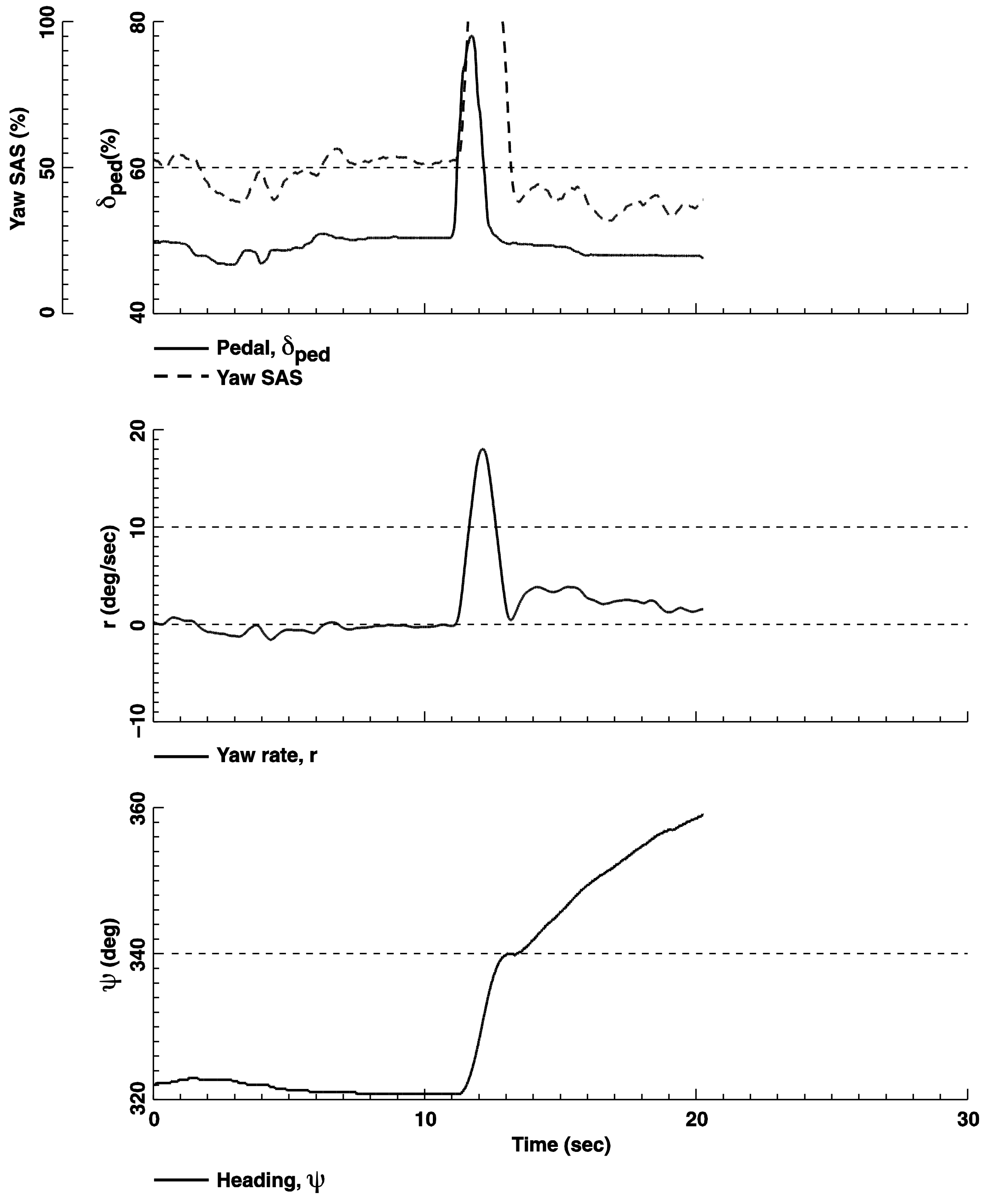


Figure E-28 Pedal Pulse, Right, Hover, Flt 212 Rec 42, 3.3.6 yaw AQ

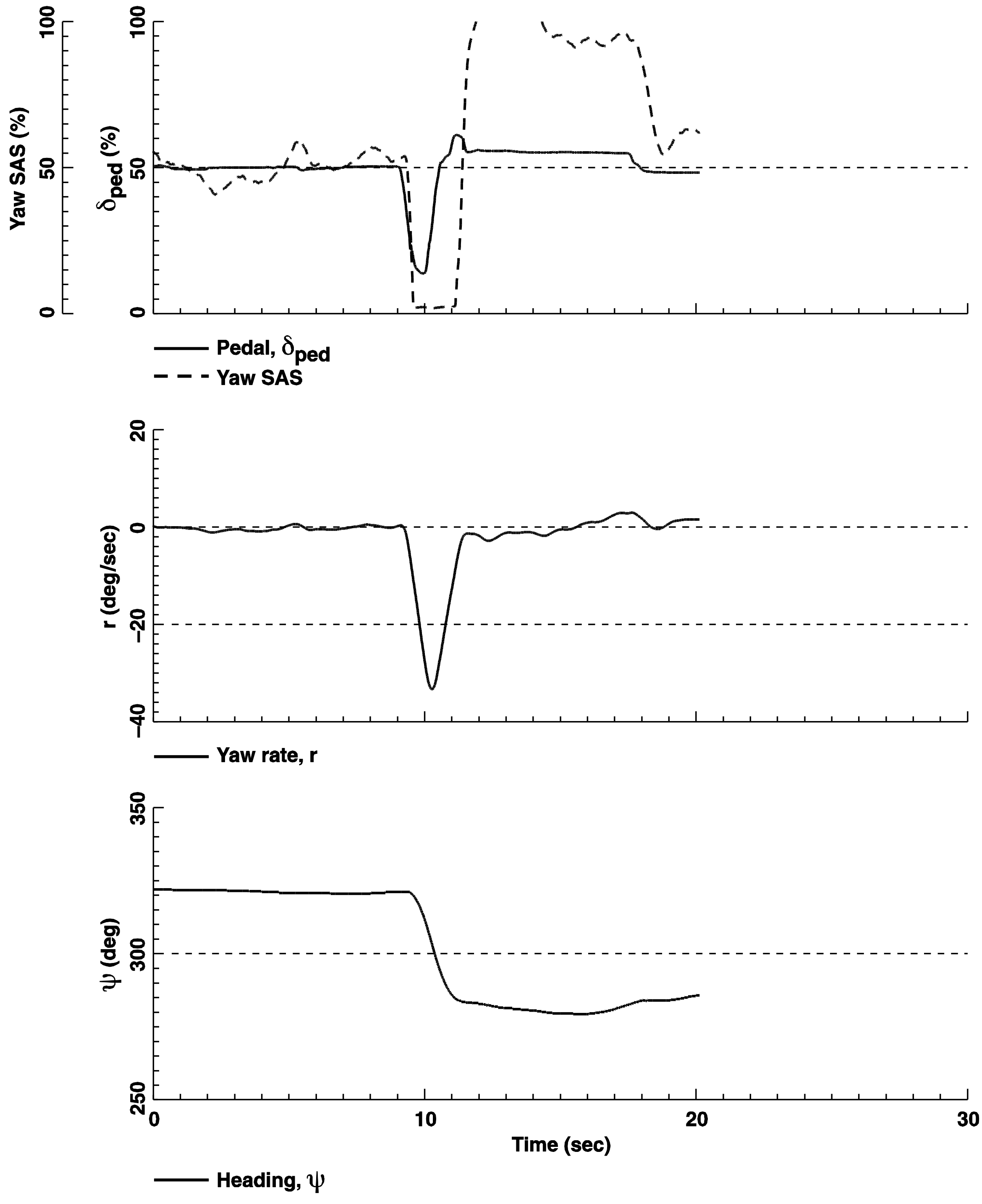


Figure E-29 Pedal Pulse, Left, Hover, Flt 212 Rec 40, 3.3.6 yaw AQ

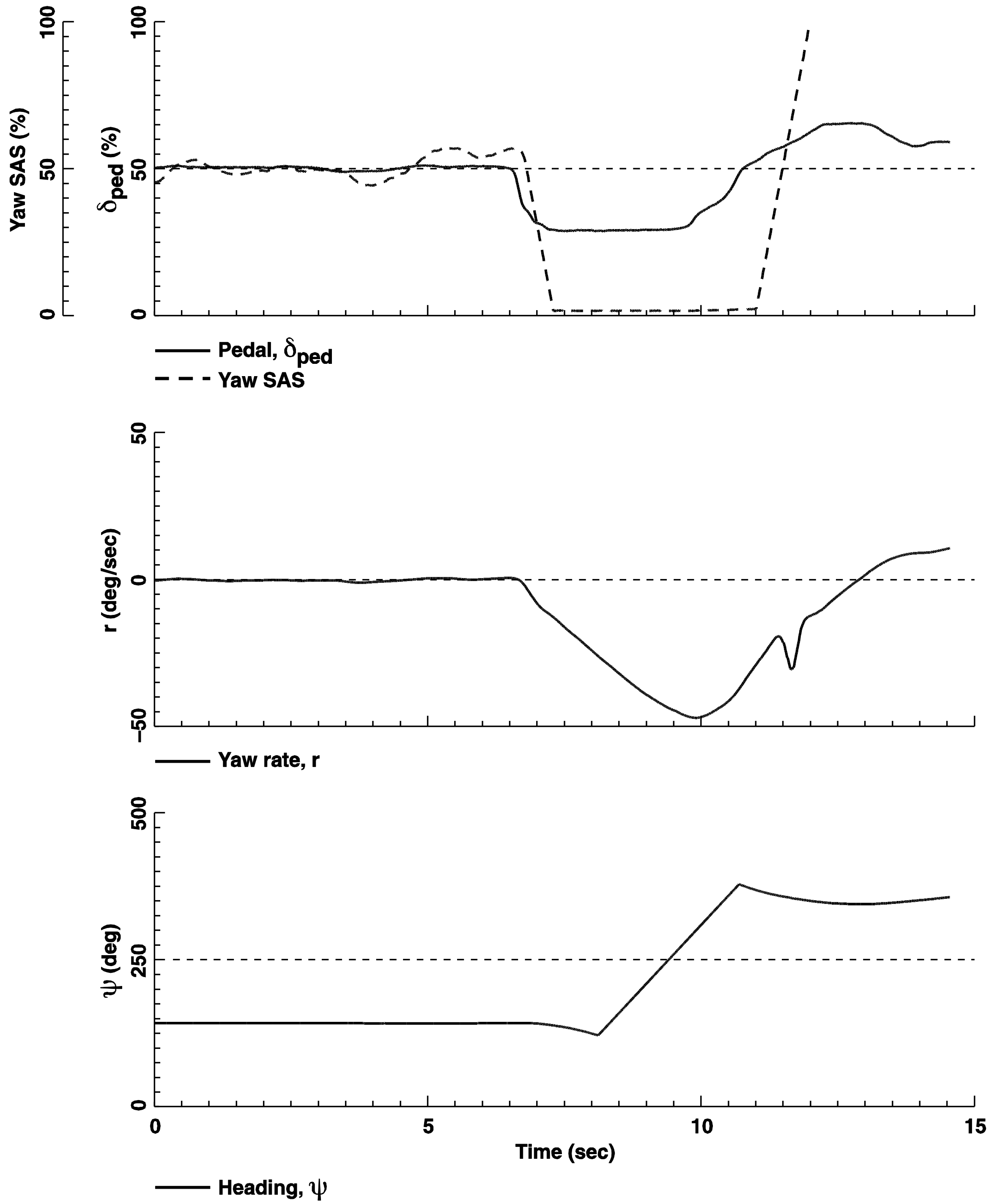


Figure E-30 Pedal Step, Right, Hover, Flt 215 Rec 49, 3.3.8 yaw large amplitude

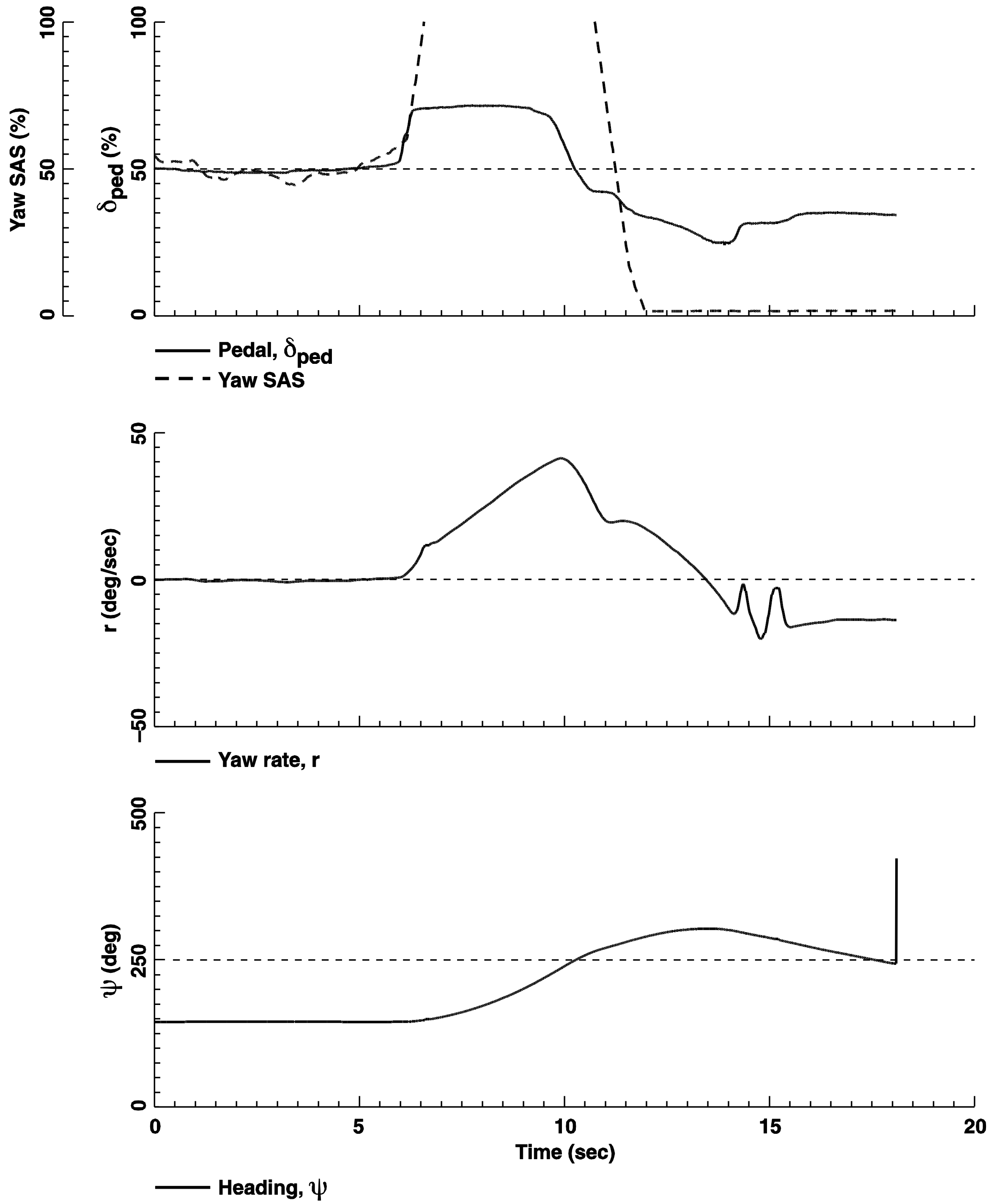


Figure E-31 Pedal Step, Left, Hover, Flt 215 Rec 50, 3.3.8 yaw large amplitude

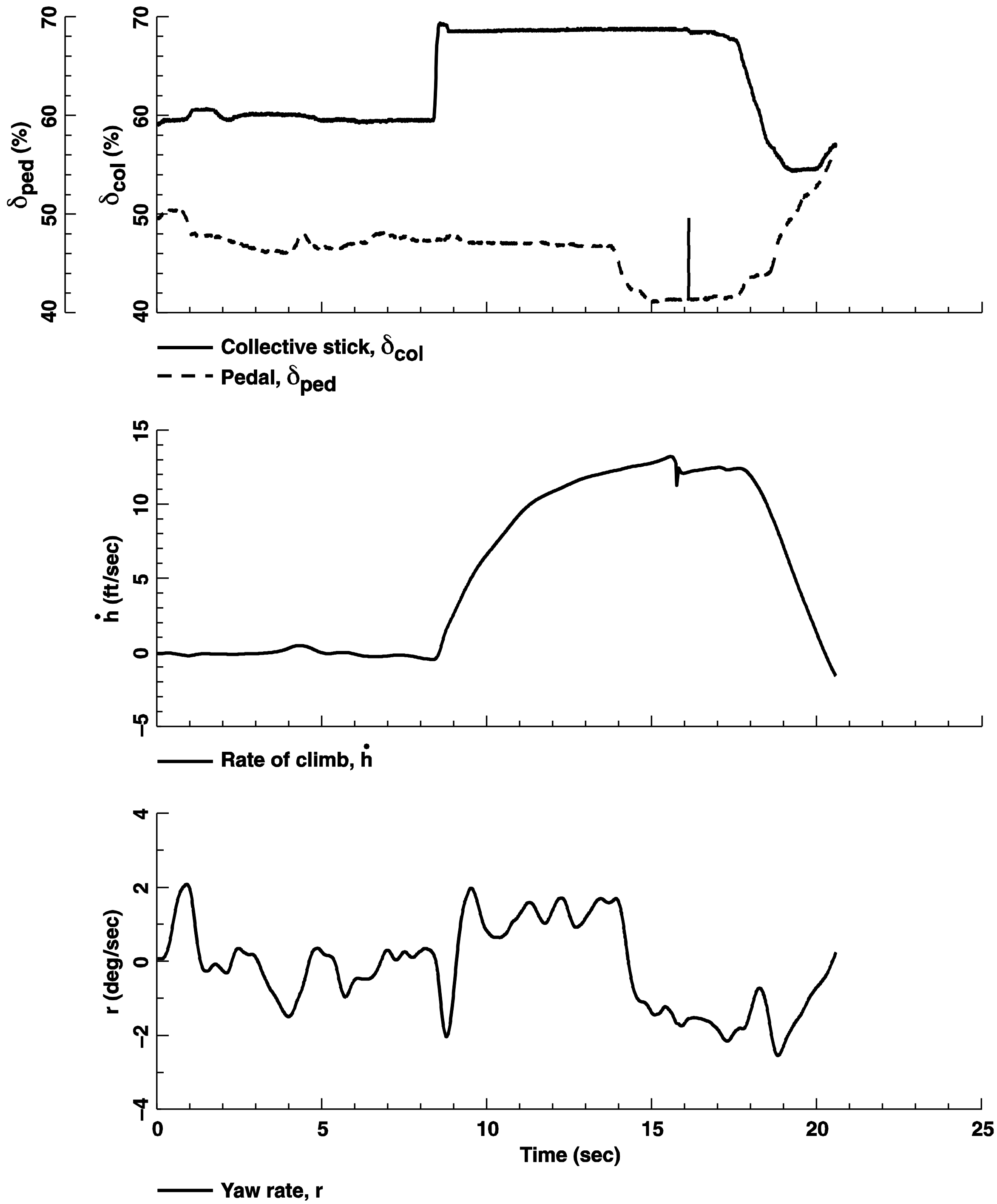


Figure E-32 Collective Step, Up, Hover, Flt 215 Rec 53, 3.3.9.1 yaw due to collective

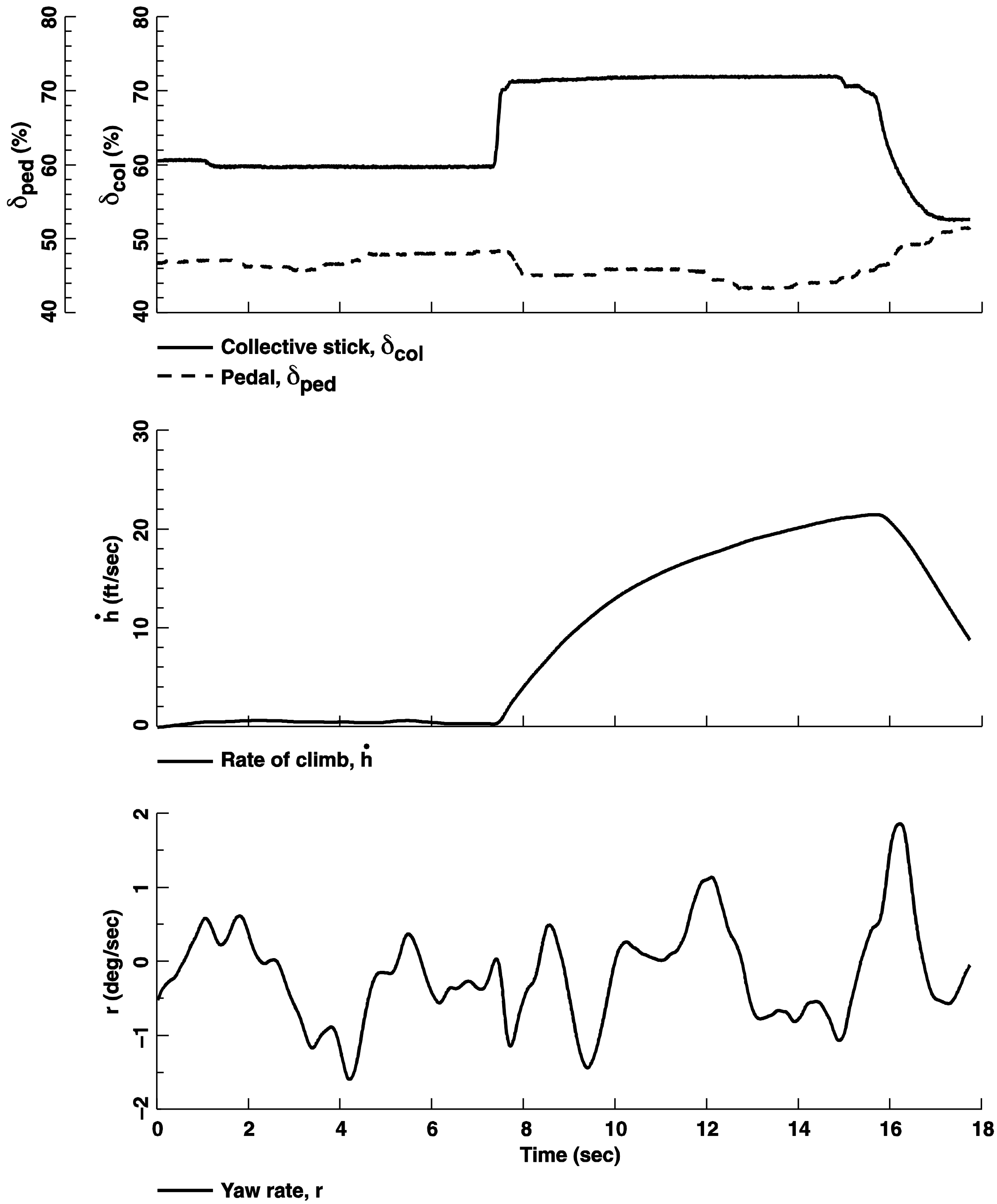


Figure E-33 Collective Step, Up, Hover, Flt 215 Rec 54, 3.3.9.1 yaw due to collective

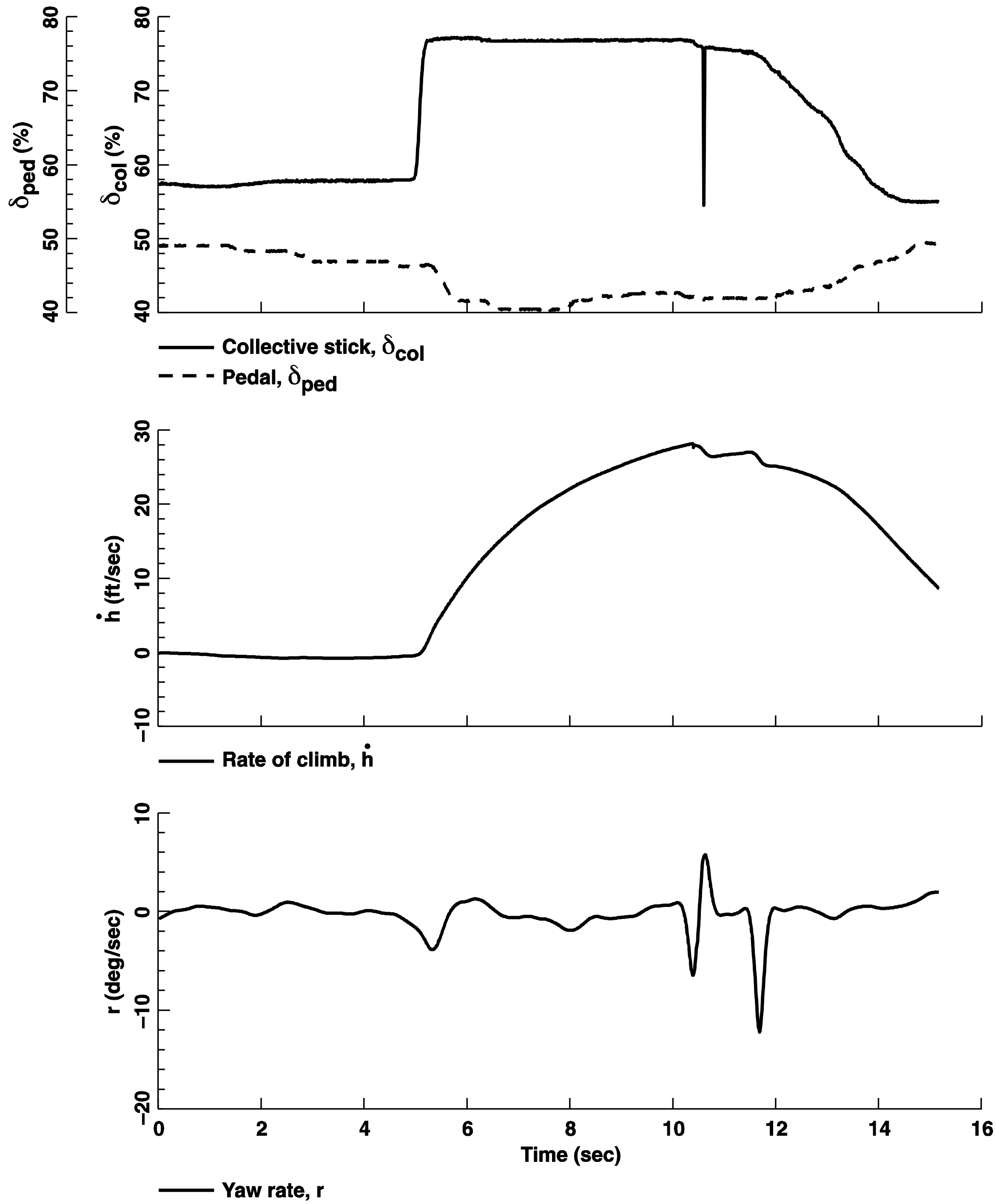


Figure E-34 Collective Step, Up, Hover, Flt 215 Rec 56, 3.3.9.1 yaw due to collective

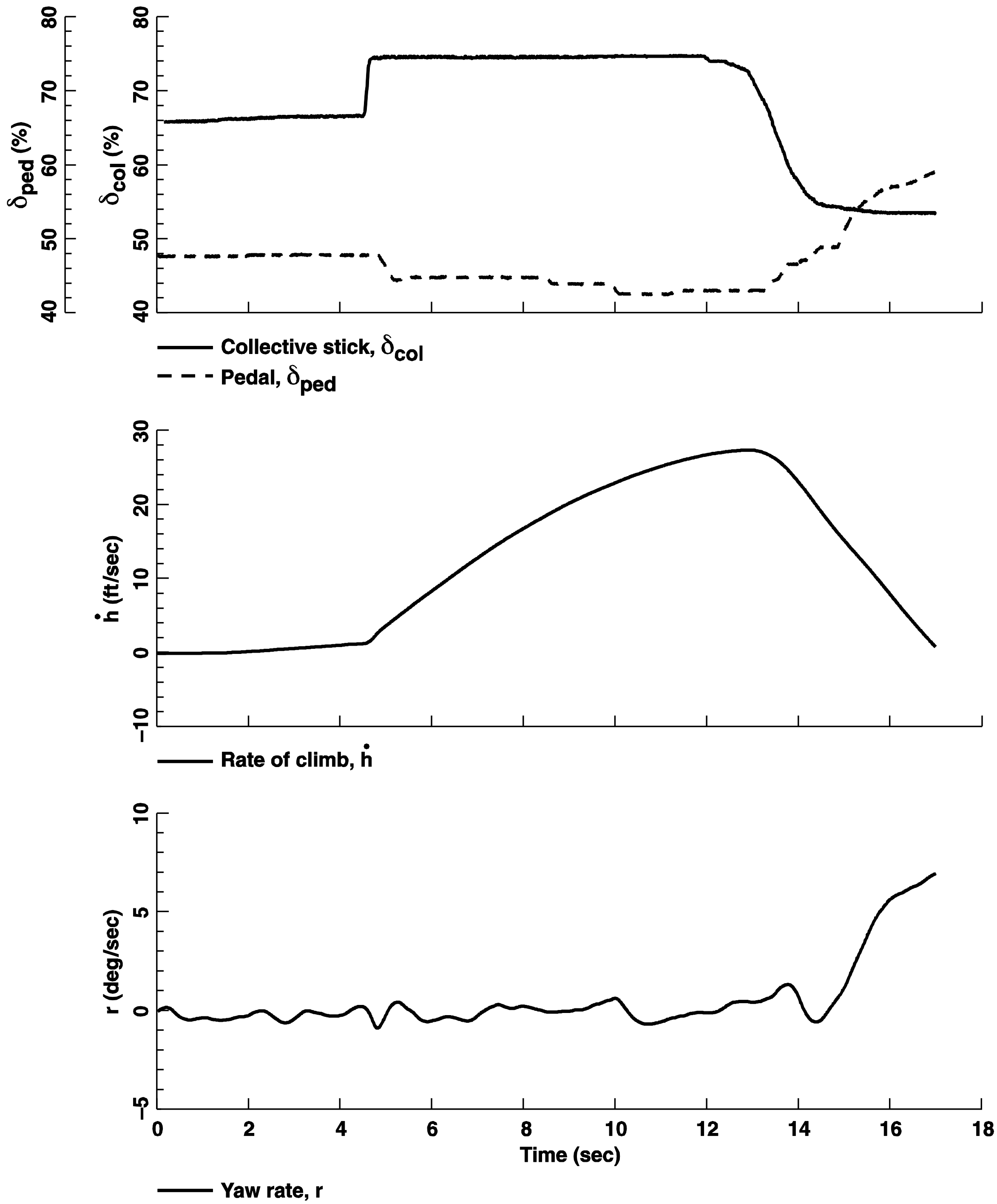


Figure E-35 Collective Step, Up, Hover, Flt 215 Rec 57, 3.3.9.1 yaw due to collective

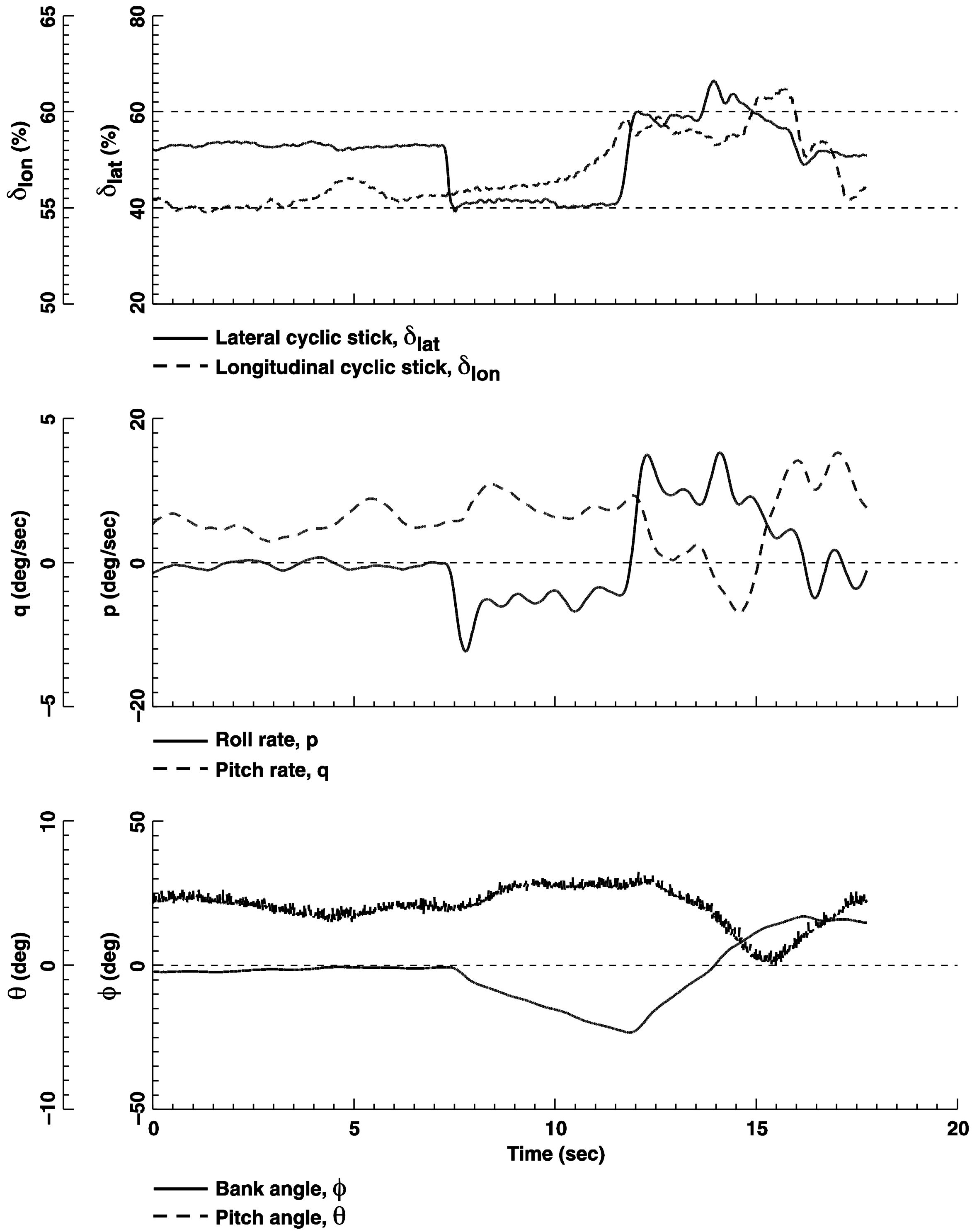


Figure E-36 Lat Step, Left, Hover, Flt 189 Rec 19, 3.3.9.2 pitch due to roll

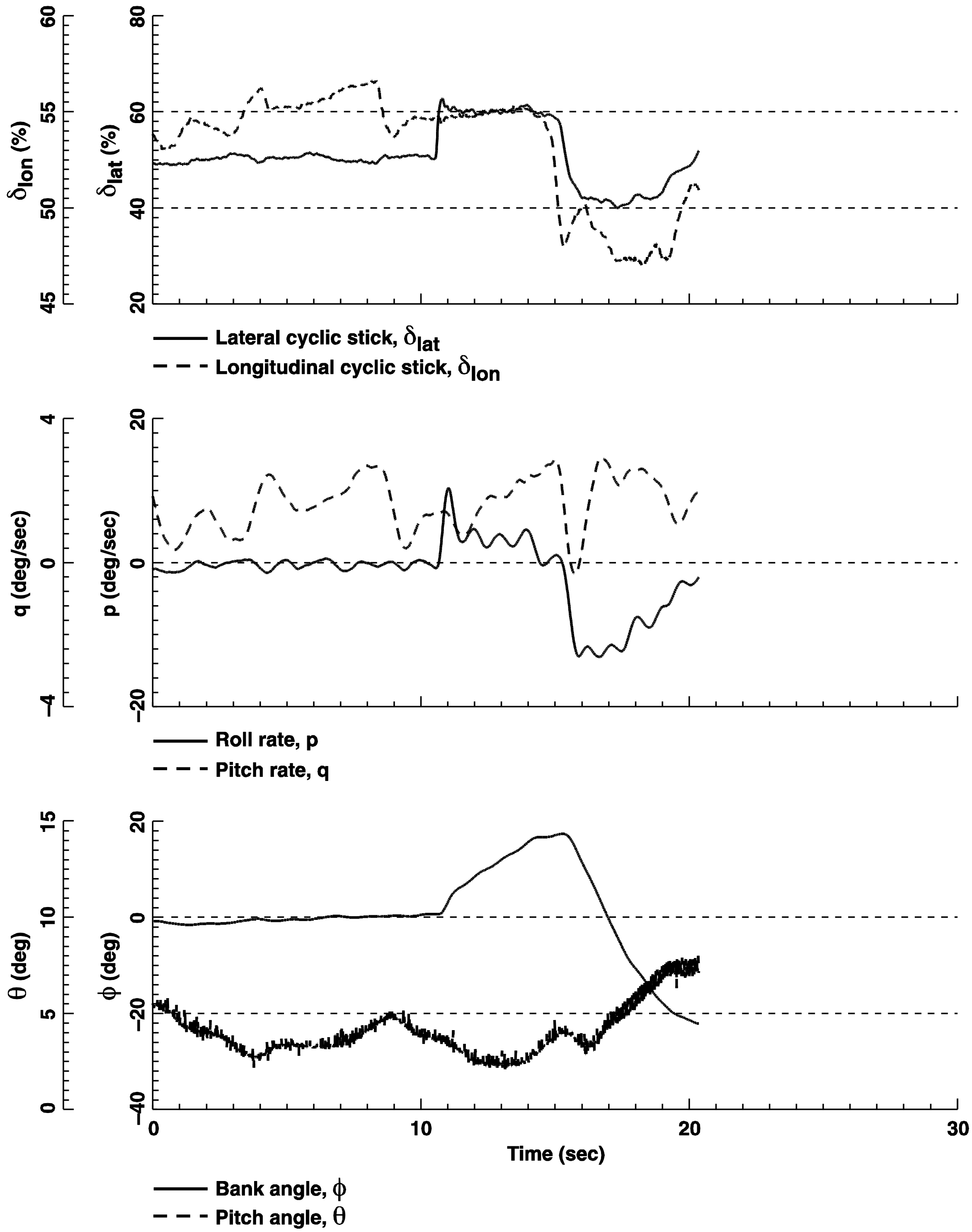


Figure E-37 Lat Step, Right, Hover, Flt 189 Rec 27, 3.3.9.2 pitch due to roll

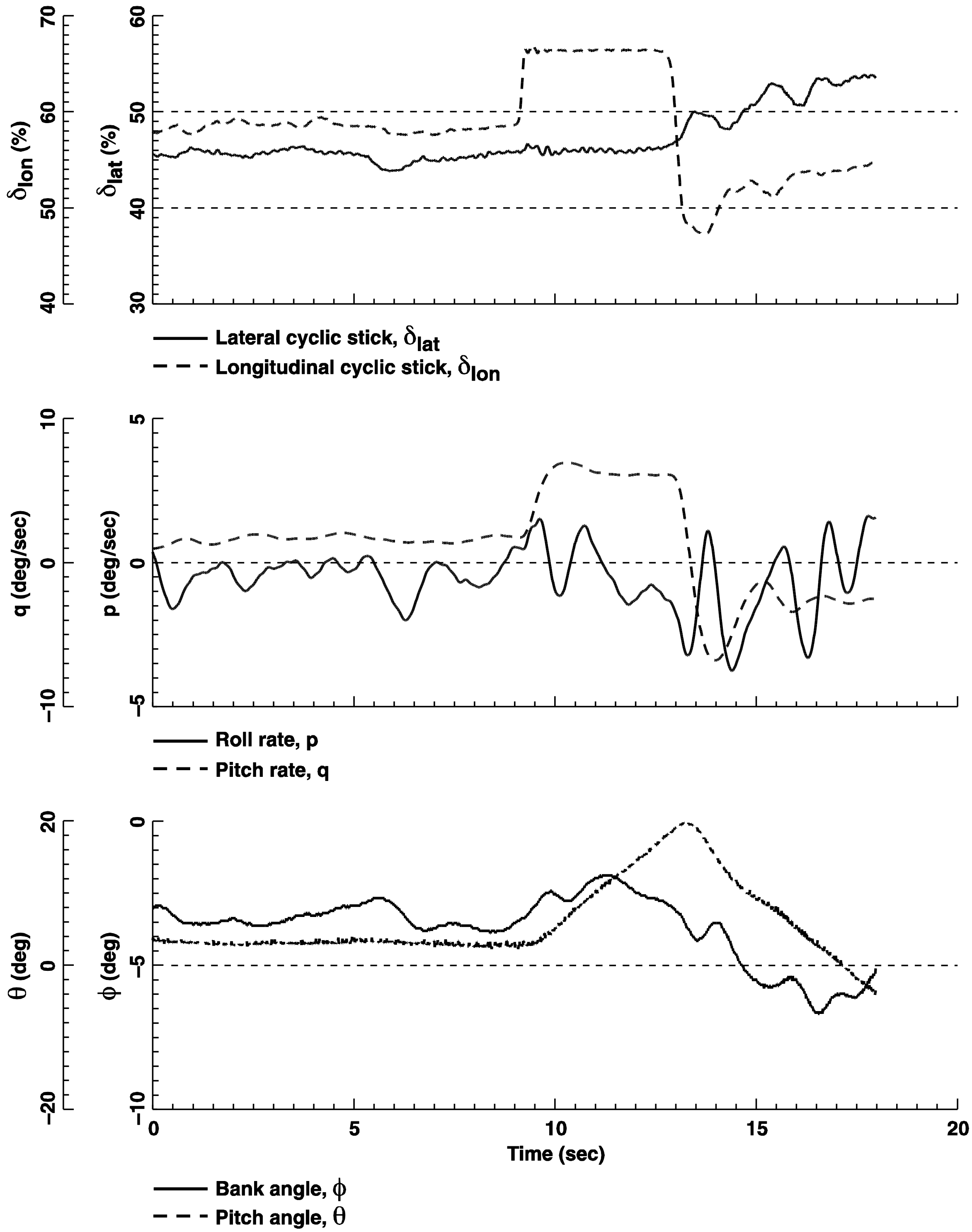


Figure E-38 Lon Step, Aft, Hover, Flt 189 Rec 48, 3.3.9.2 roll due to pitch

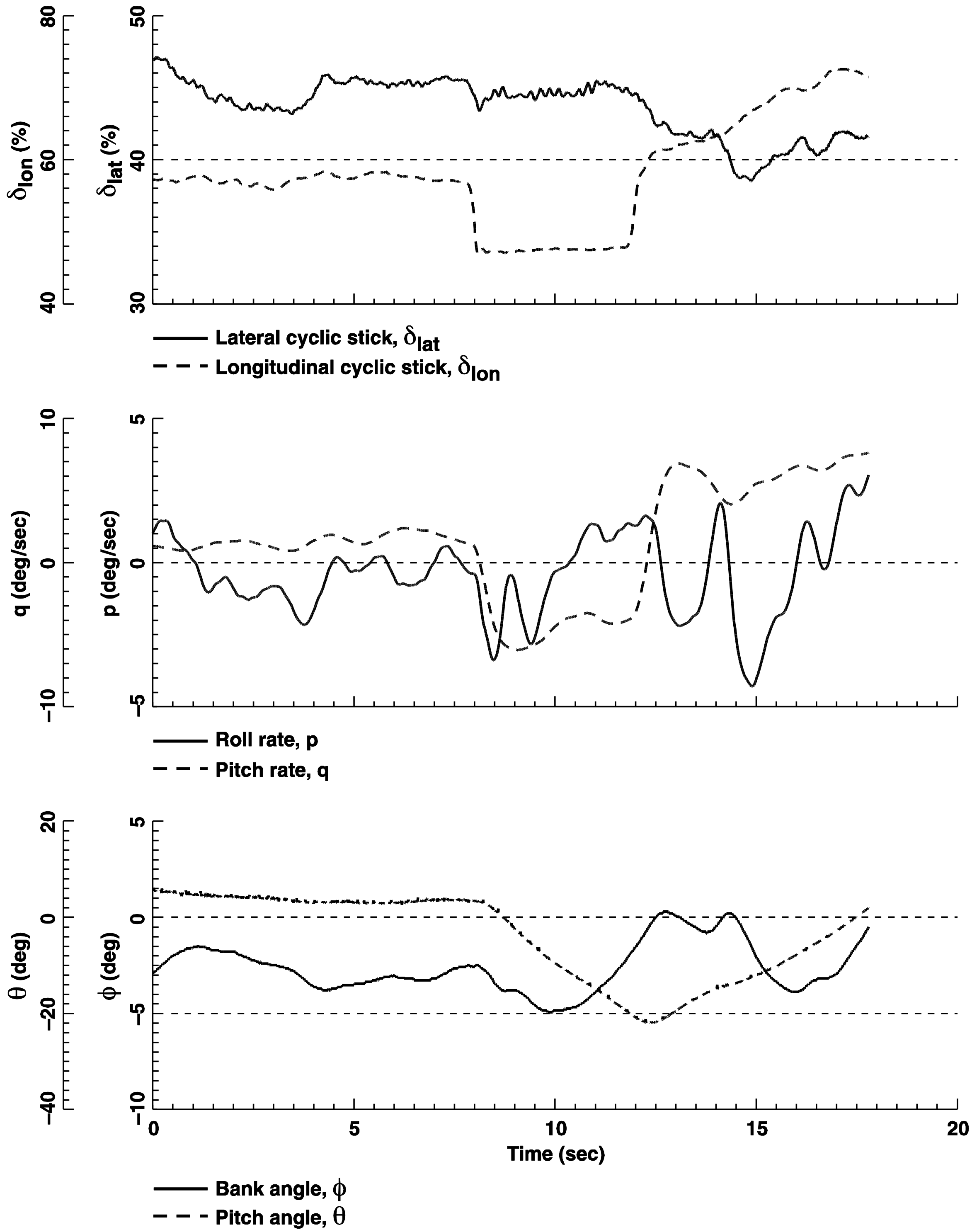


Figure E-39 Lon Step, Fwd, Hover, Flt 189 Rec 51, 3.3.9.2 roll due to pitch

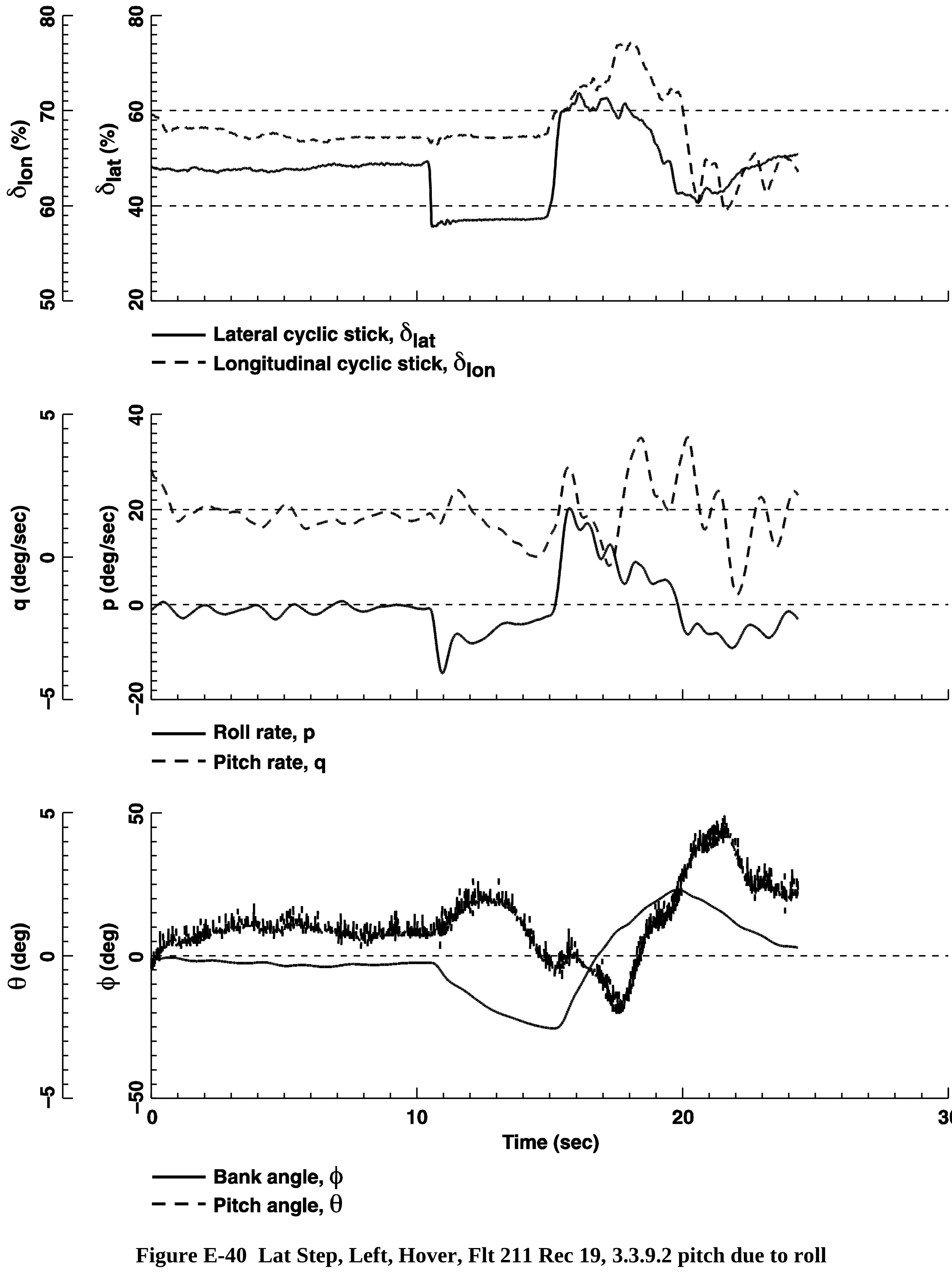


Figure E-40 Lat Step, Left, Hover, Flt 211 Rec 19, 3.3.9.2 pitch due to roll

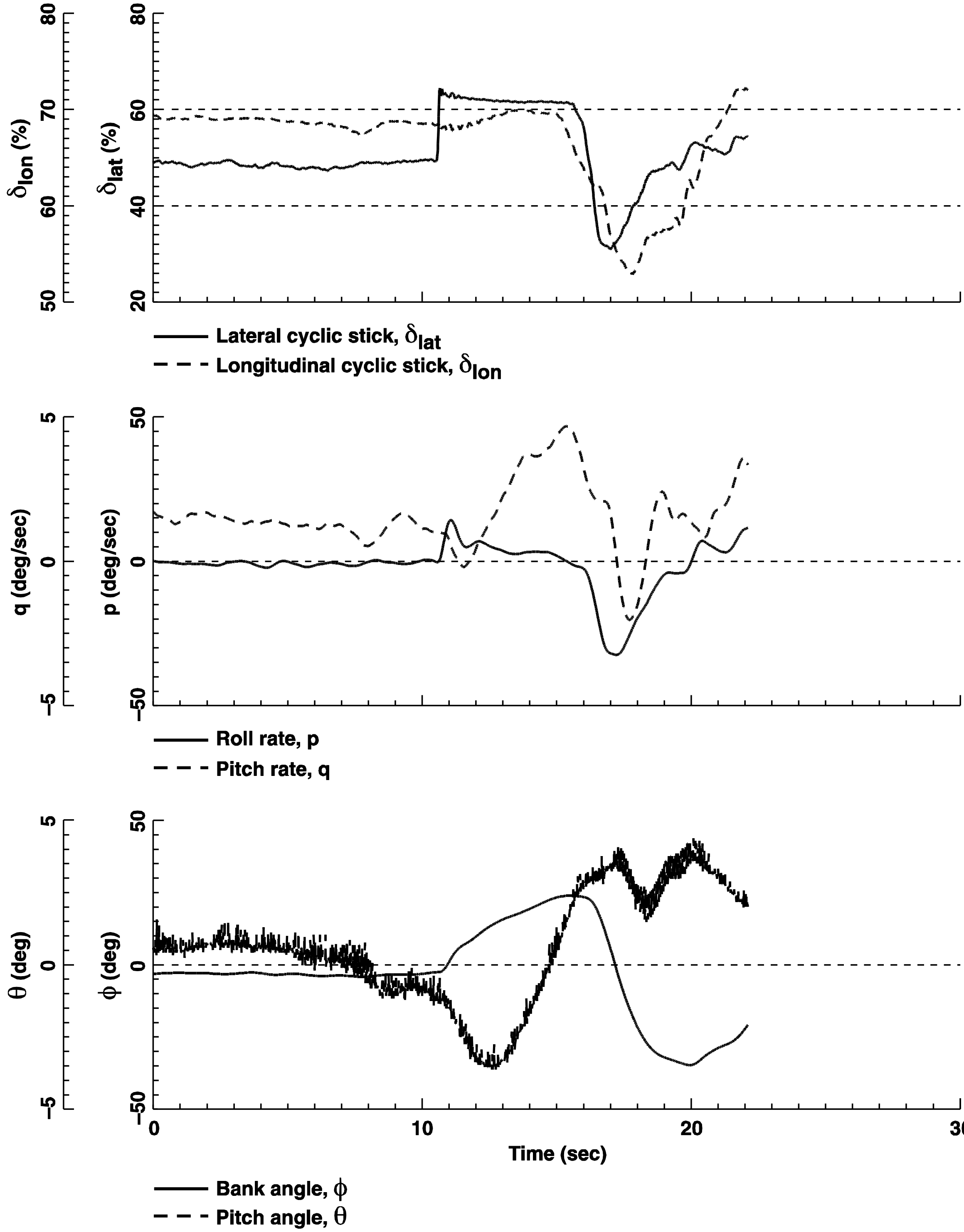


Figure E-41 Lat Step, Right, Hover, Flt 211 Rec 23, 3.3.9.2 pitch due to roll

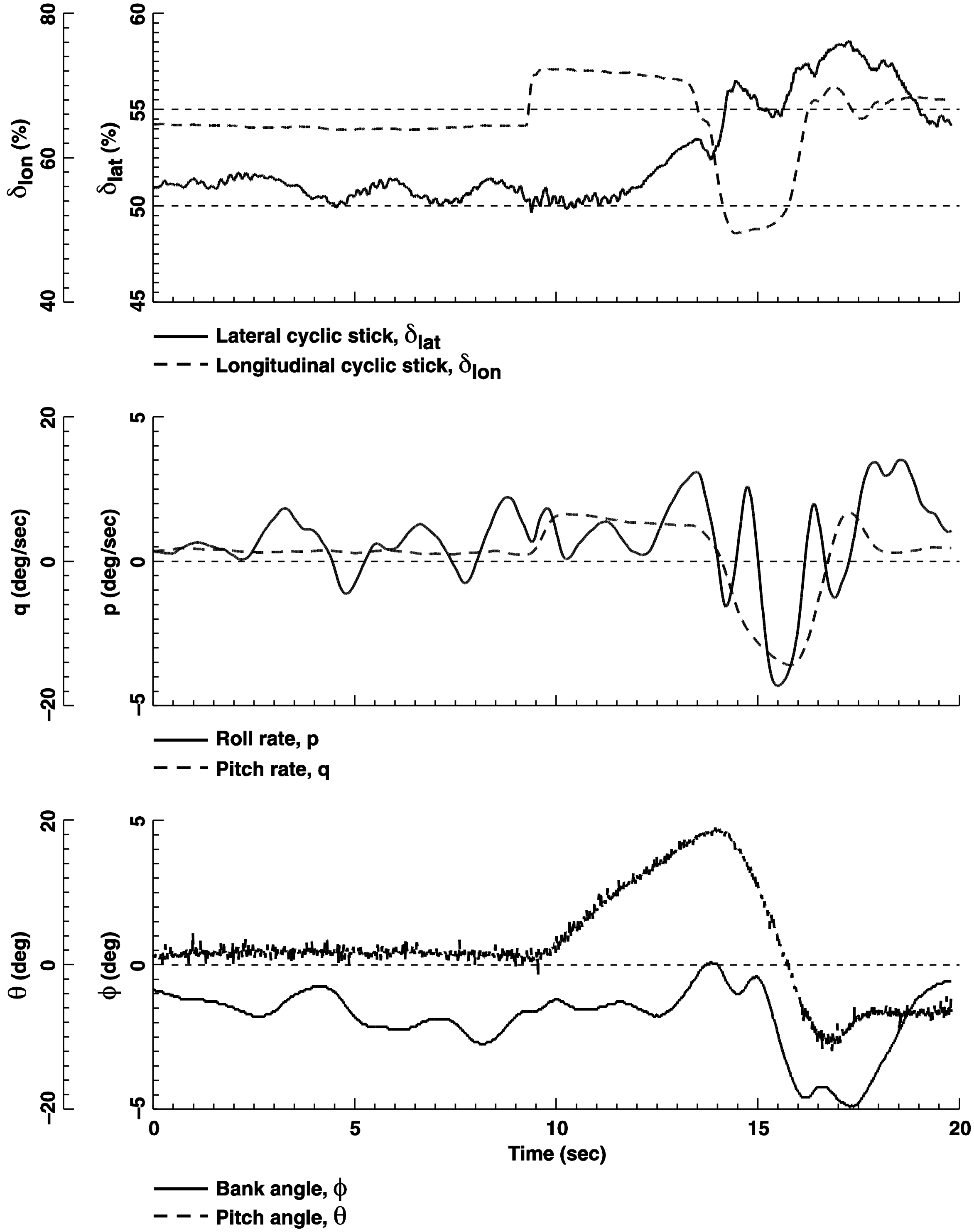


Figure E-42 Lon Step, Aft, Hover, Flt 212 Rec 2, 3.3.9.2 roll due to pitch

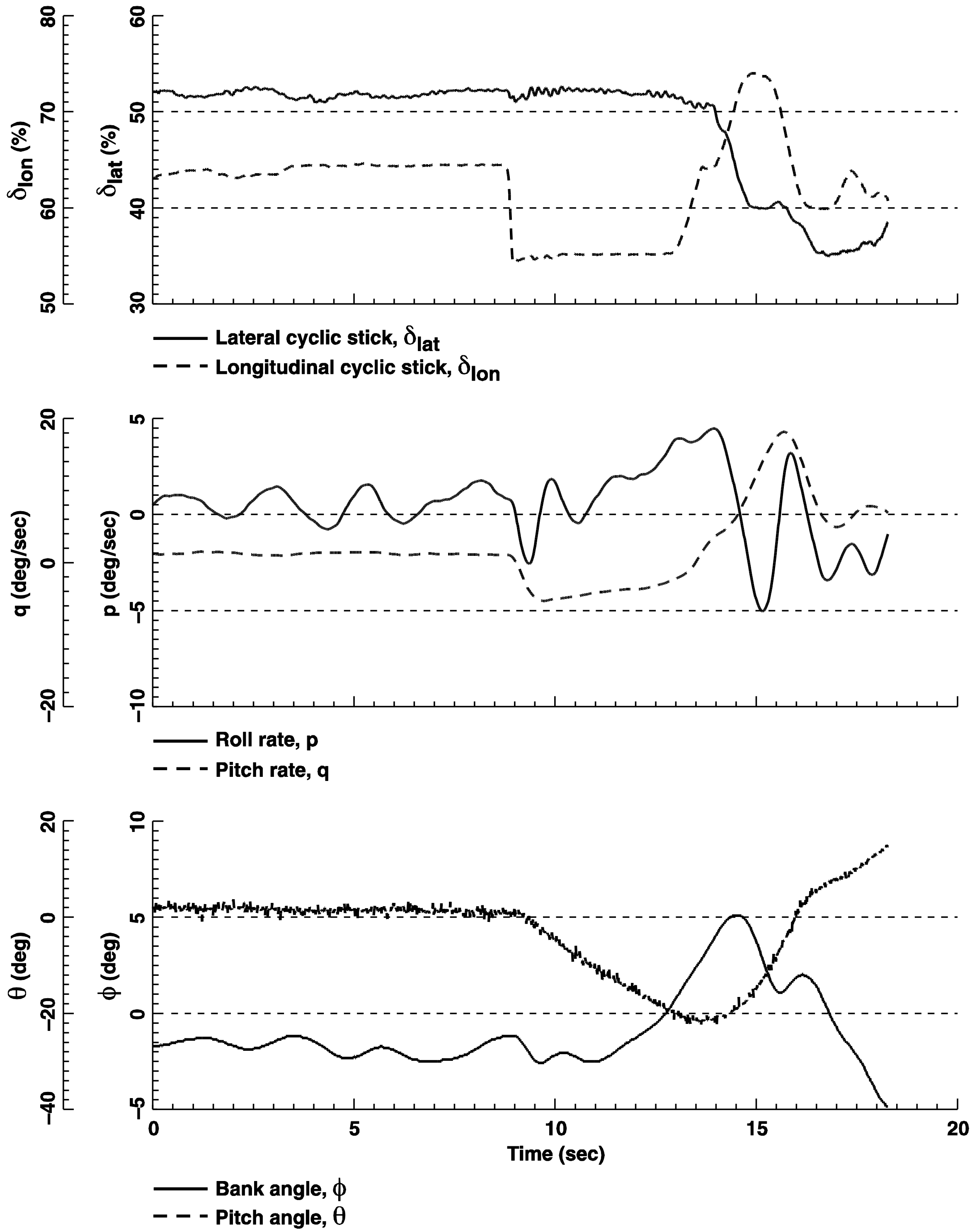


Figure E-43 Lon Step, Fwd, Hover, Flt 212 Rec 6, 3.3.9.2 roll due to pitch

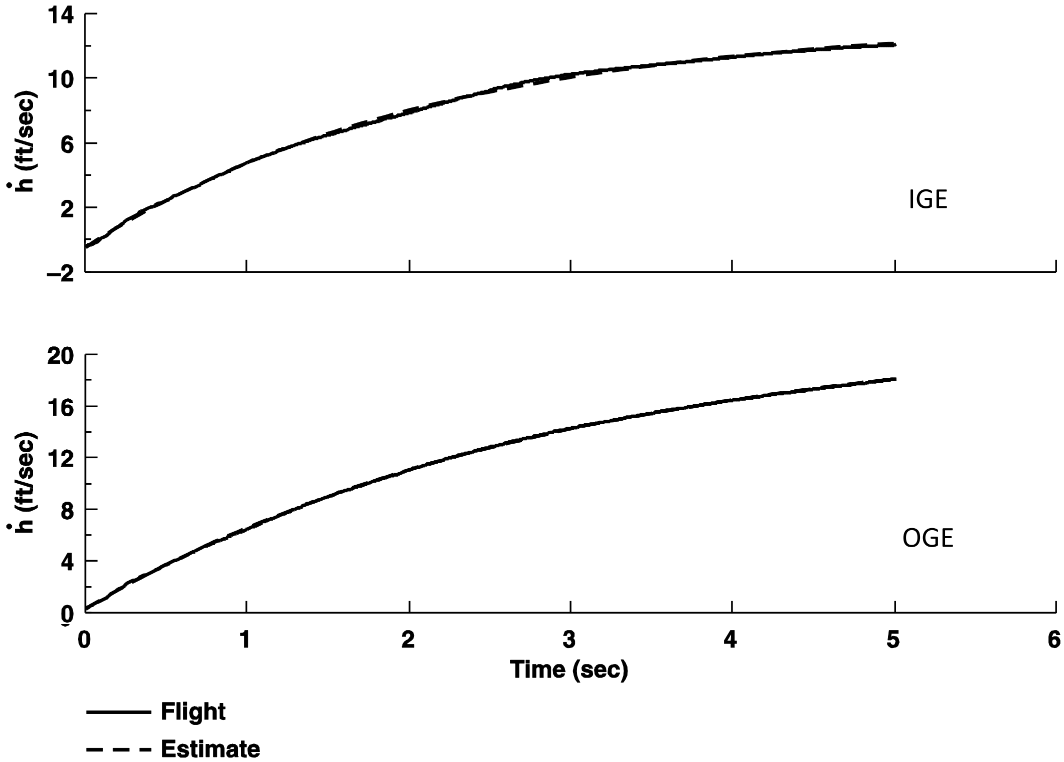


Figure E-44 Flt 215 Rec 53–54, 3.3.10 vertical response, Hover

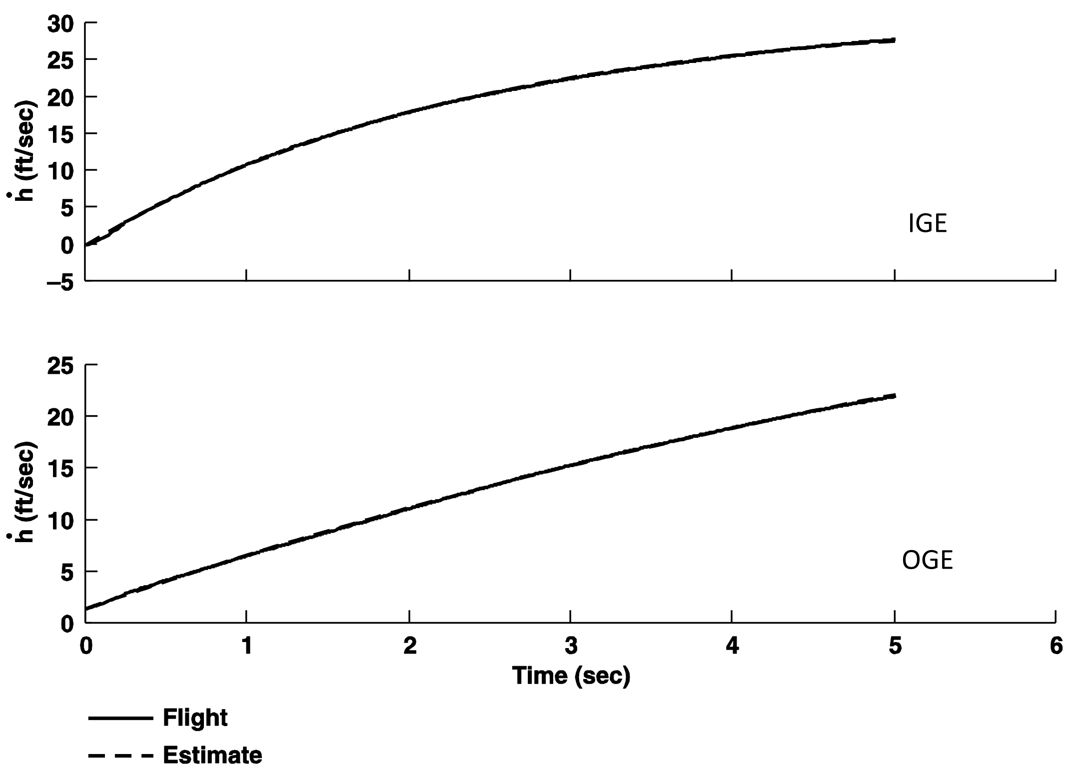


Figure E-45 Flt 215 Rec 56–57, 3.3.10 vertical response, Hover

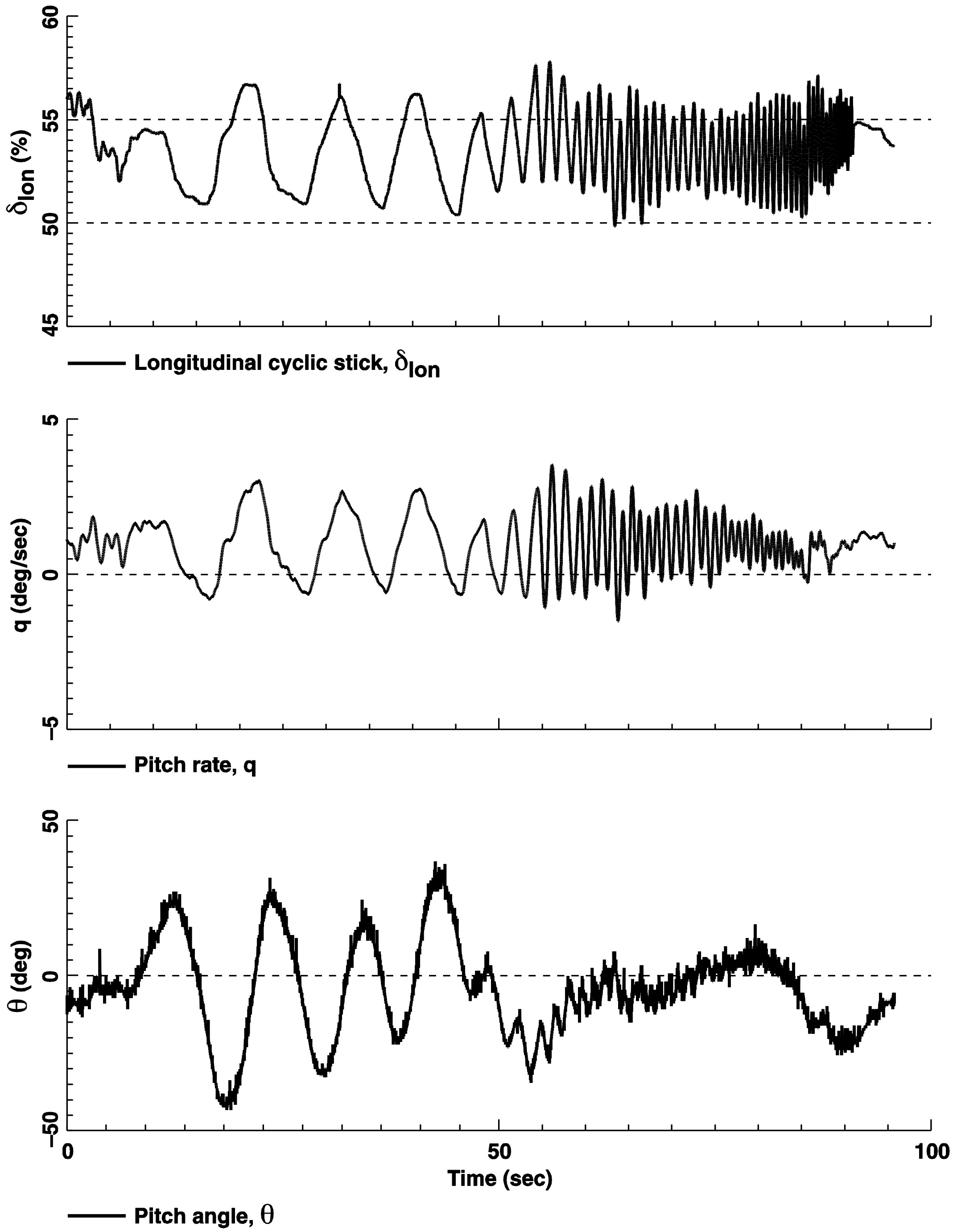


Figure E-46 Typical Longitudinal Frequency Sweep, 80 knots, Flt 214 Rec 8, 3.4.1.1

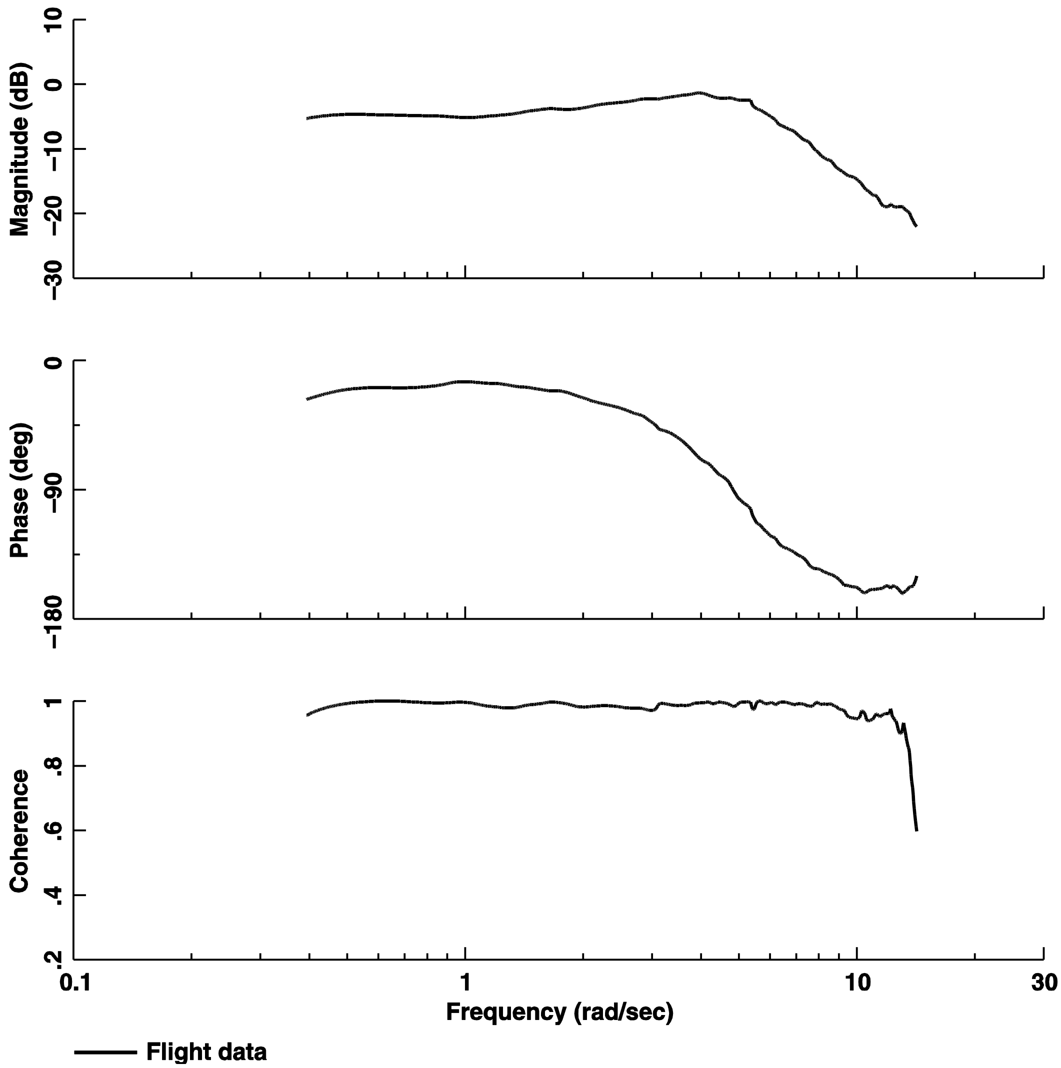


Figure E-47 3.4.1.1 80-knot pitch bode

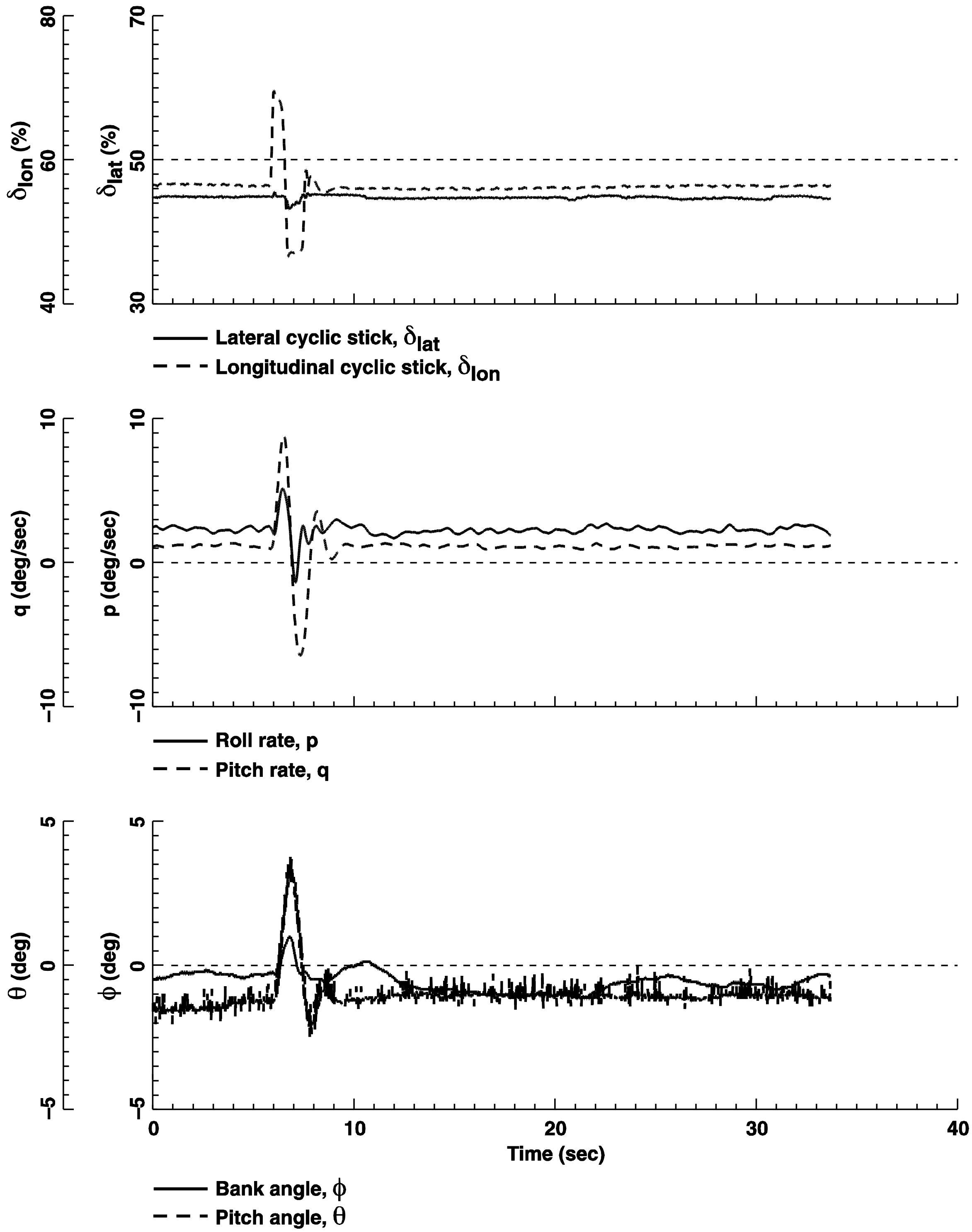


Figure E-48 Lon Doublet, Aft, 80 knots, Flt 214 Rec 16, 3.4.1.2 long mid-term

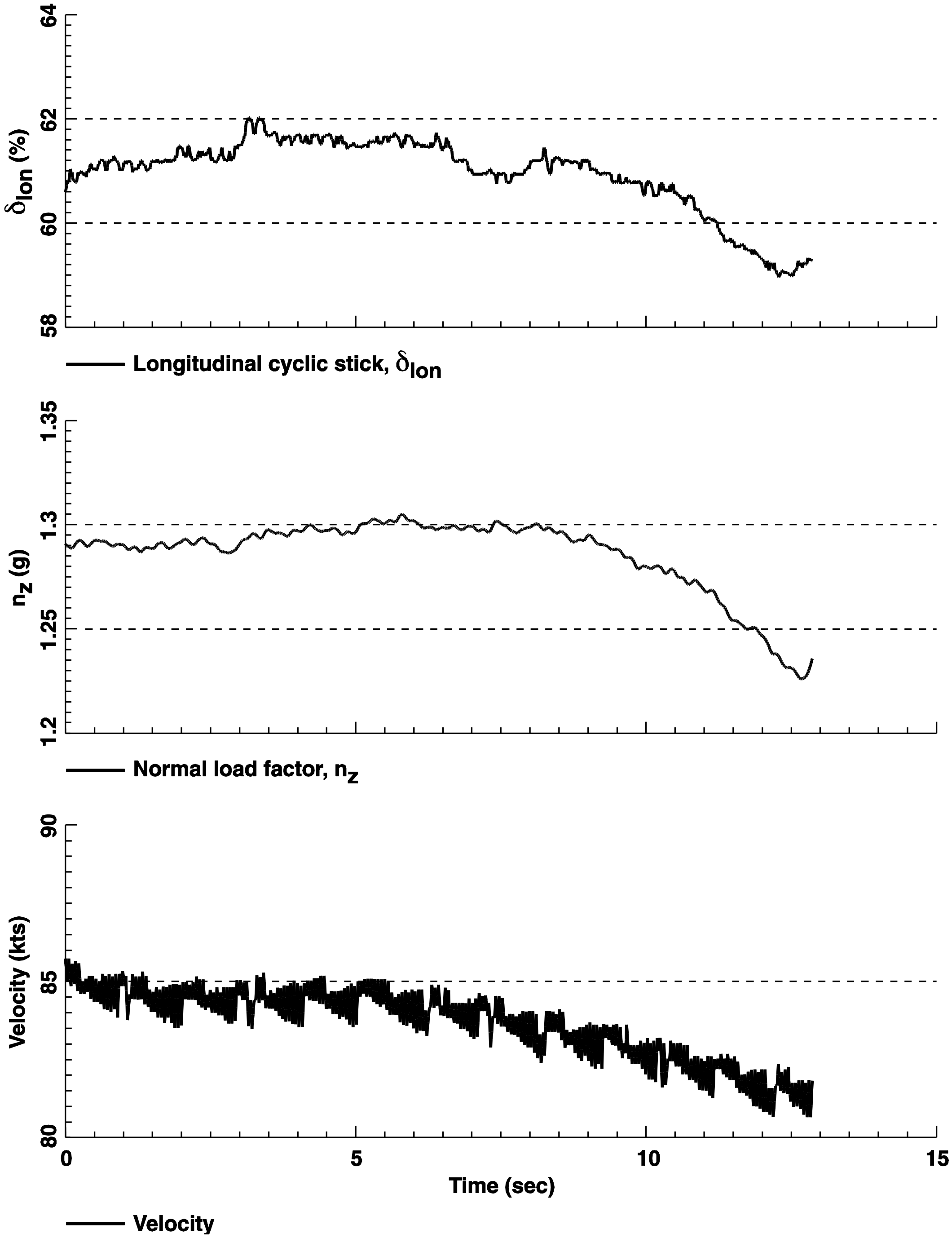


Figure E-49 Steady Right Turn, 80 knots, Flt 213 Rec 3, 3.4.1.3

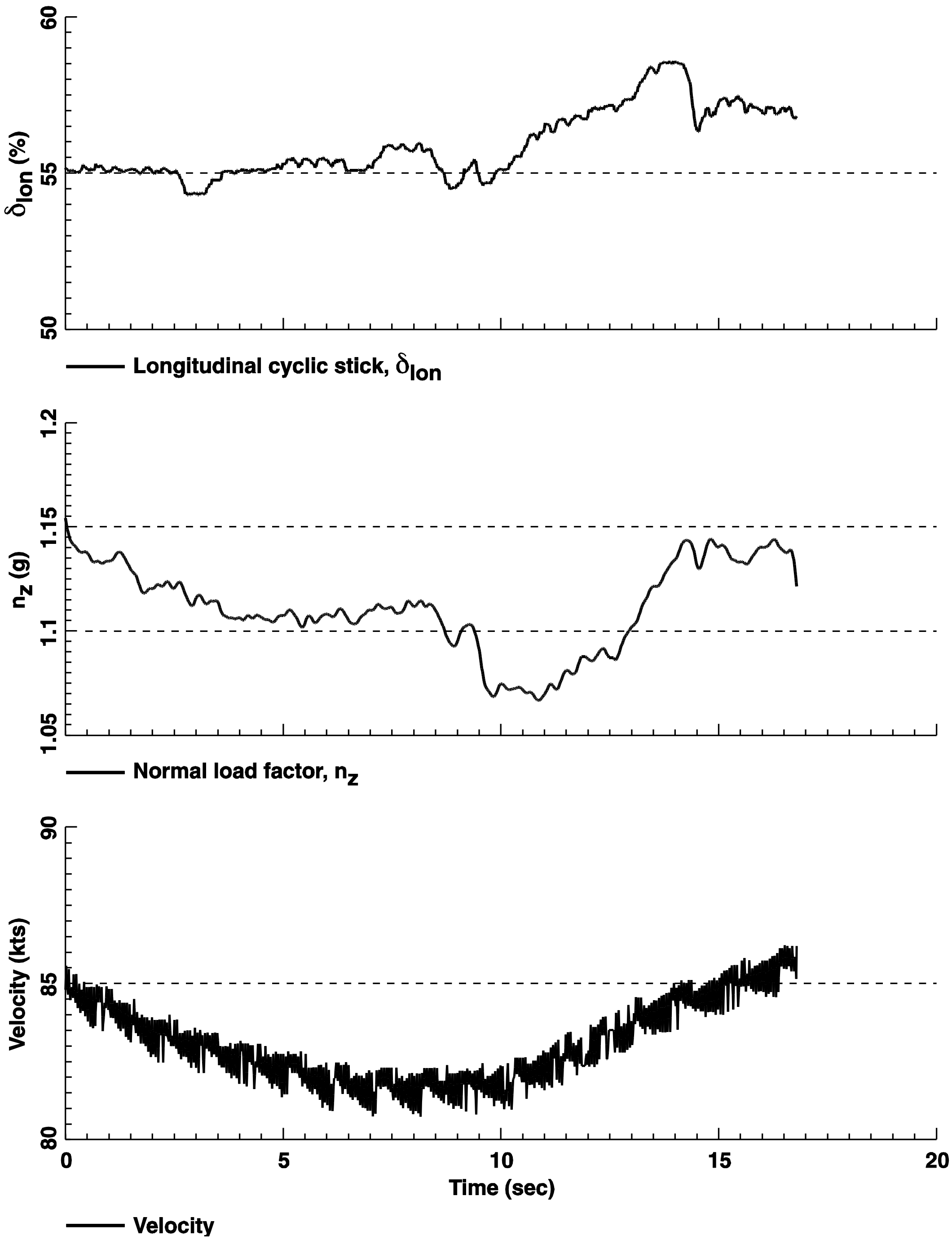


Figure E-50 Steady Left Turn, 80 knots, Flt 213 Rec 7, 3.4.1.3

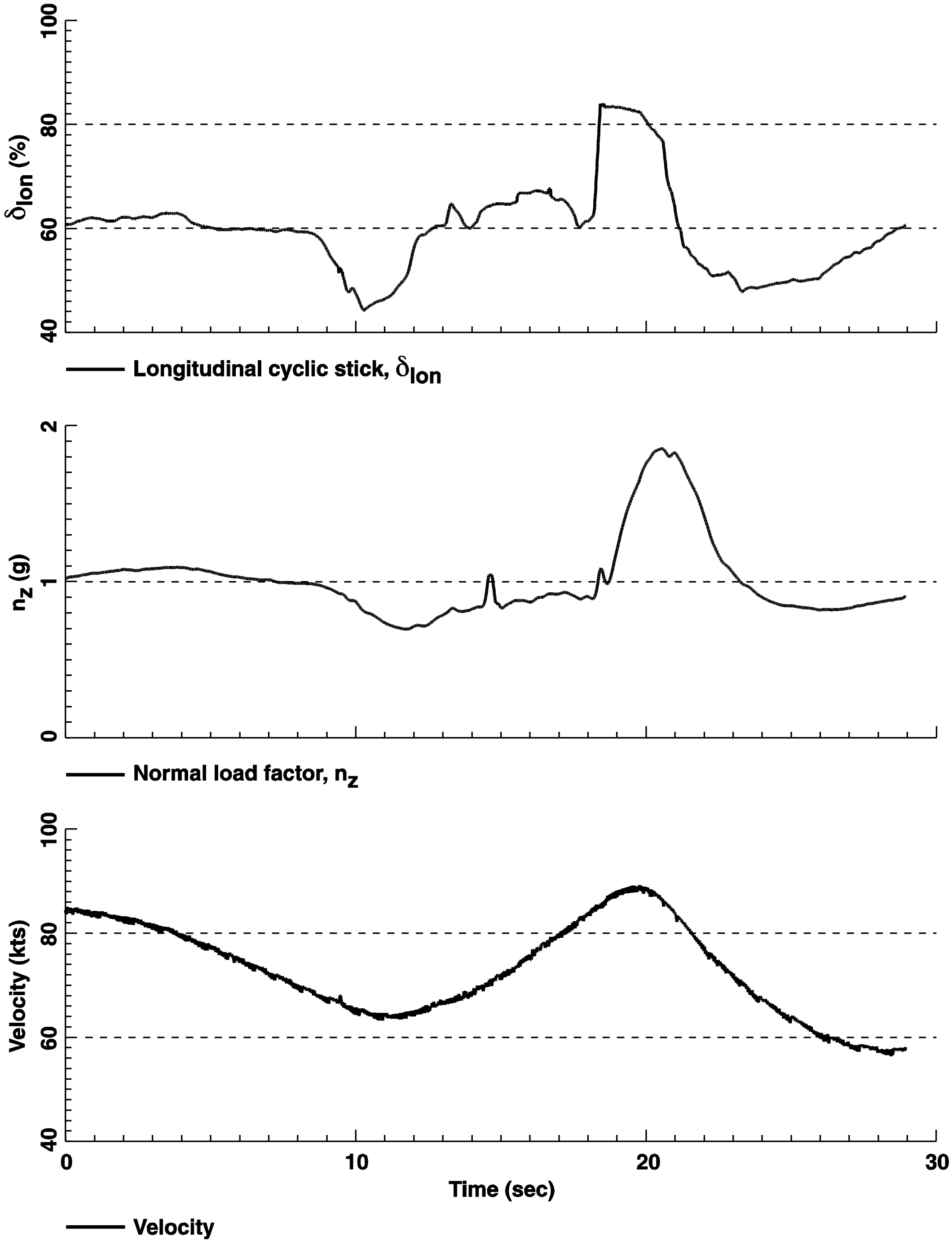


Figure E-51 Steady Pull-Up, 2 g, 80 knots, Flt 213 Rec 19, 3.4.1.3

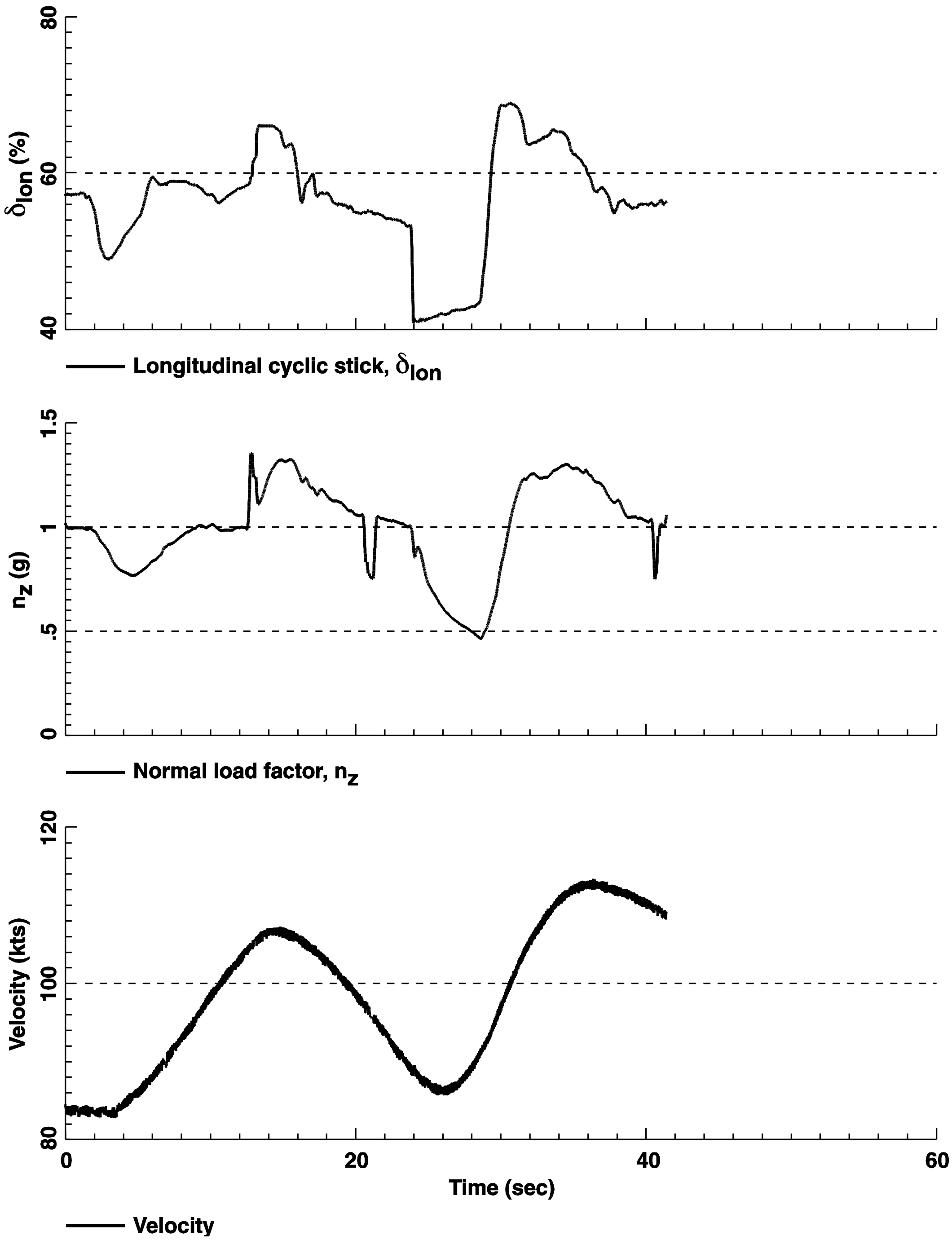


Figure E-52 Steady Push-Over, 80 knots, Flt 213 Rec 22, 3.4.1.3

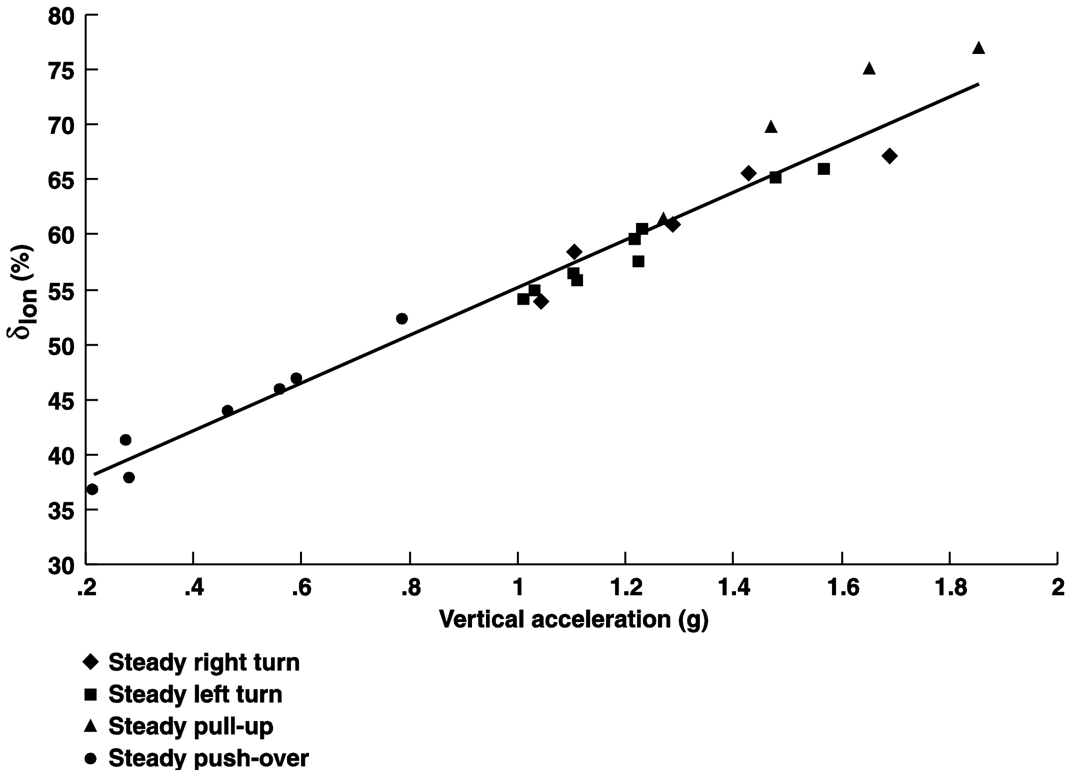


Figure E-53 3.4.1.3 long cyclic vs load factor

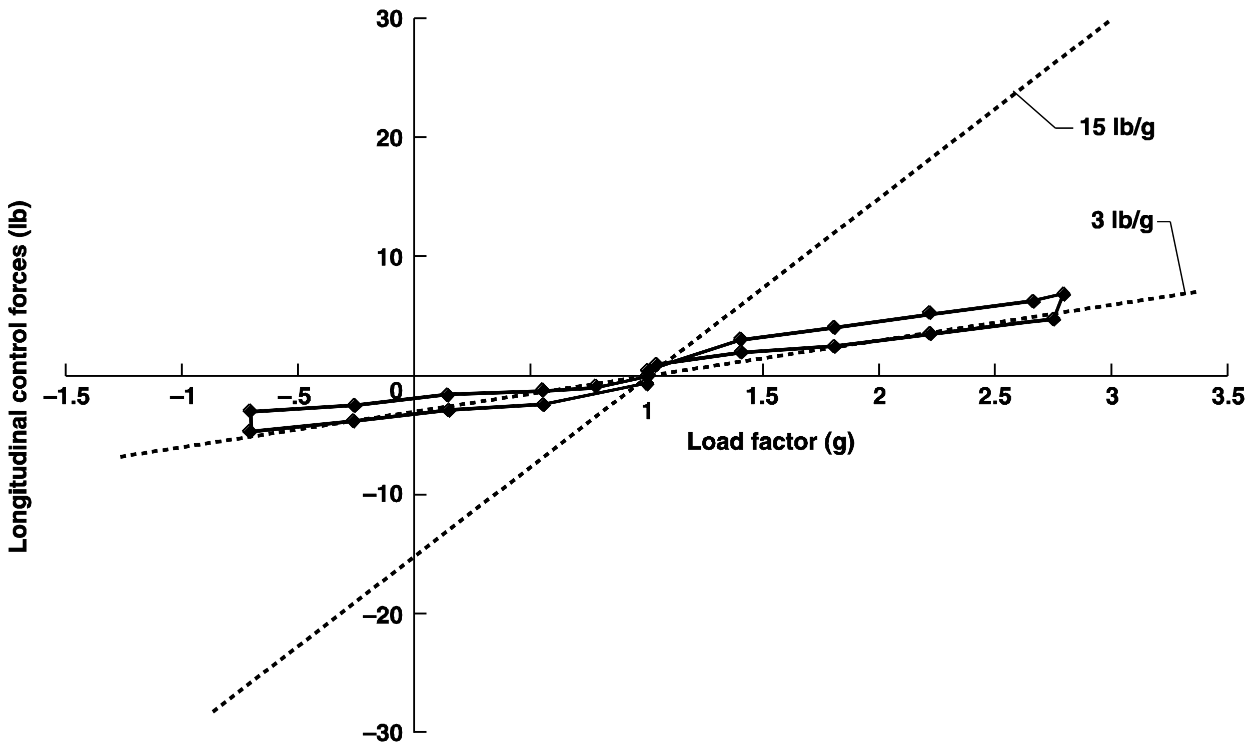


Figure E-54 3.4.1.3 long controller forces, coll up

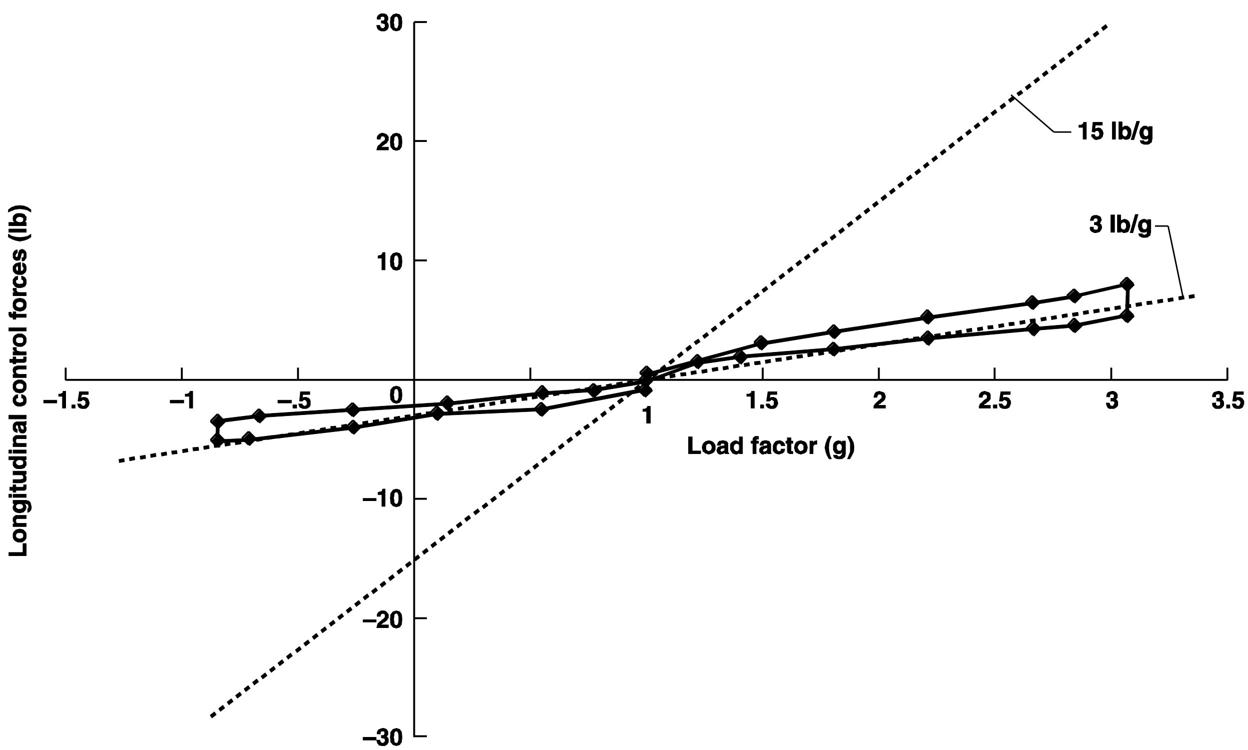


Figure E-55 3.4.1.3 long controller forces, coll down

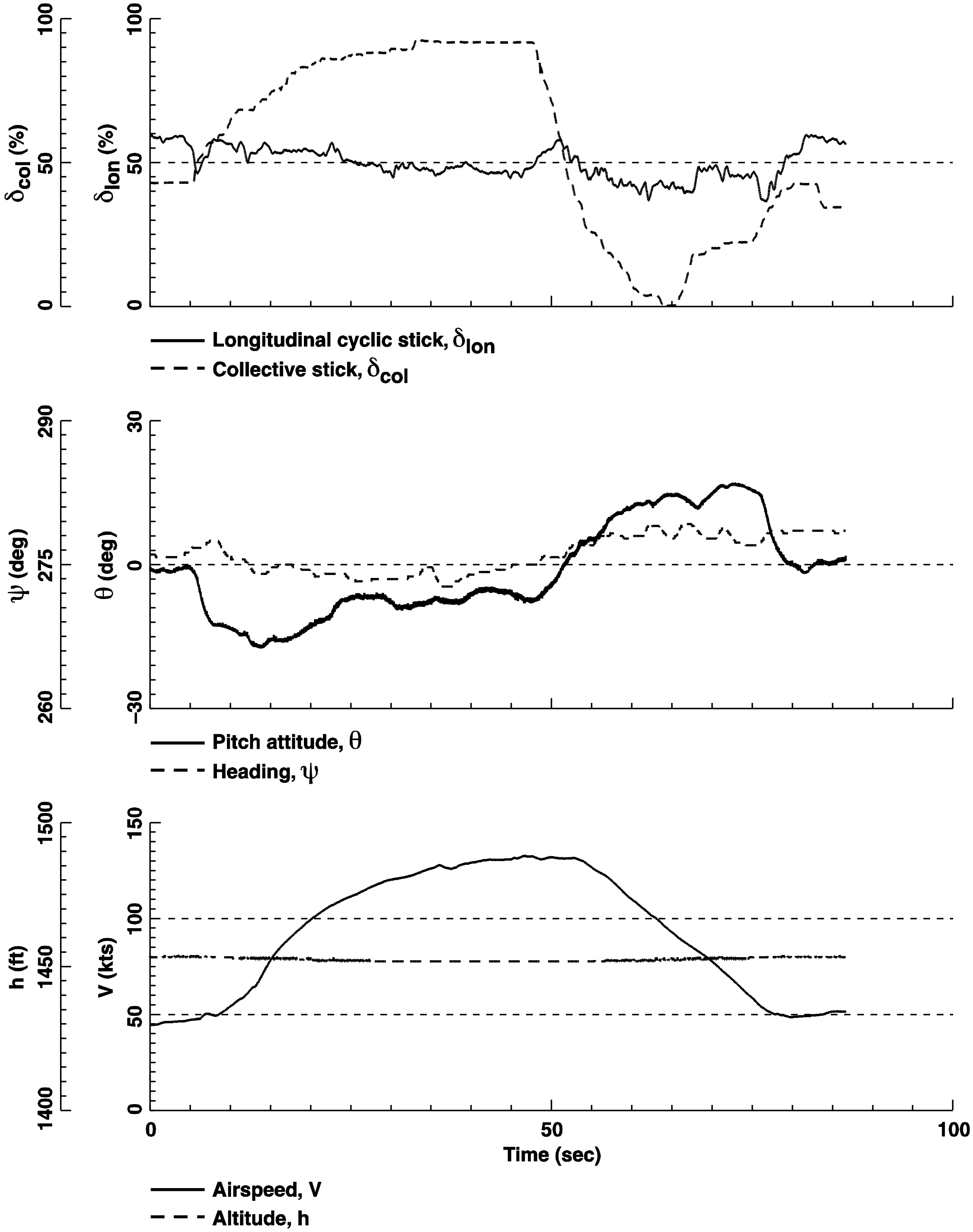


Figure E-56 accel/decel

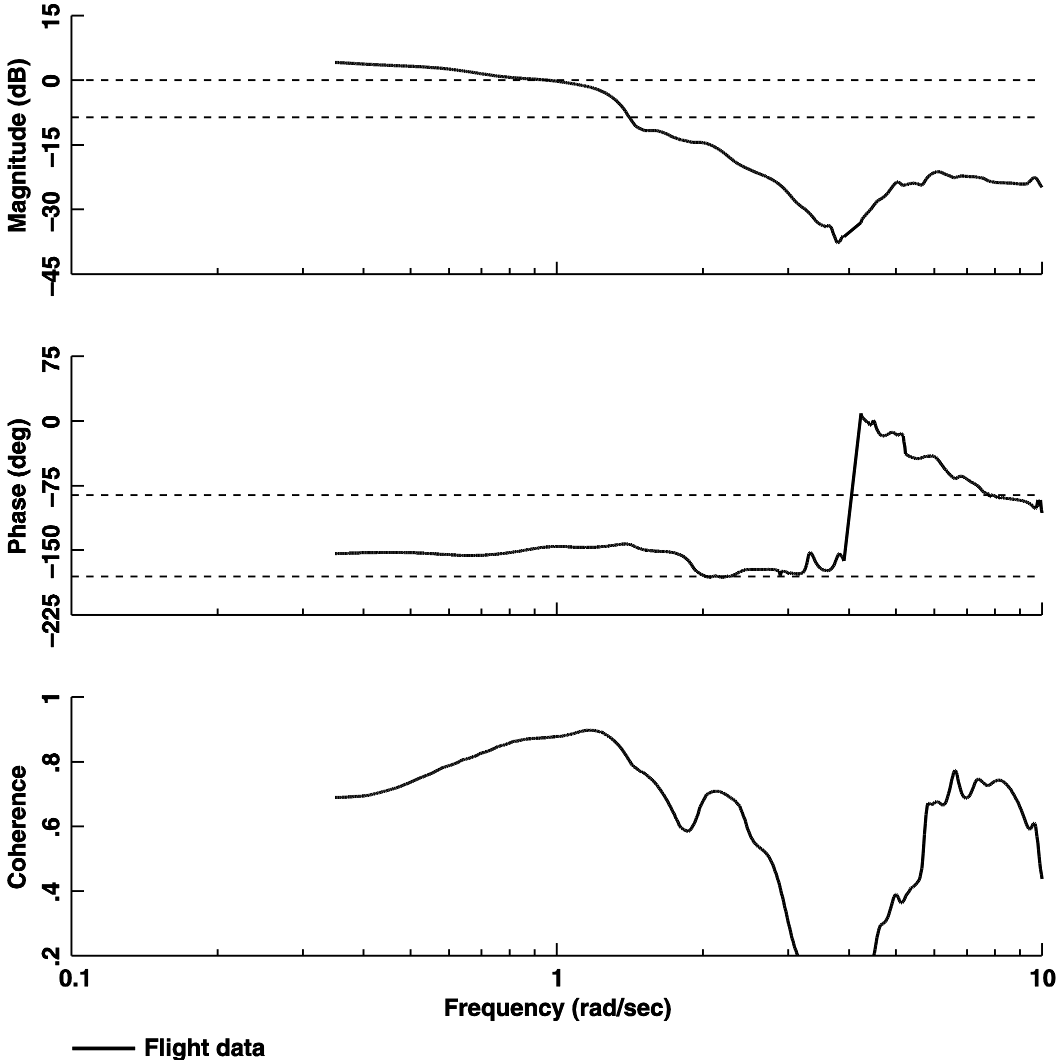


Figure E-57 3.4.3.1 hdot bode

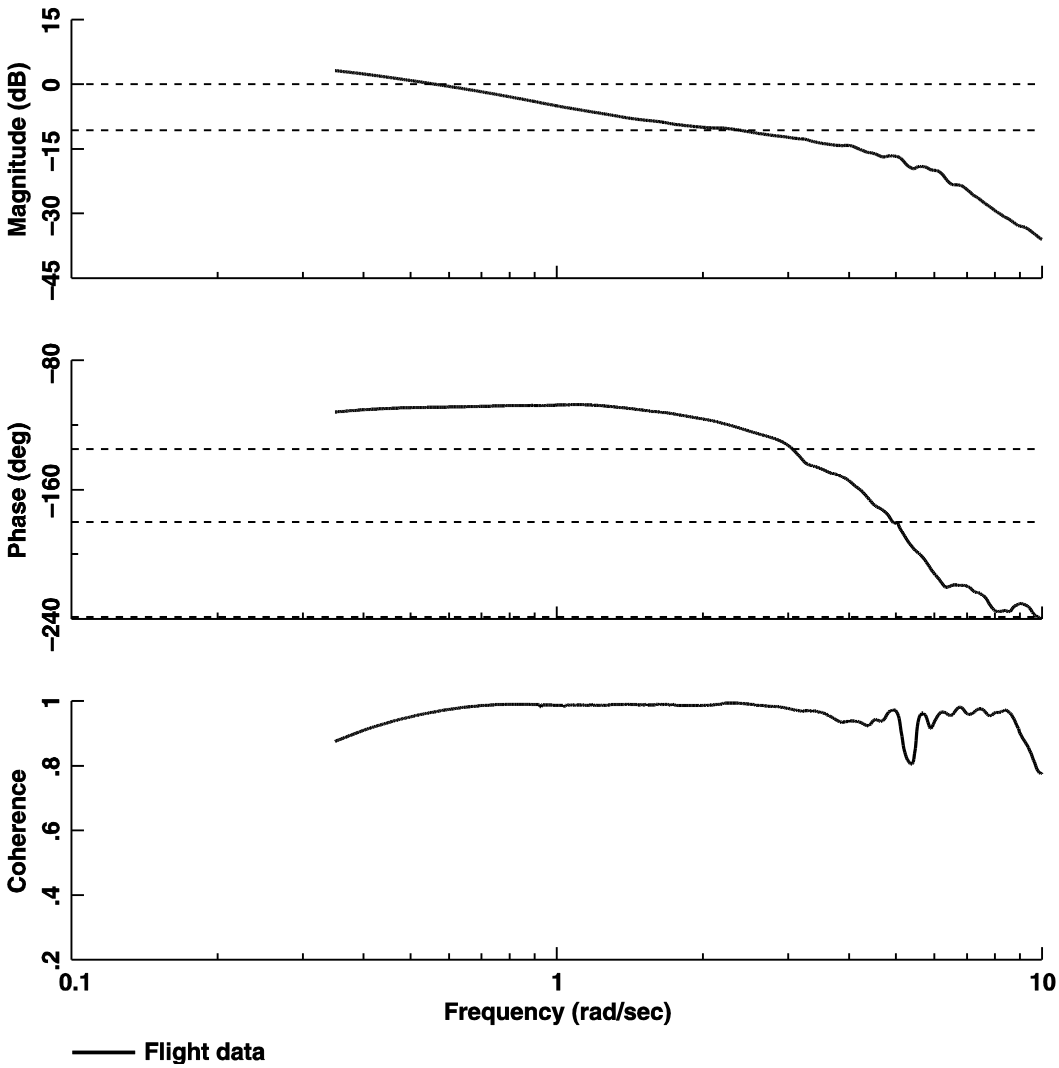


Figure E-58 3.4.3.1 theta bode

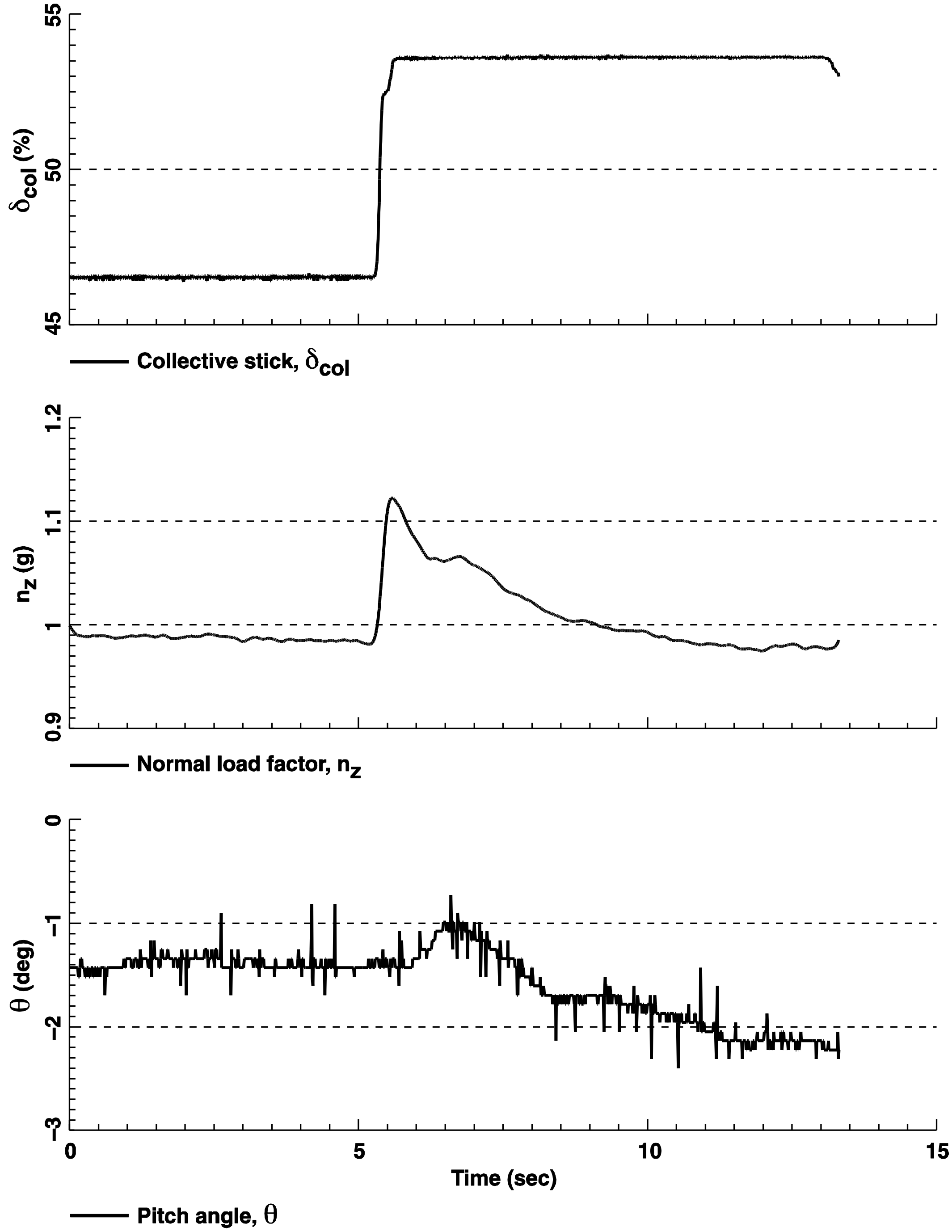


Figure E-59 Collective Step, Small, Up, 80 knots, Flt 213 Rec 58, 3.4.5.1

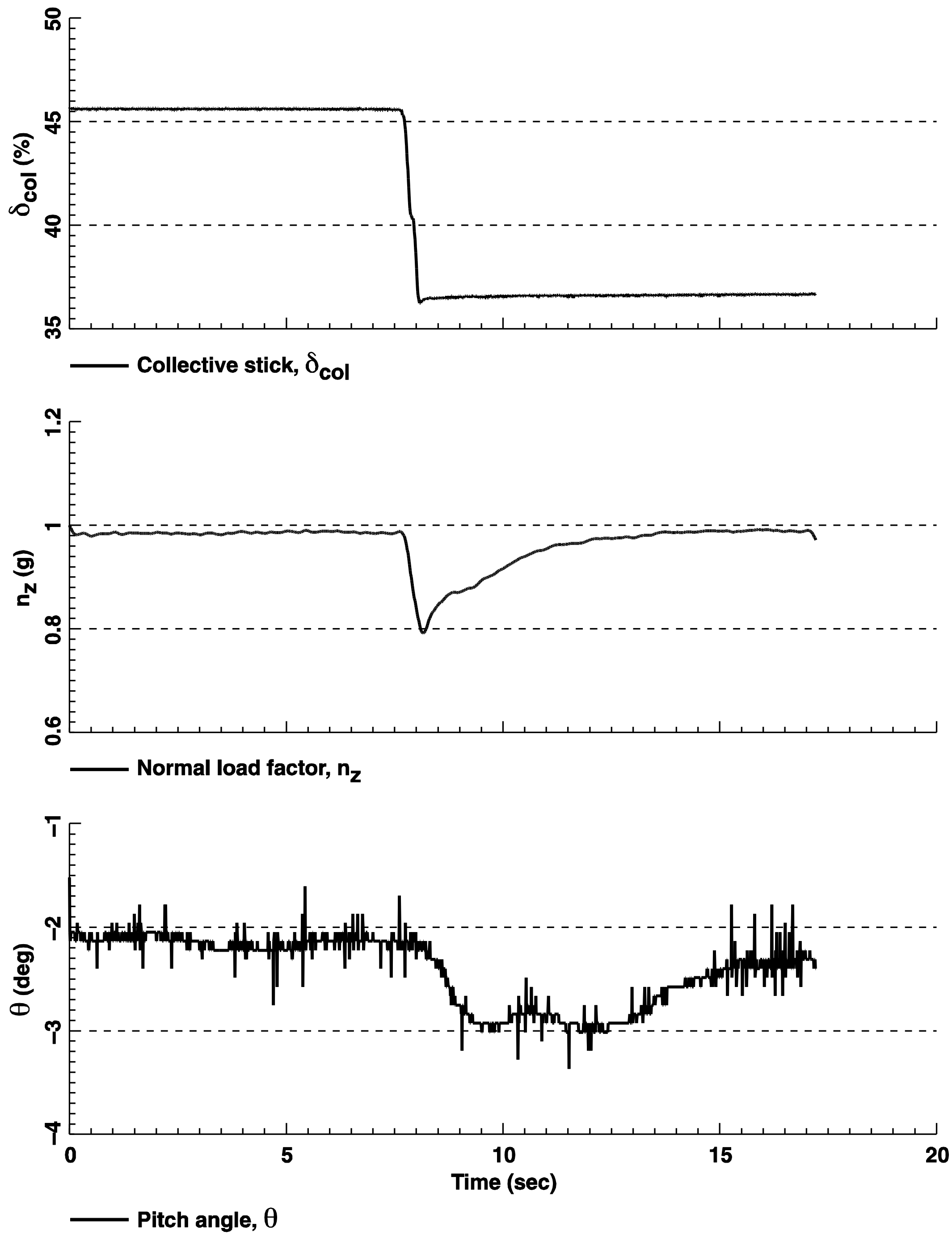


Figure E-60 Collective Step, Small, Down, 80 knots, Flt 213 Rec 62, 3.4.5.1

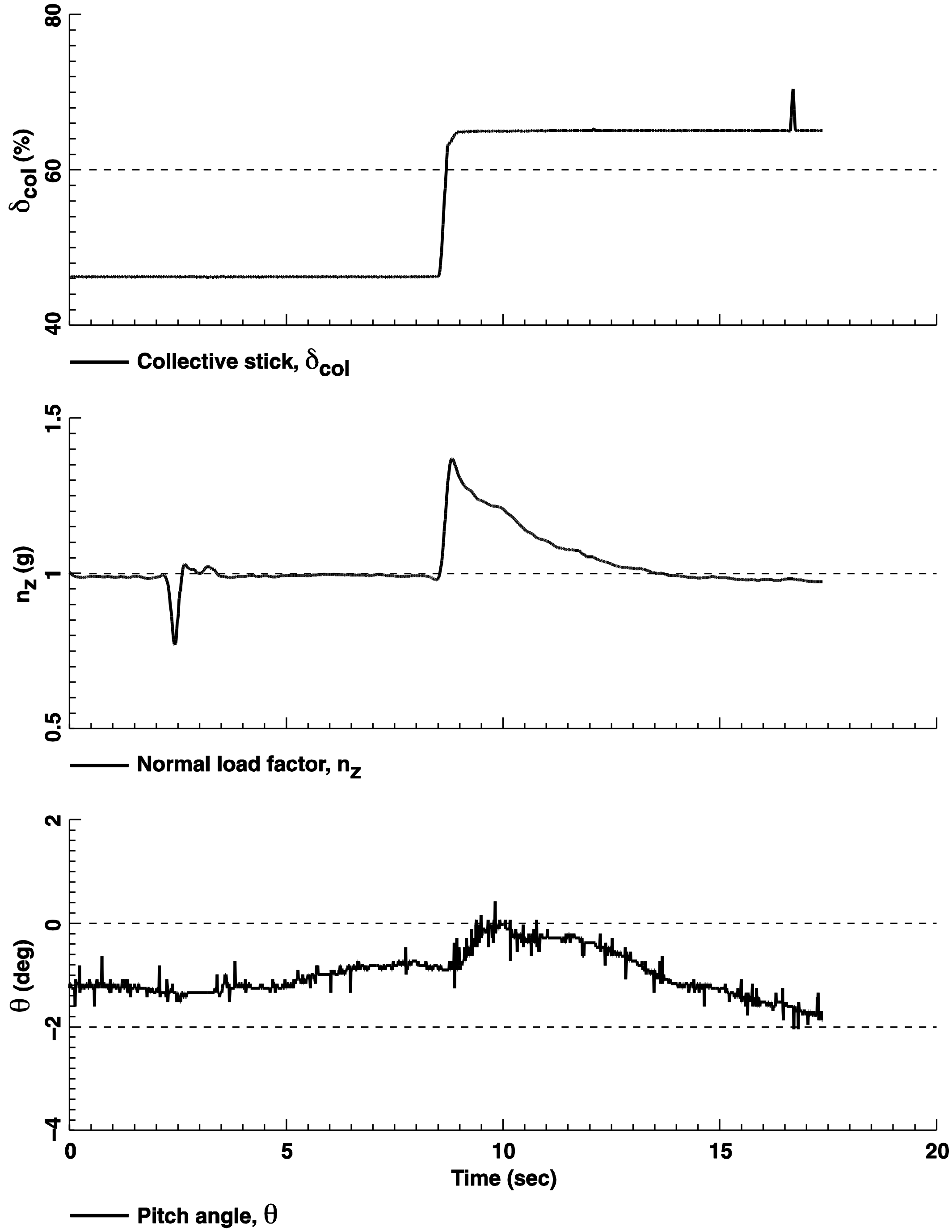


Figure E-61 Collective Step, Large, Up, 80 knots, Flt 213 Rec 64, 3.4.5.1

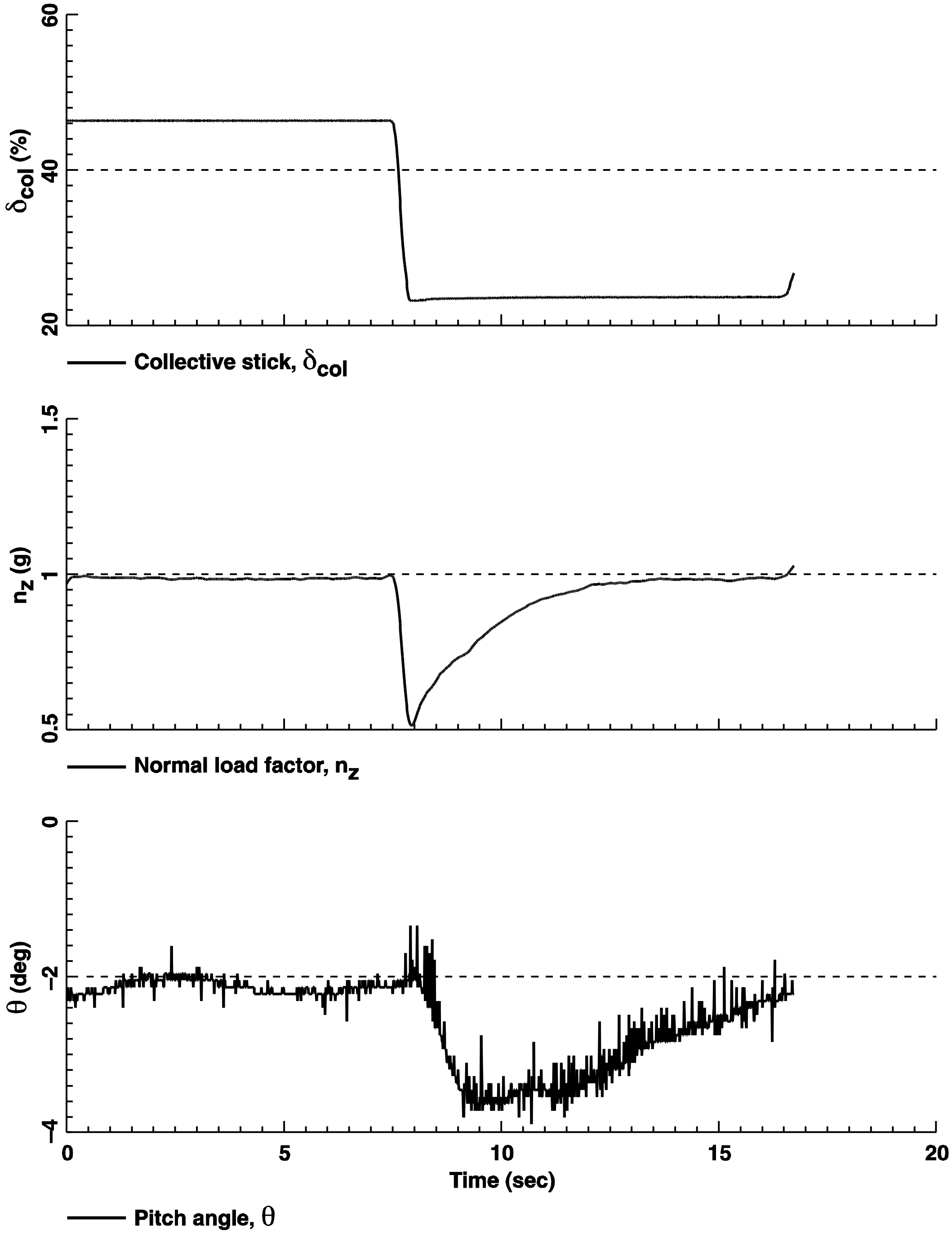


Figure E-62 Collective Step, Large, Down, 80 knots, Flt 213 Rec 67, 3.4.5.1

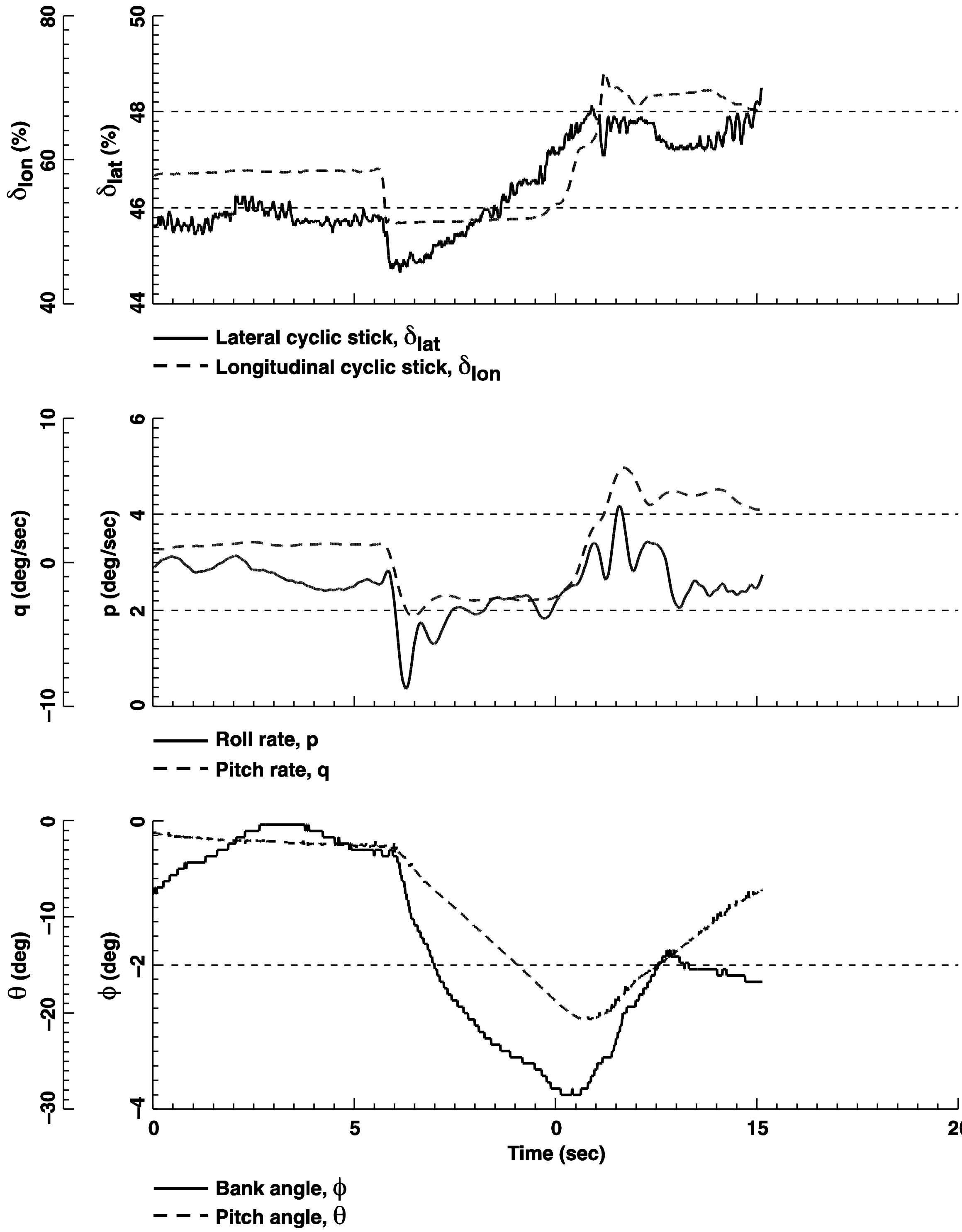


Figure E-63 Lon Step, Fwd, 80 knots, Flt 213 Rec 54, 3.4.5.2 roll due to pitch, aggressive agility

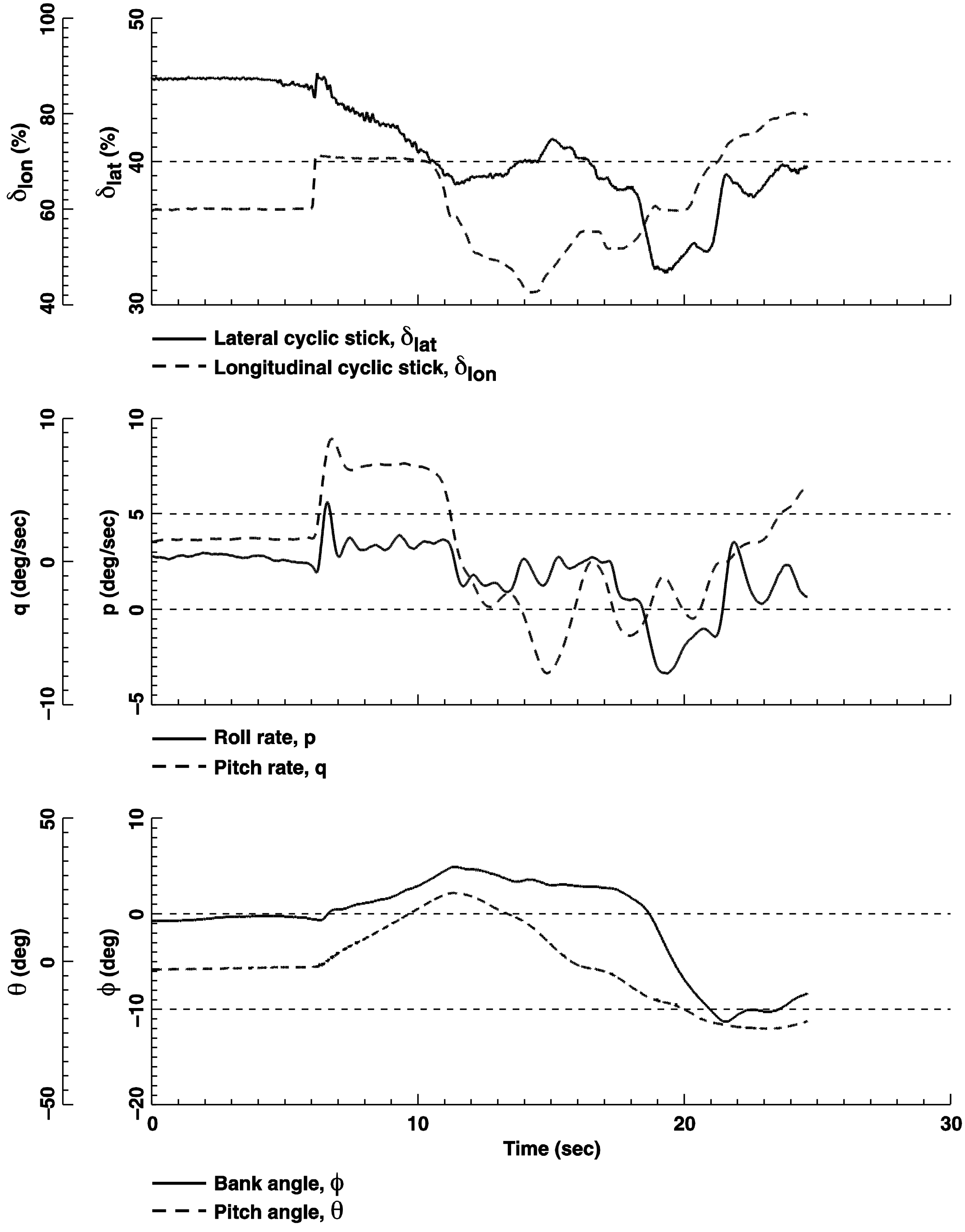


Figure E-64 Lon Step, Aft, 80 knots, Flt 213 Rec 53, 3.4.5.2 roll due to pitch, aggressive agility

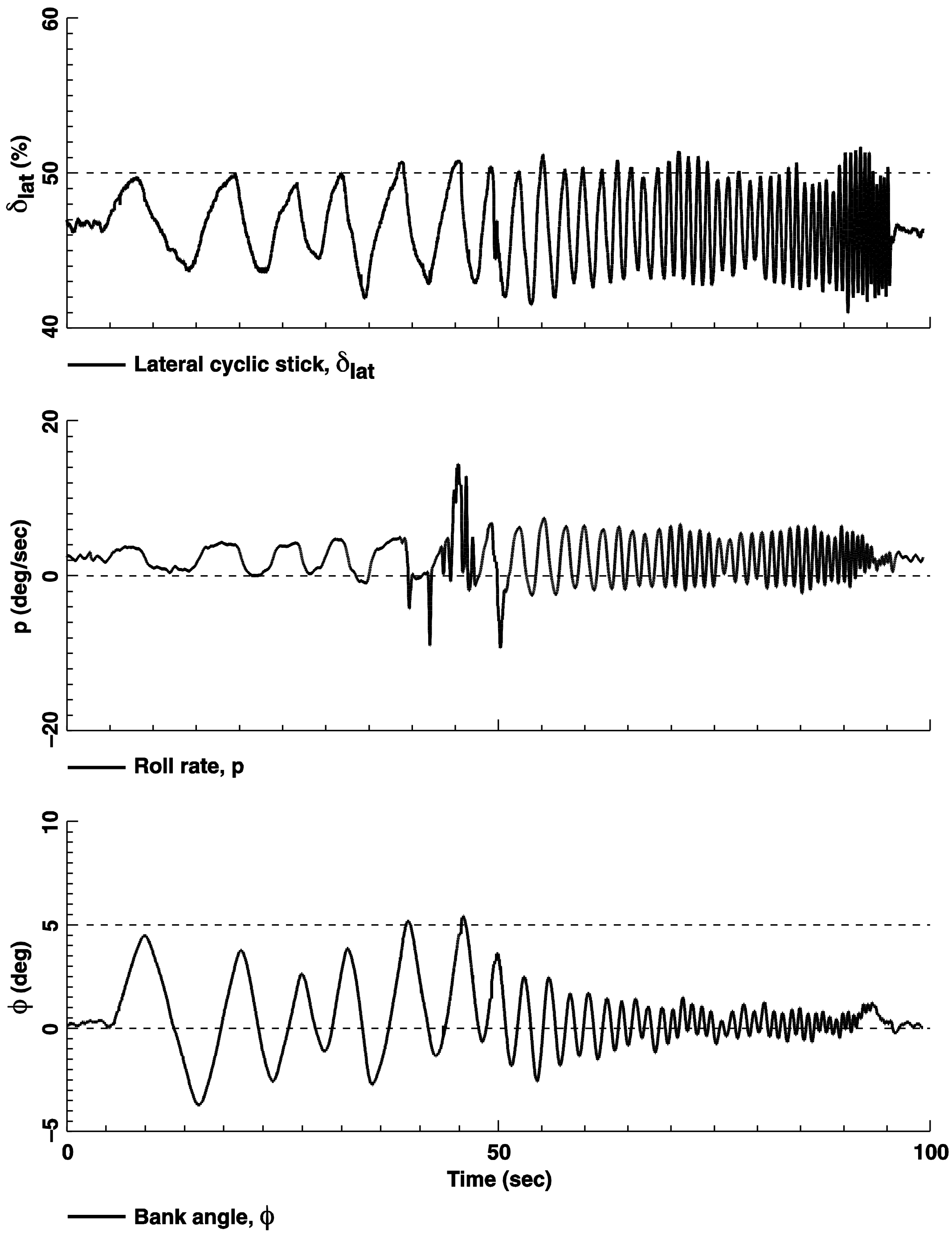


Figure E-65 Typical Lateral Frequency Sweep, 80 knots, Flt 214 Rec 10, 3.4.6.1

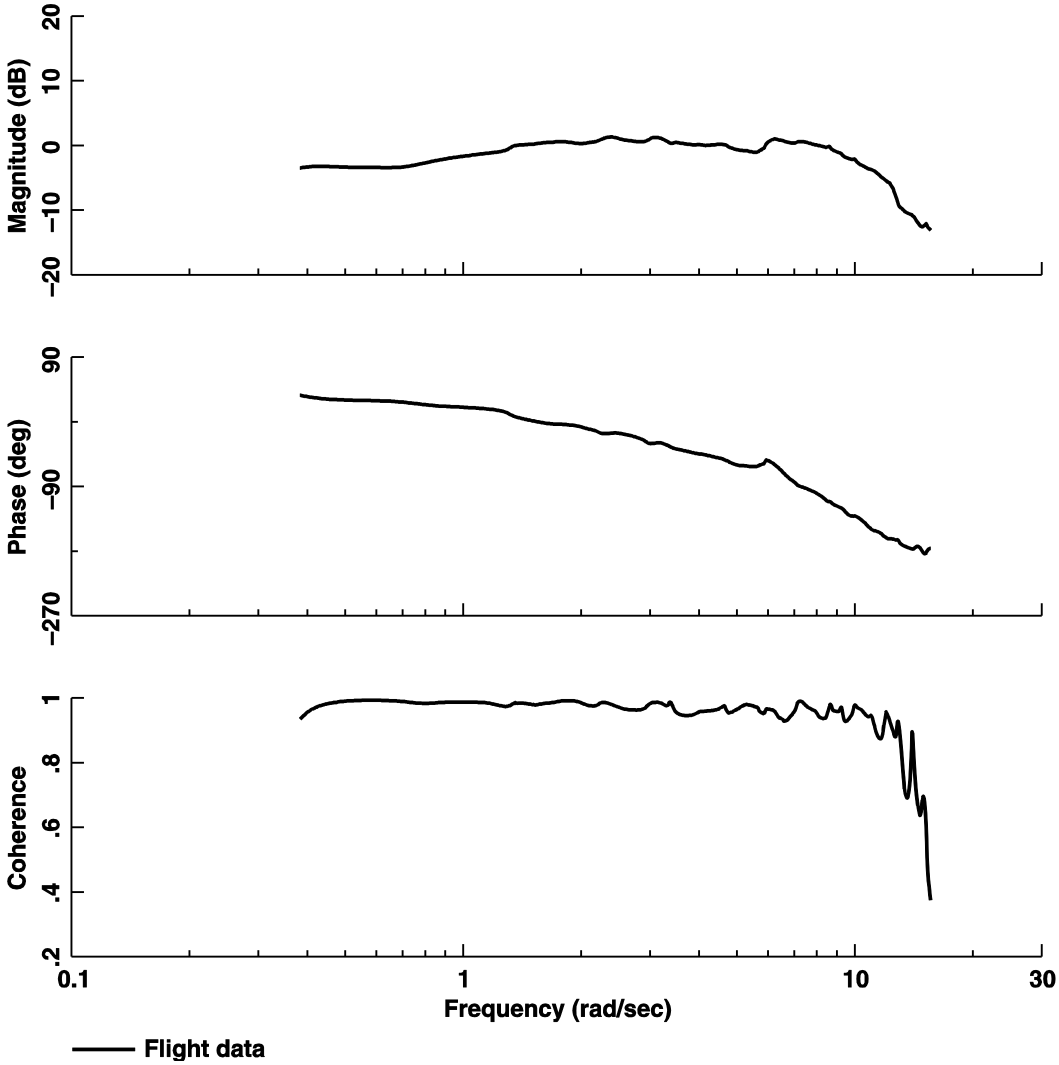


Figure E-66 3.4.6.1 80-knot roll bode

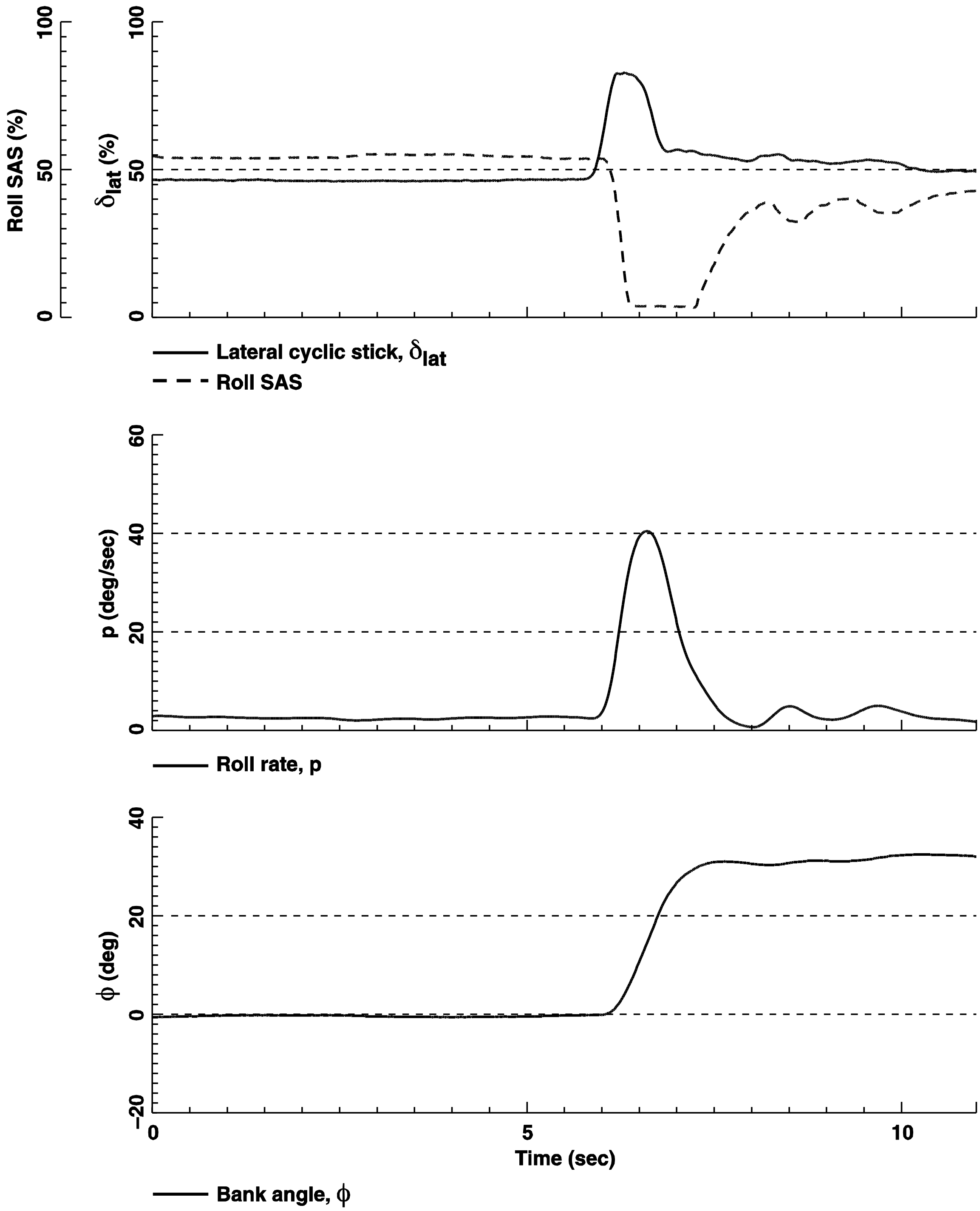


Figure E-67 Lat Pulse, Right, 80 knots, Flt 214 Rec 52, 3.4.6.2 roll AQ

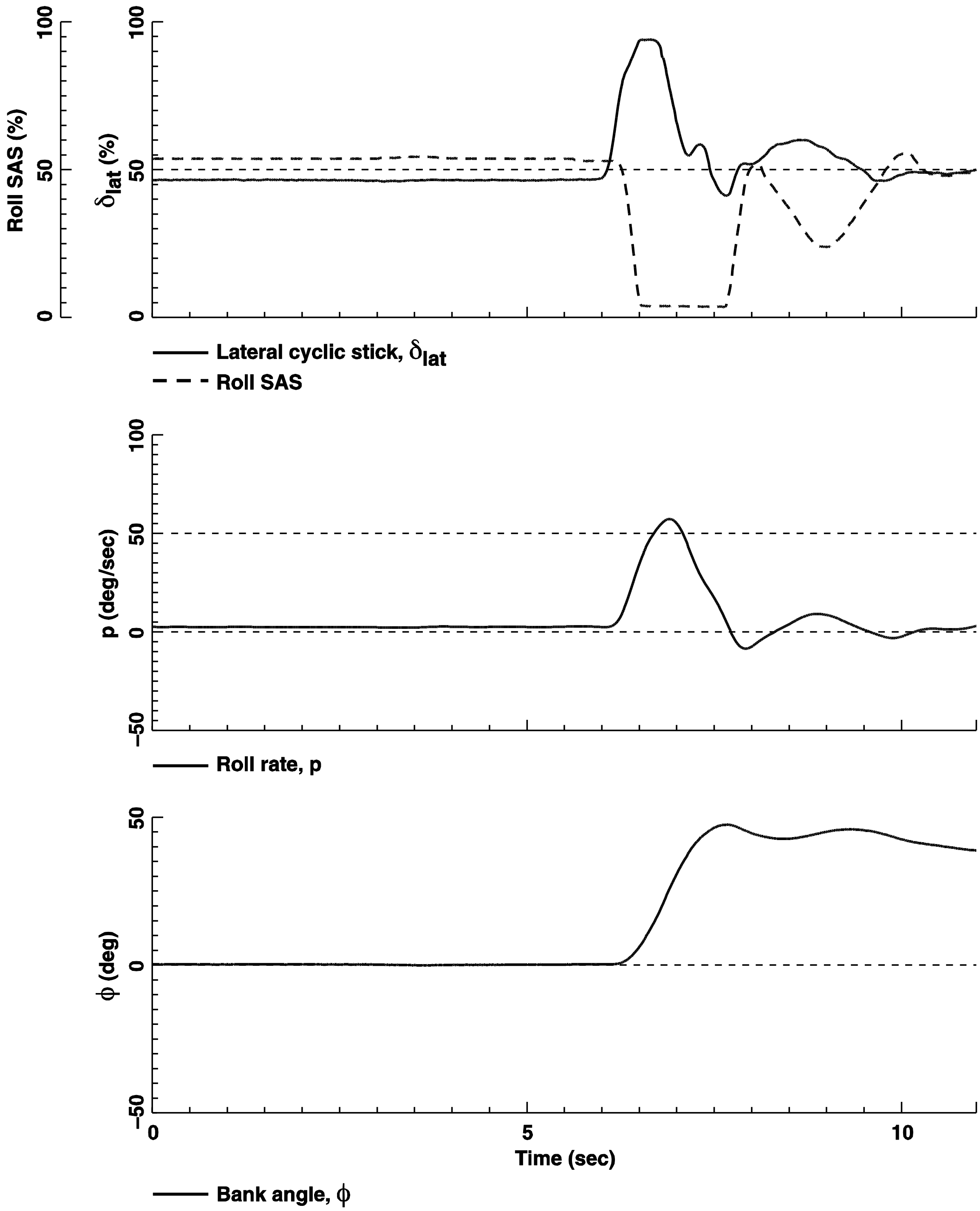


Figure E-68 Lat Pulse, Right, 80 knots, Flt 214 Rec 54, 3.4.6.2 roll AQ

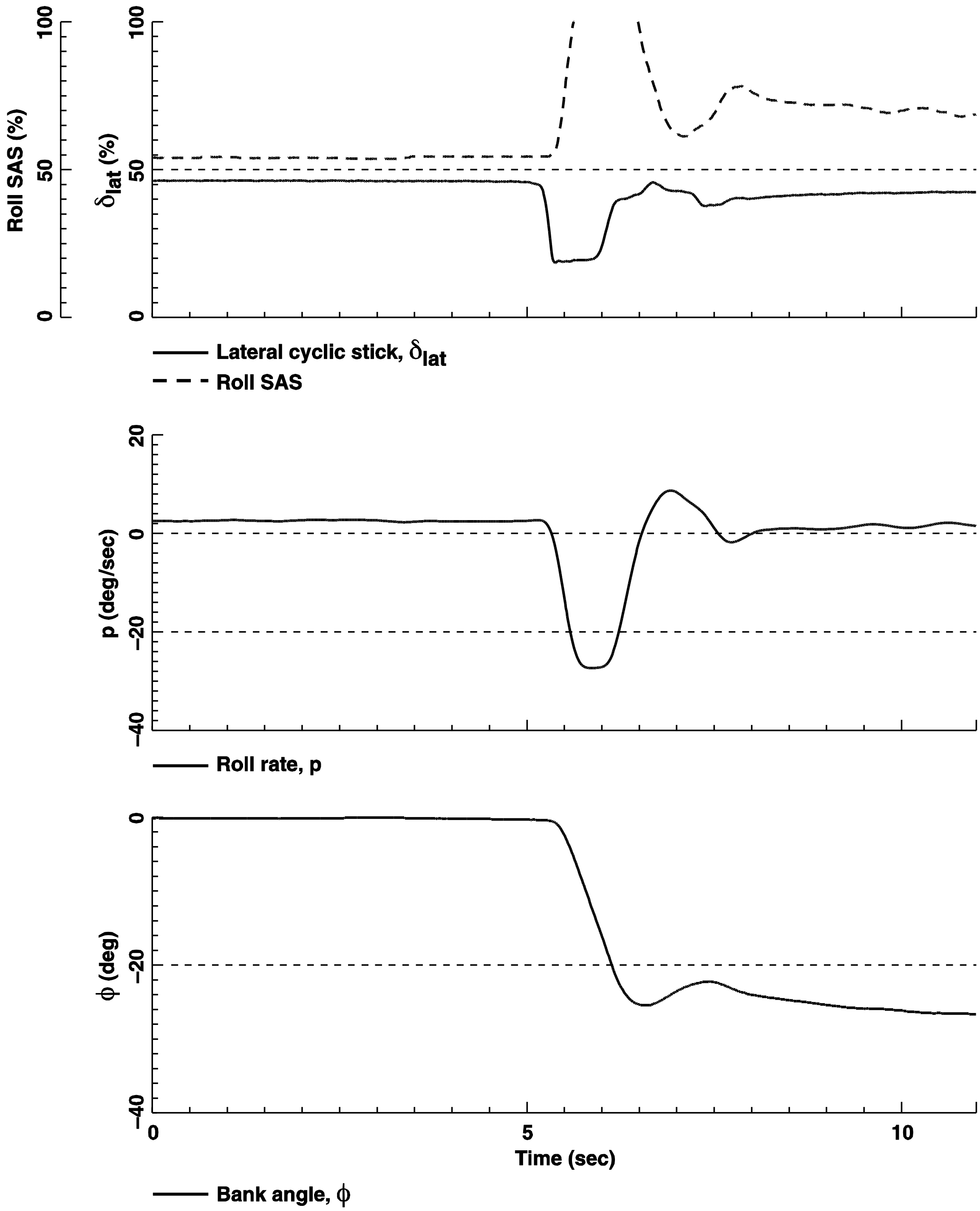


Figure E-69 Lat Pulse, Left, 80 knots, Flt 214 Rec 58, 3.4.6.2 roll AQ

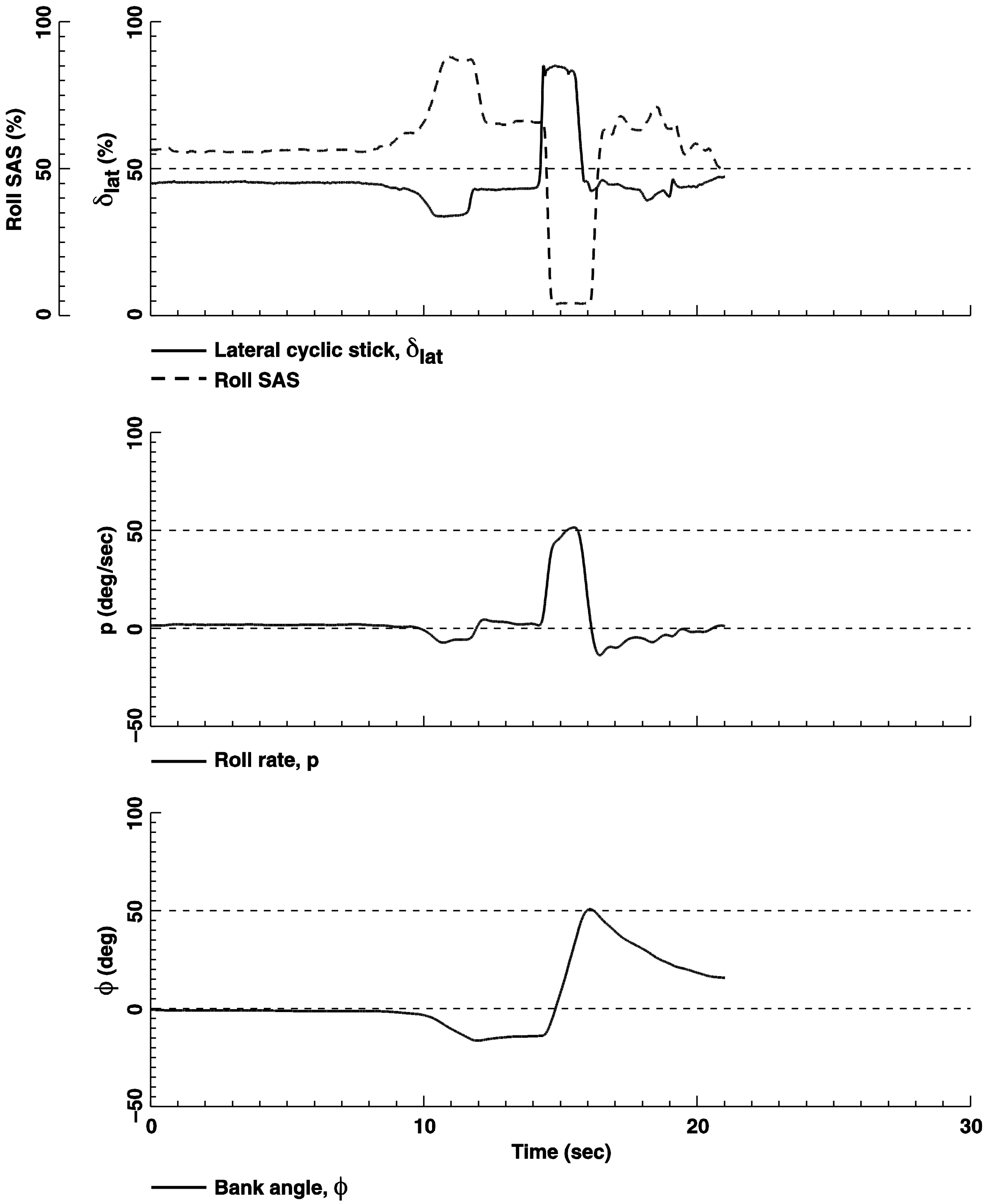


Figure E-70 Lat Step, Right, 80 knots, Flt 213 Rec 44, 3.4.6.3 large amplitude roll

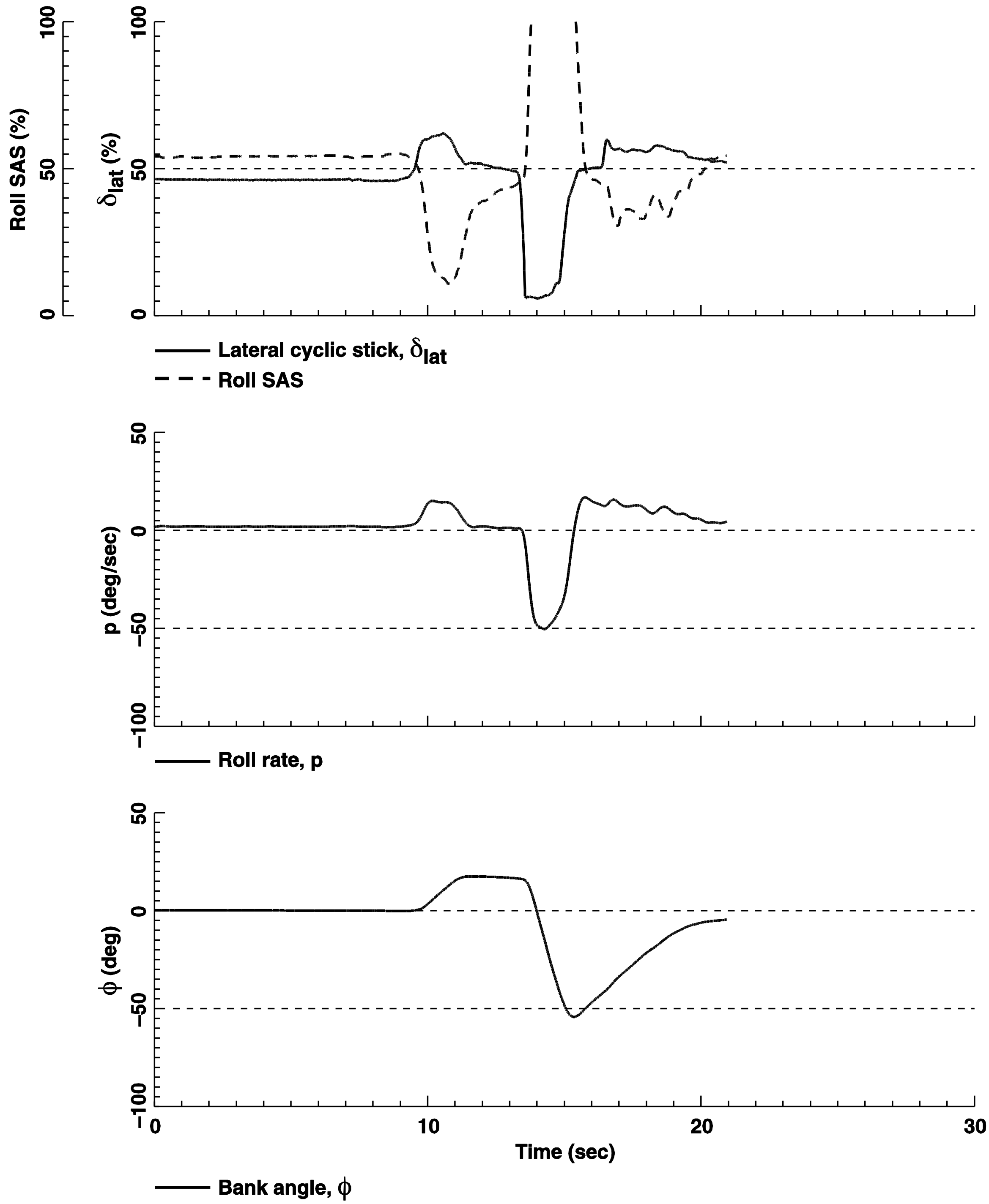


Figure E-71 Lat Step, Left, 80 knots, Flt 213 Rec 50, 3.4.6.3 large amplitude roll

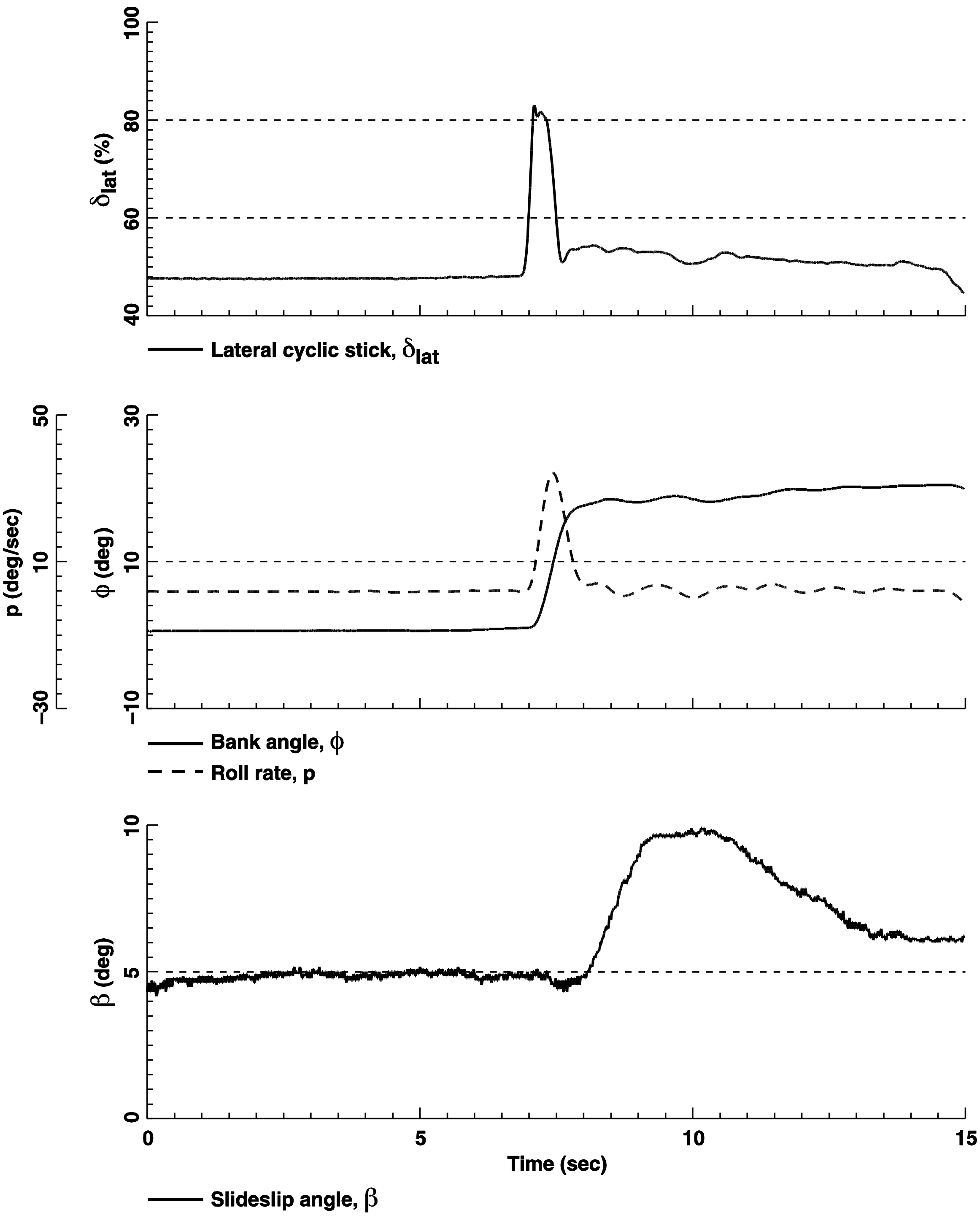


Figure E-72 Lat Pulse, Right, 80 knots, Flt 213 Rec 29, 3.4.7.1 bank angle oscillations

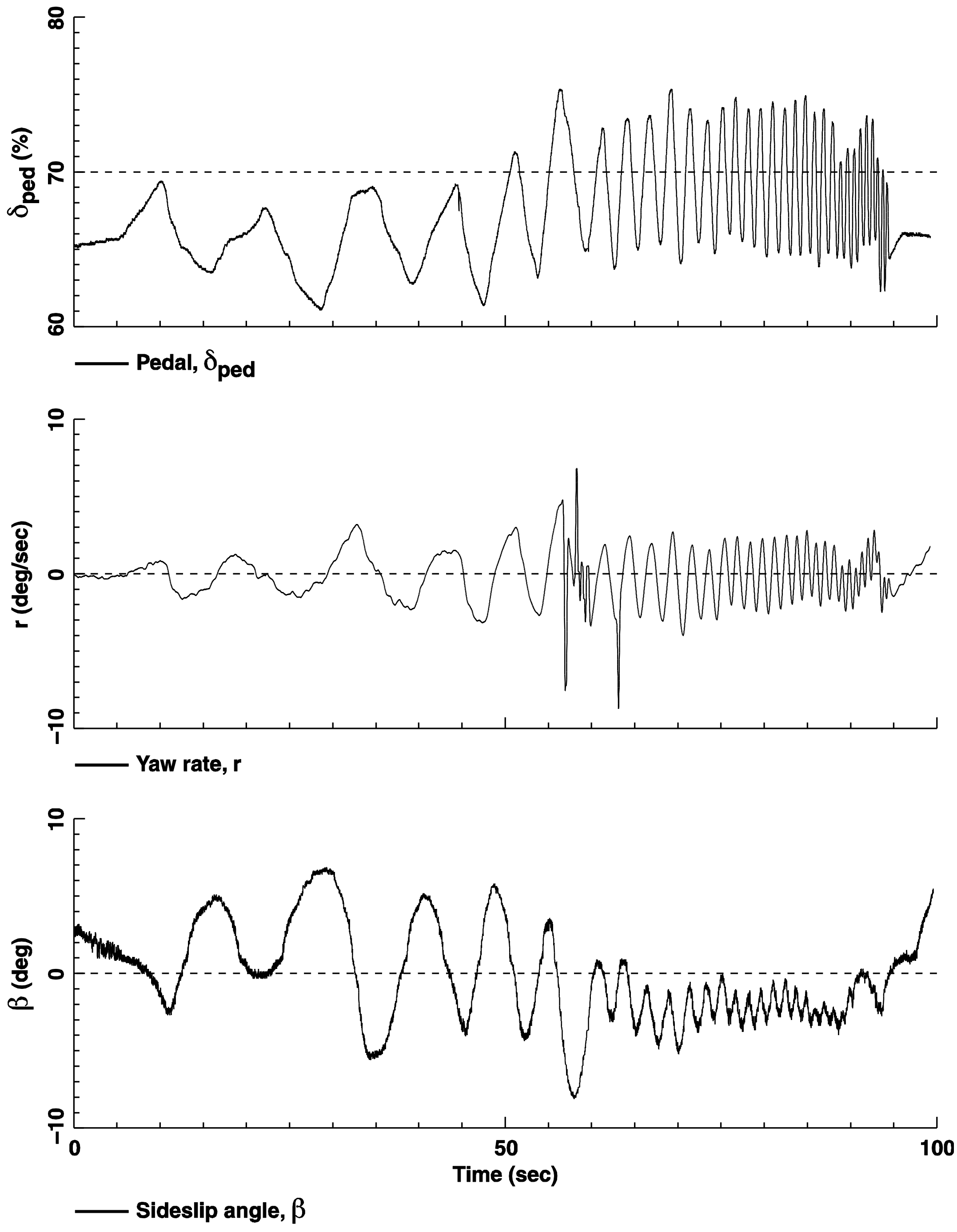


Figure E-73 Typical Pedal Frequency Sweep, 80 knots, Flt 214 Rec 14, 3.4.8.1

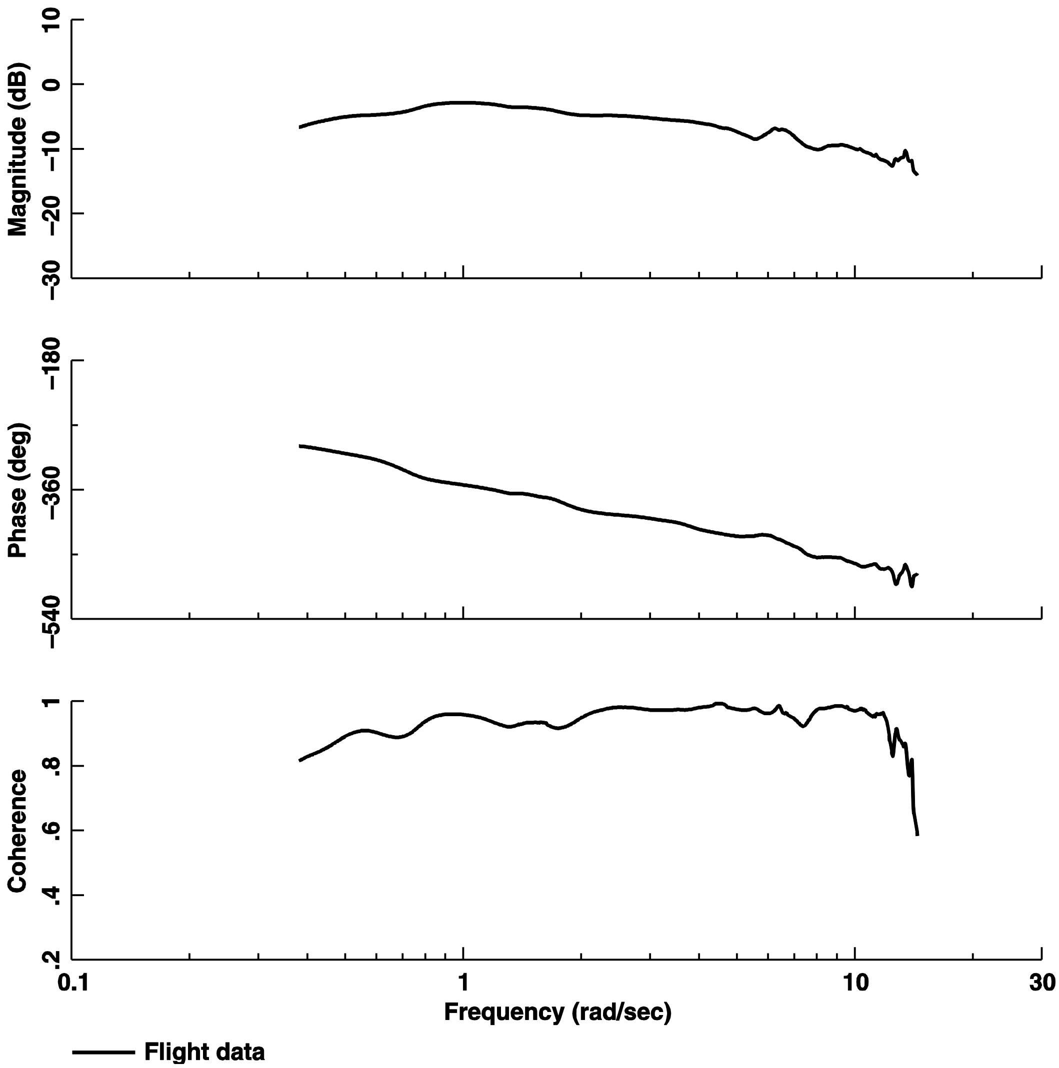


Figure E-74 3.4.8.1 yaw bode

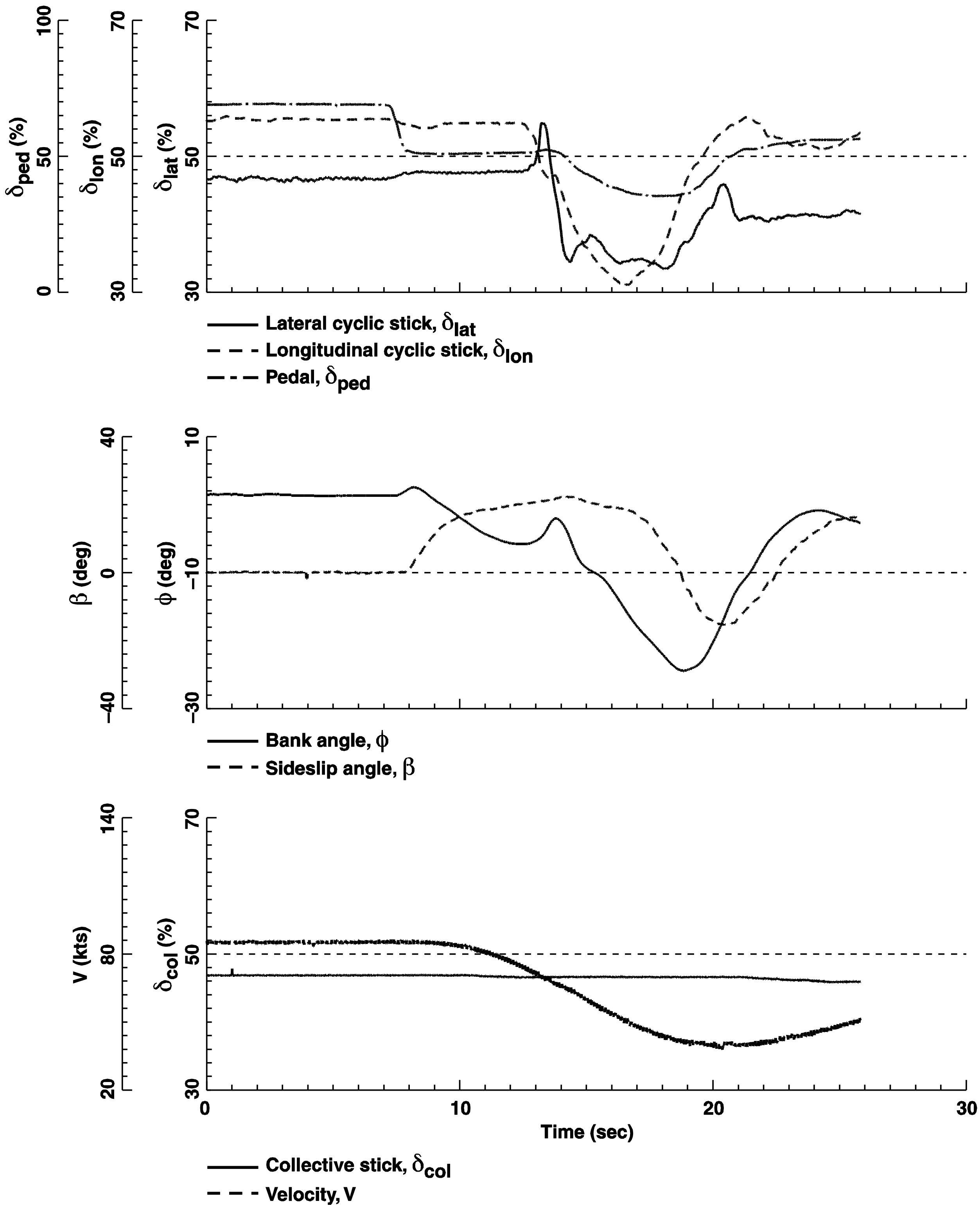


Figure E-75 Pedal Step, Left, 80 knots, Flt 214 Rec 45, 3.4.8.2 yaw large amplitude

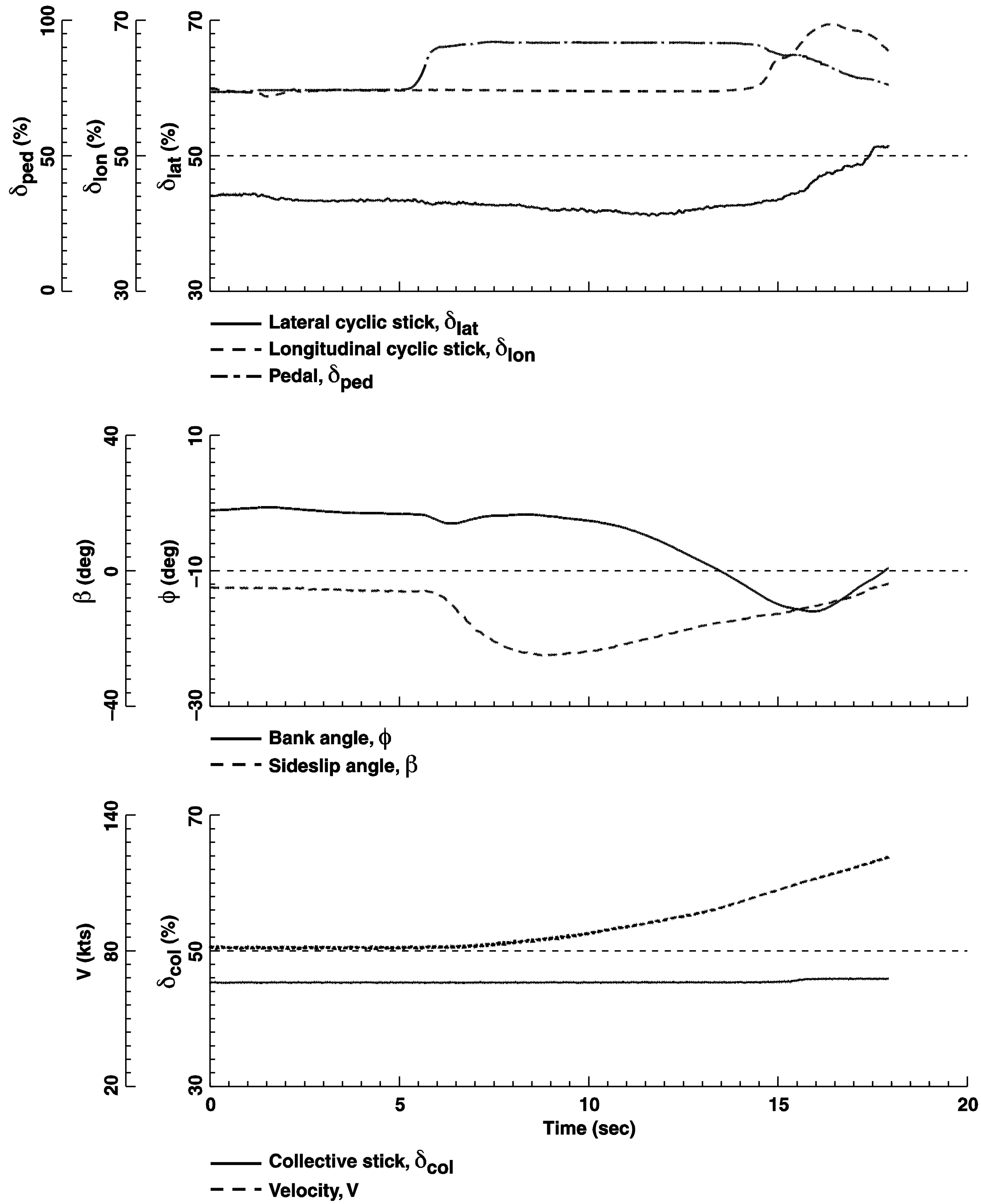


Figure E-76 Pedal Step, Right, 80 knots, Flt 214 Rec 47, 3.4.8.2 yaw large amplitude

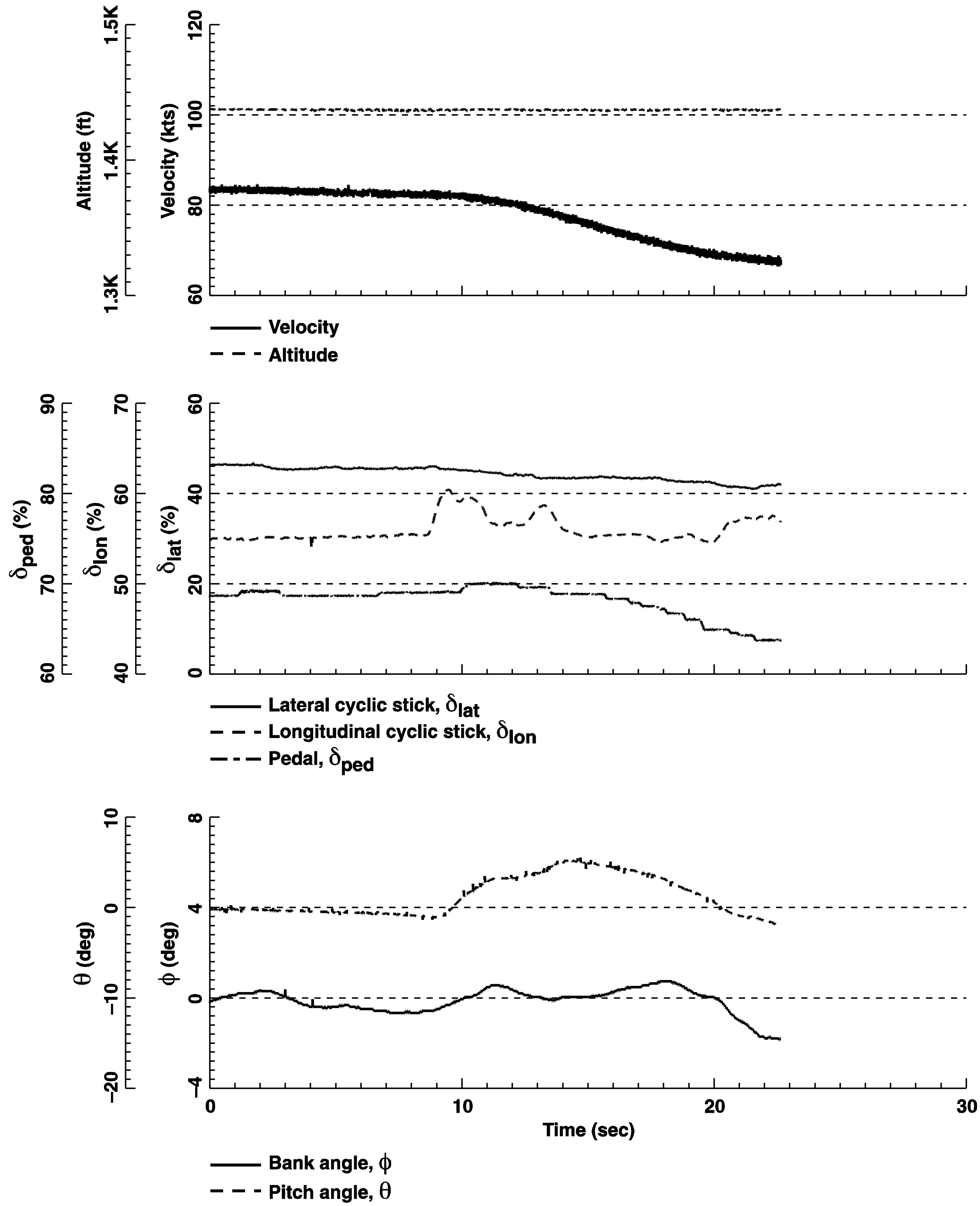


Figure E-77 Deceleration, 80–60 knots, Flt 214 Rec 29, 3.4.8.4 yaw control with speed changes

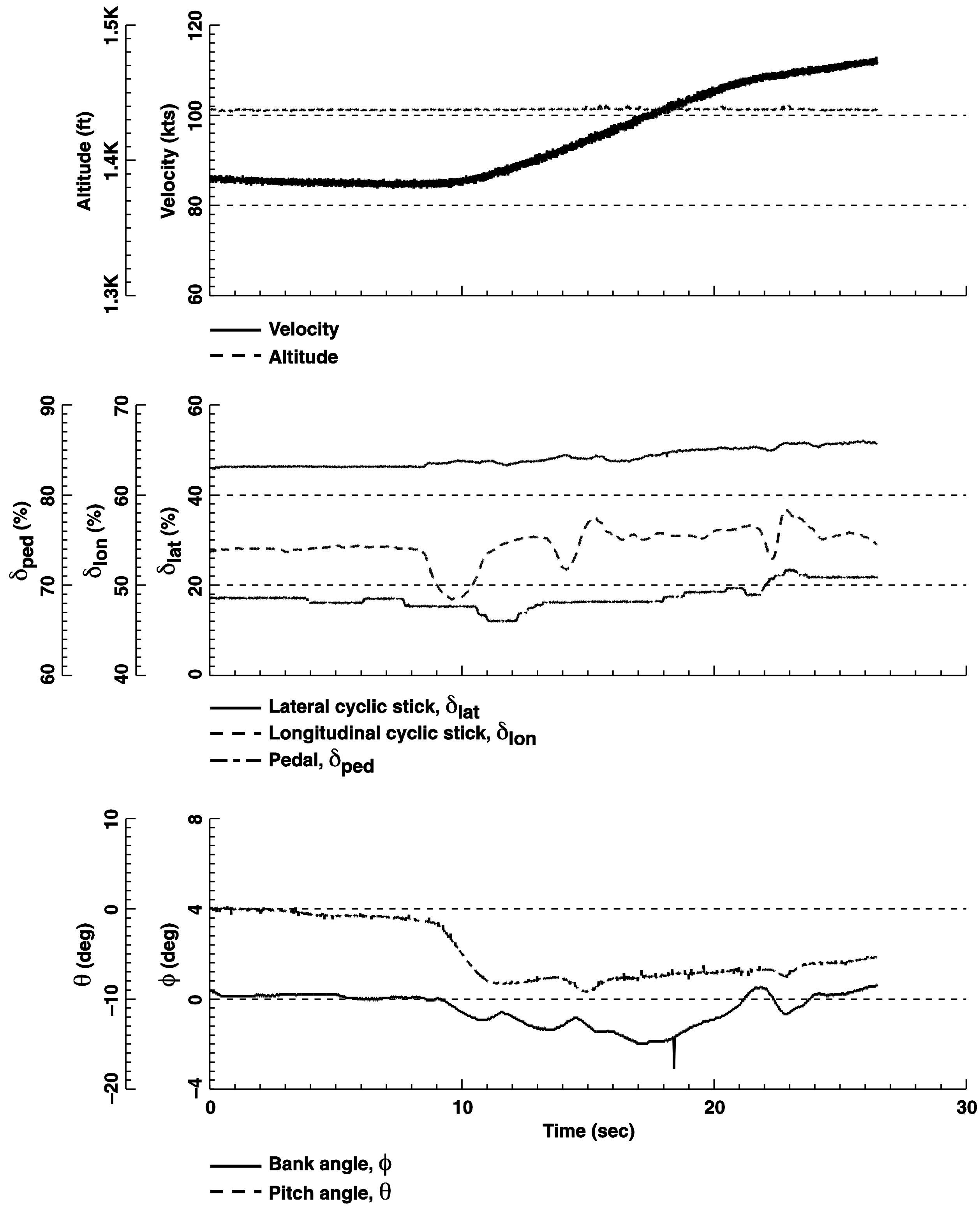


Figure E-78 Acceleration, 80–100 knots, Flt 214 Rec 33, 3.4.8.4 yaw control with speed changes

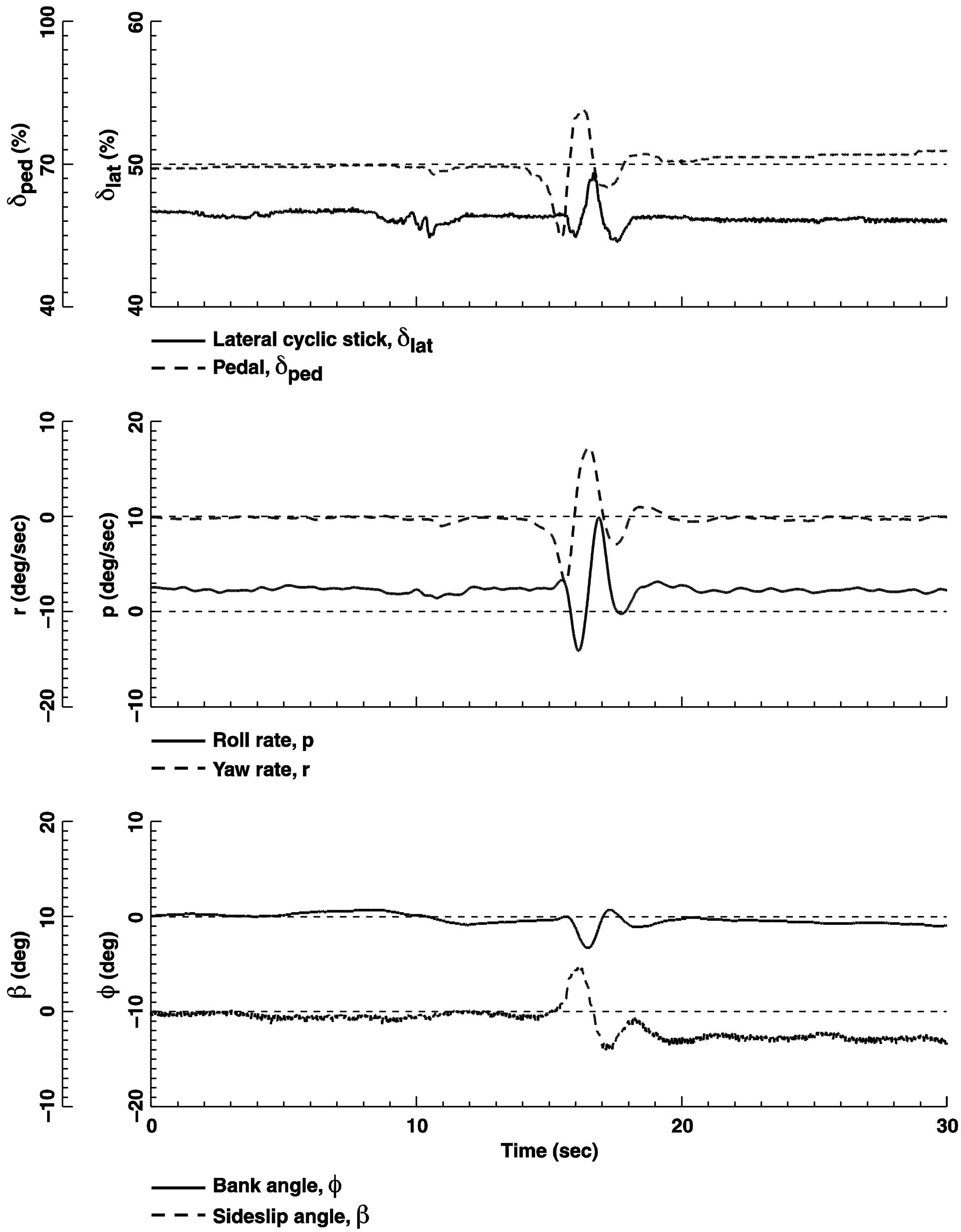


Figure E-79 Pedal Doublet, Left, 80 knots, Flt 214 Rec 27, 3.4.9.1 lat-dir oscillations

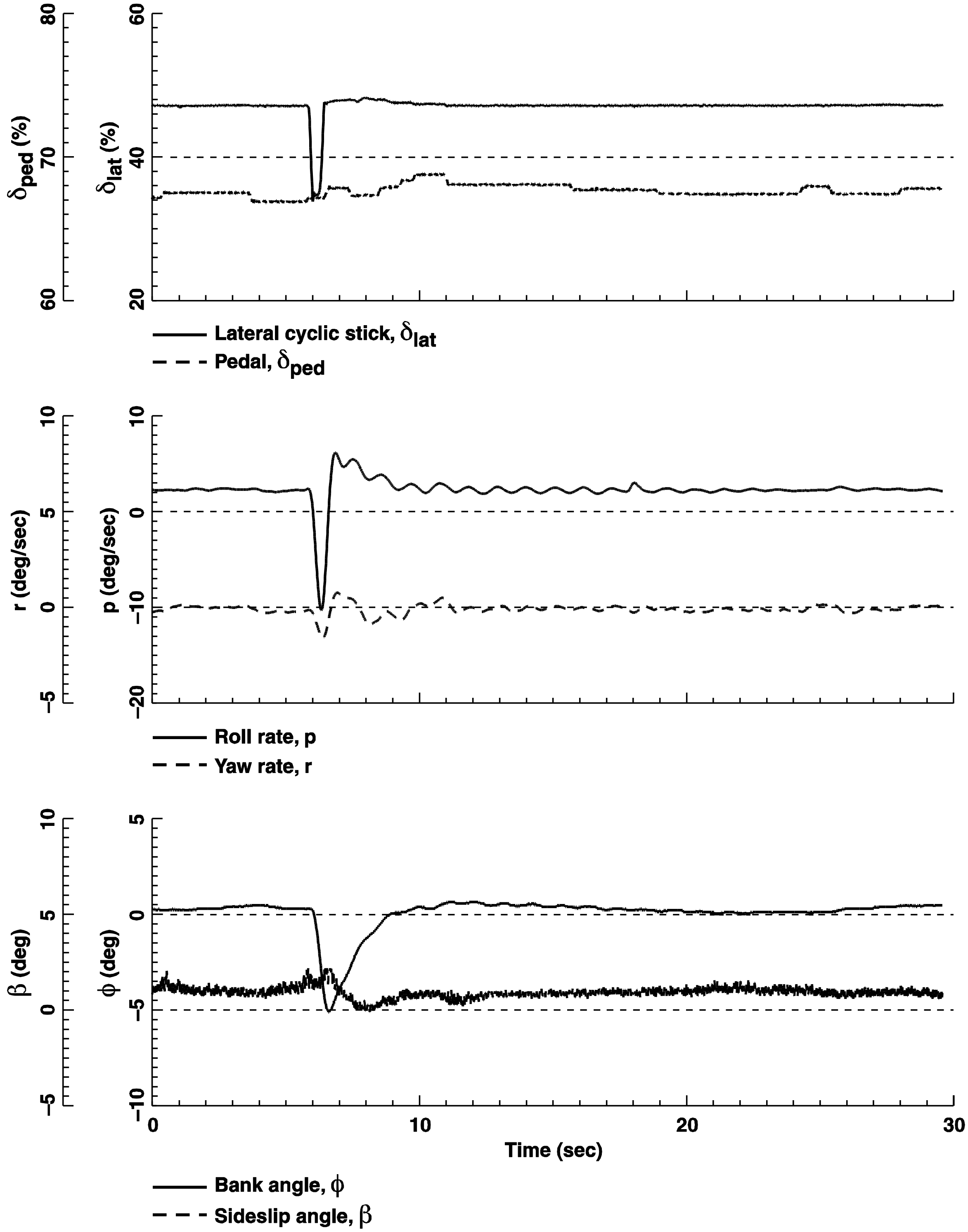


Figure E-80 Lat Pulse, Left, 80 knots, Flt 214 Rec 19, 3.4.9.1 lat-dir oscillations

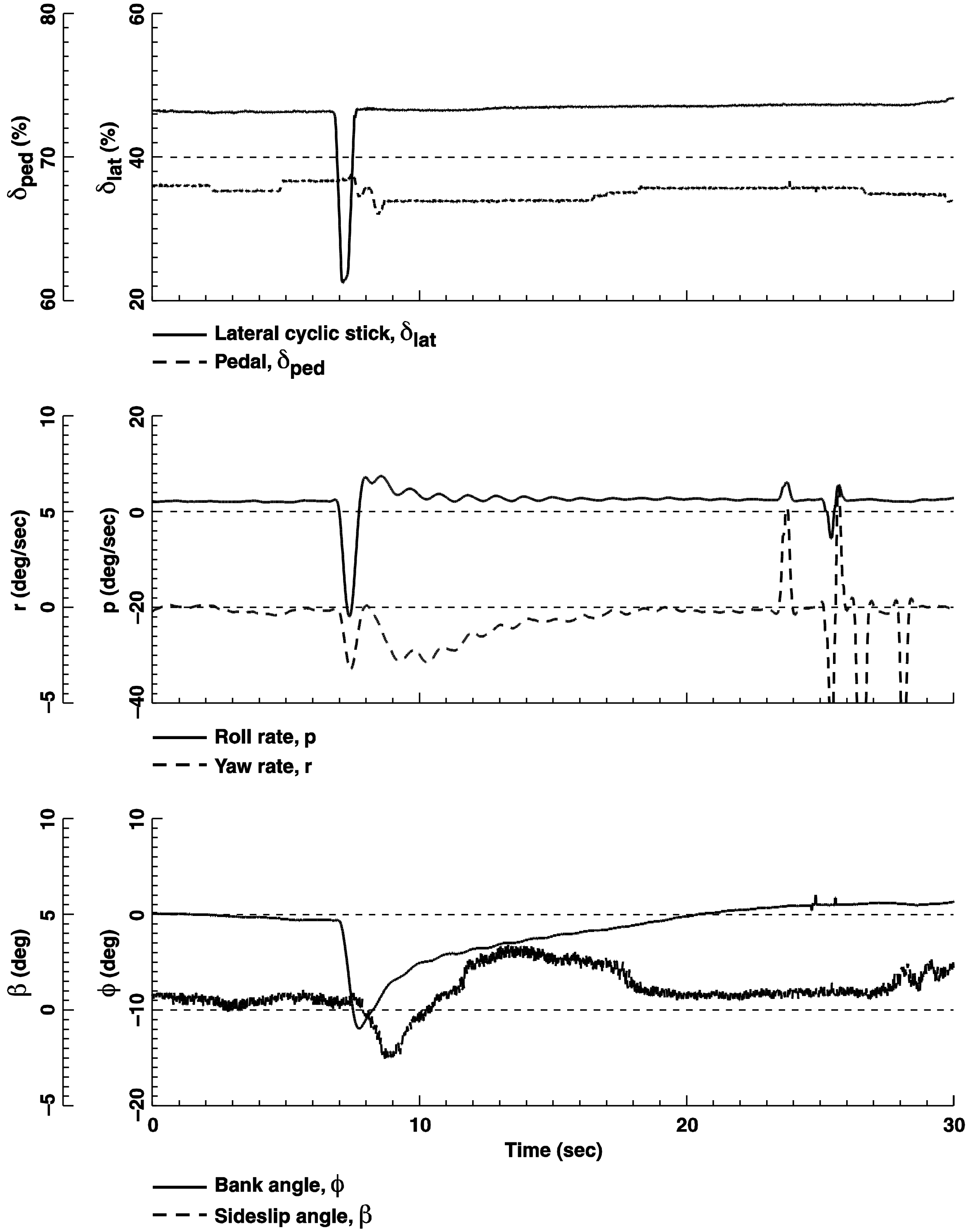


Figure E-81 Lat Pulse, Left, 80 knots, Flt 214 Rec 21, 3.4.9.1 lat-dir oscillations

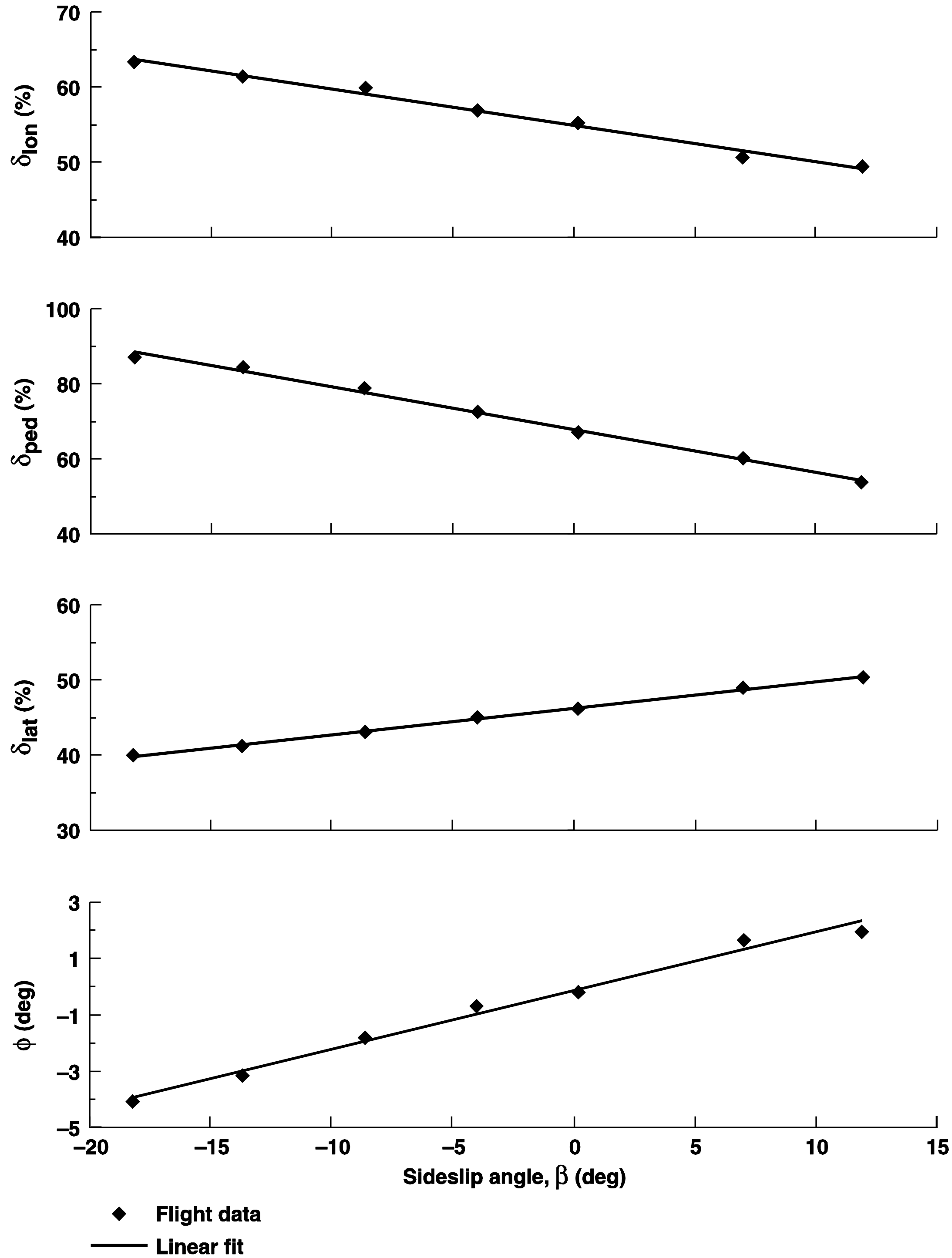
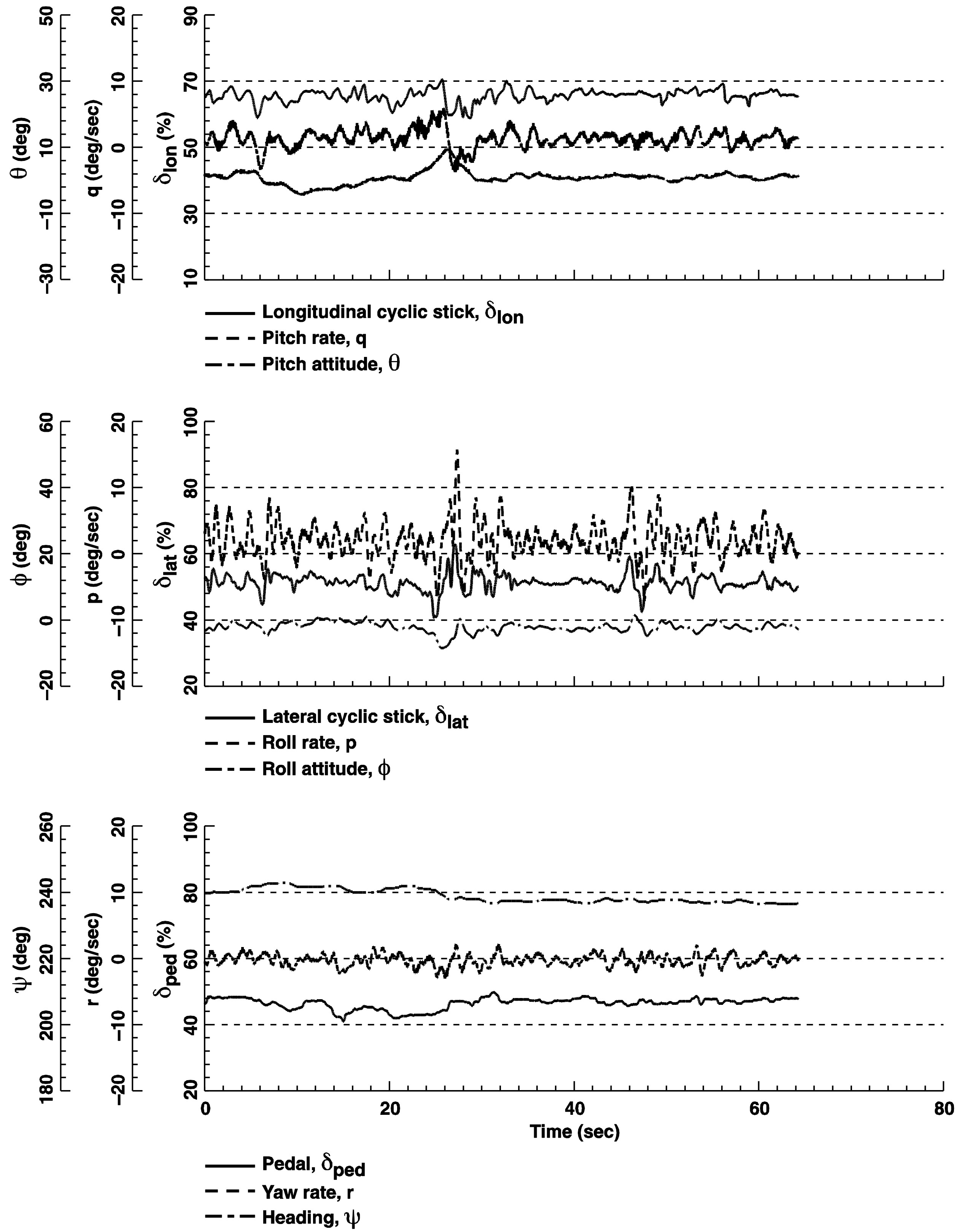


Figure E-82 3.4.10 lat-dir steady sideslip


θ (deg)
q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, φ
ψ (deg)
r (deg/sec)
δped (%)
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20
40
60
80
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

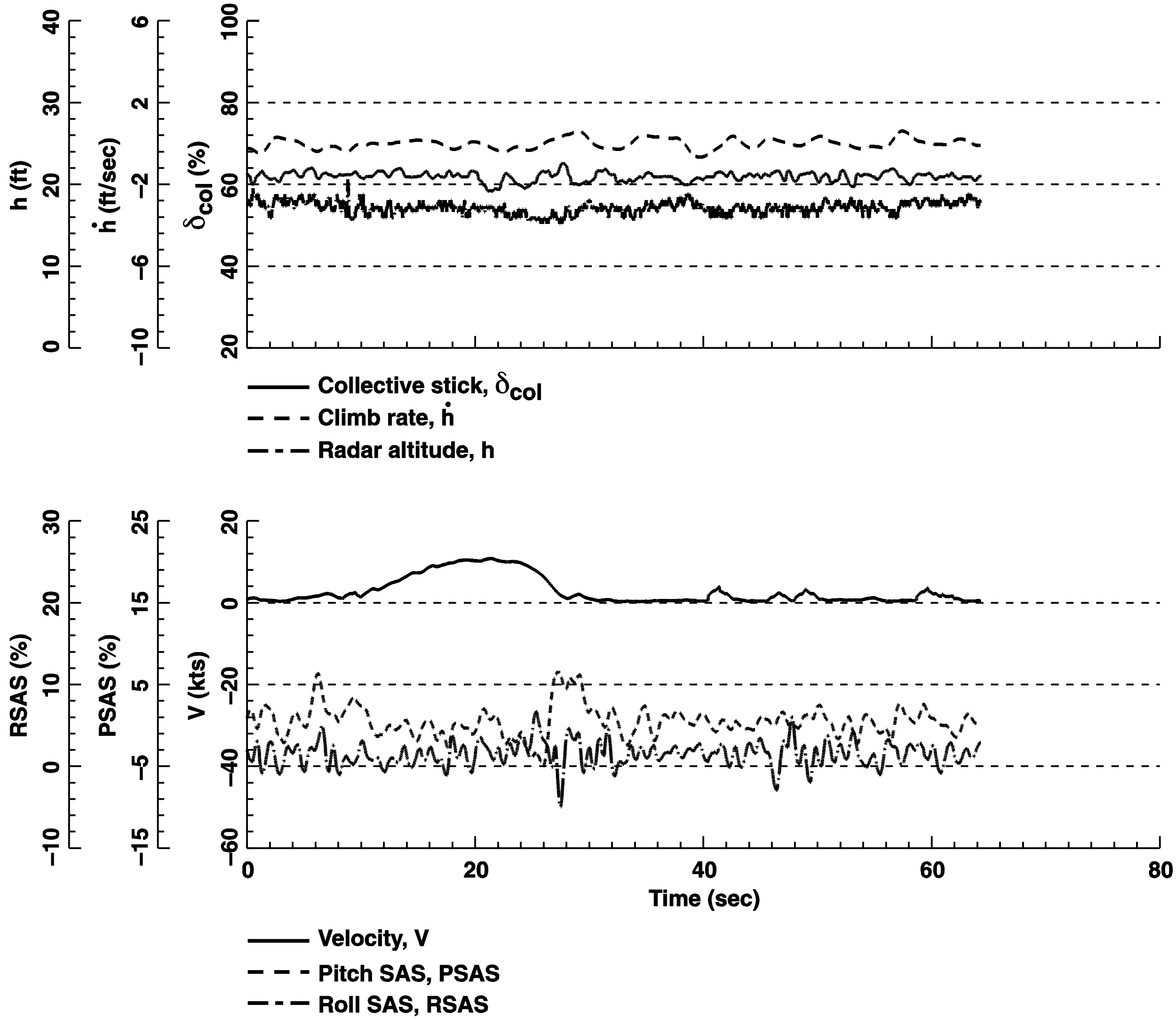
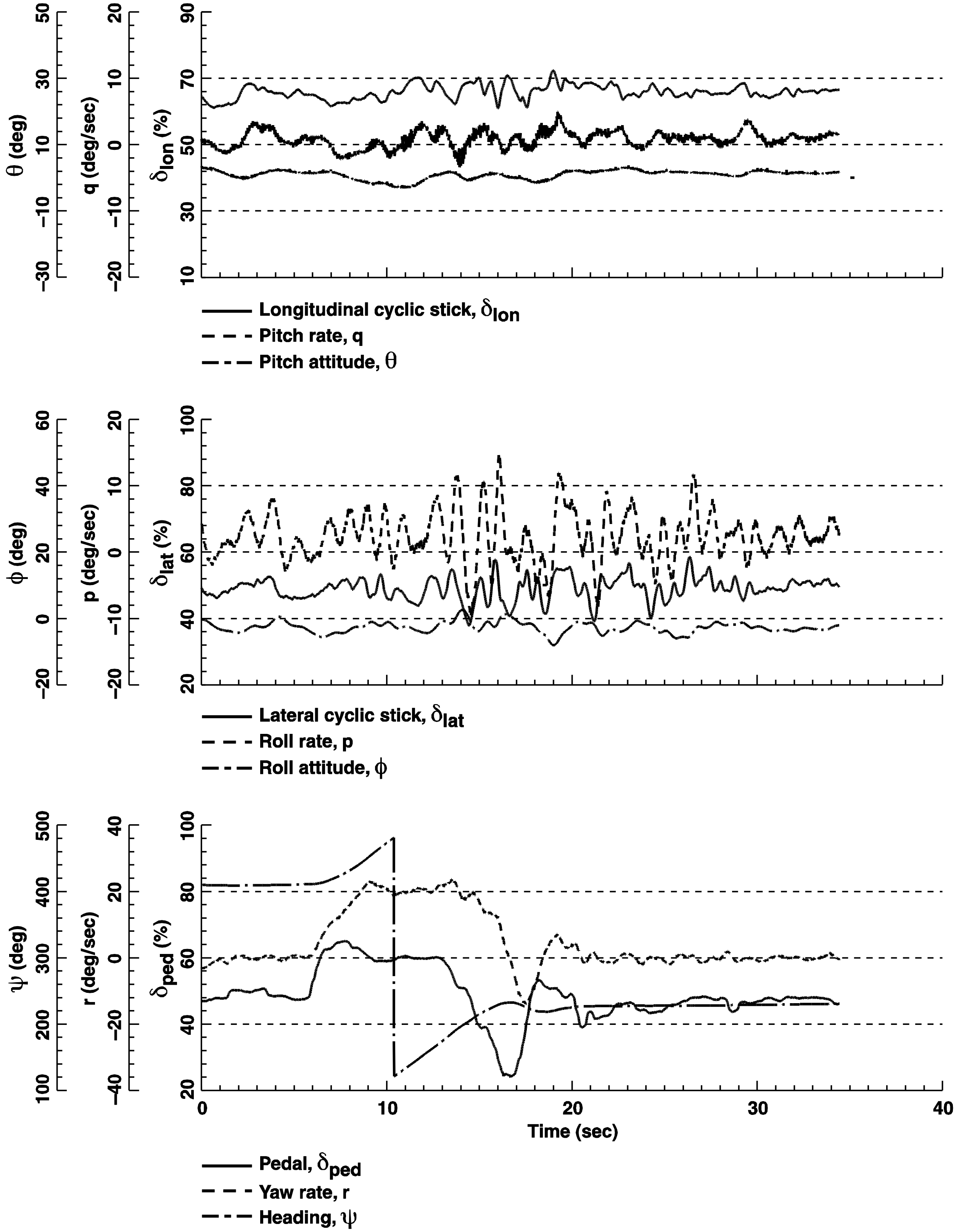


Figure E-83 Hover MTE, Flt 206 Rec 11, 3.11.1


θ (deg)
q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
ϕ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, ϕ
ψ (deg)
r (deg/sec)
δped (%)
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

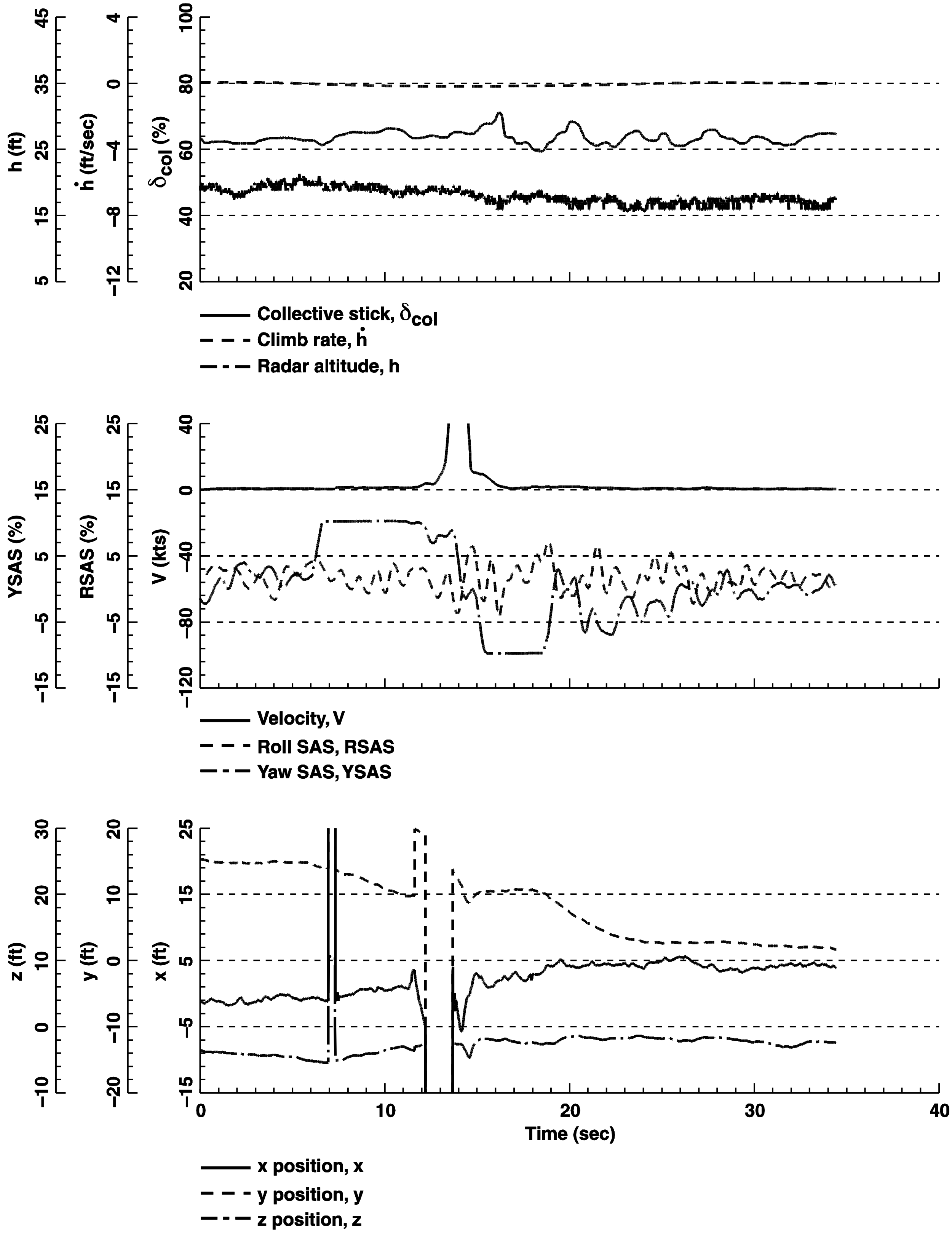
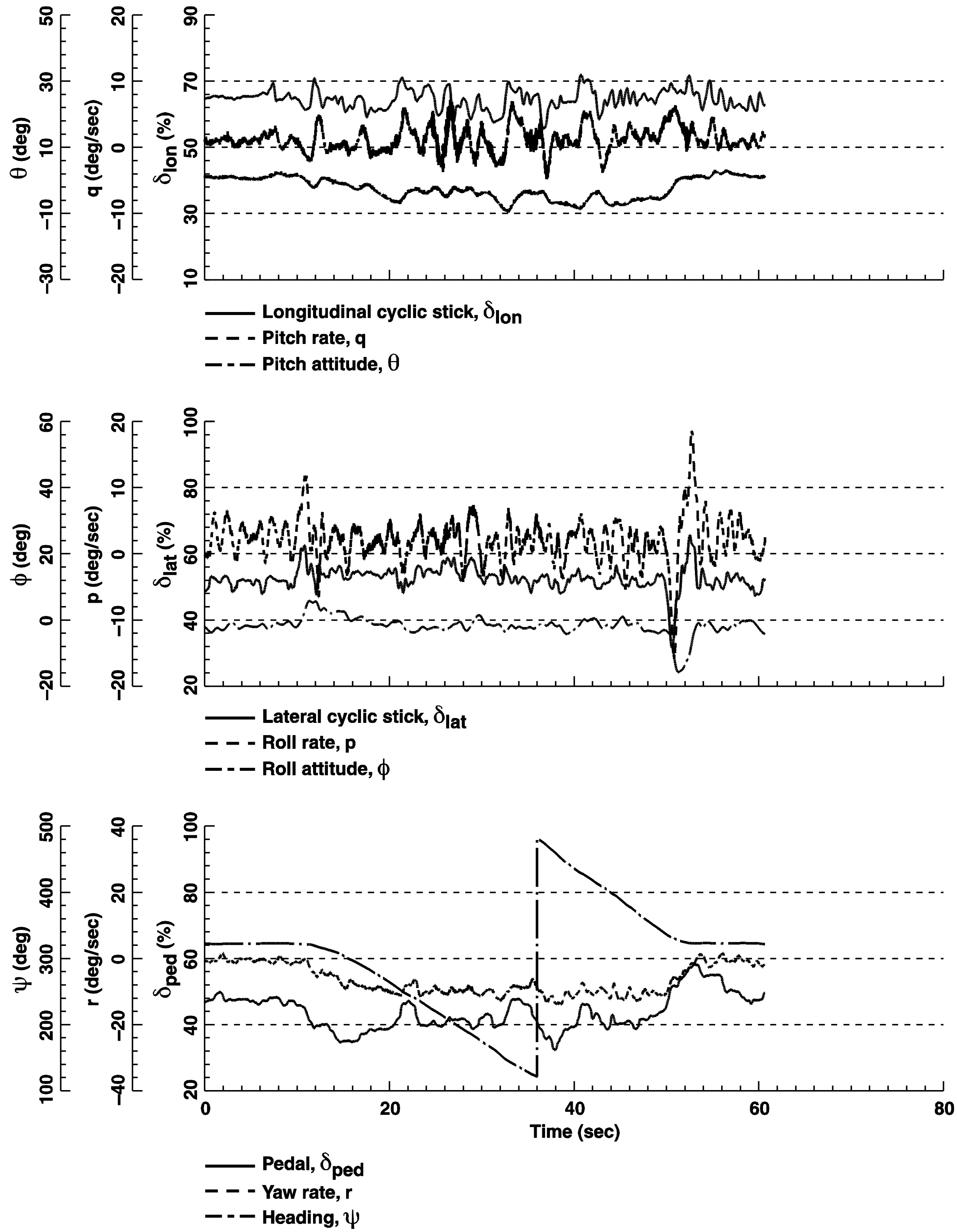


Figure E-84 Hovering Turn MTE, Flt 208 Rec 5, 3.11.4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q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, φ
ψ (deg)
r (deg/sec)
δped (%)
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

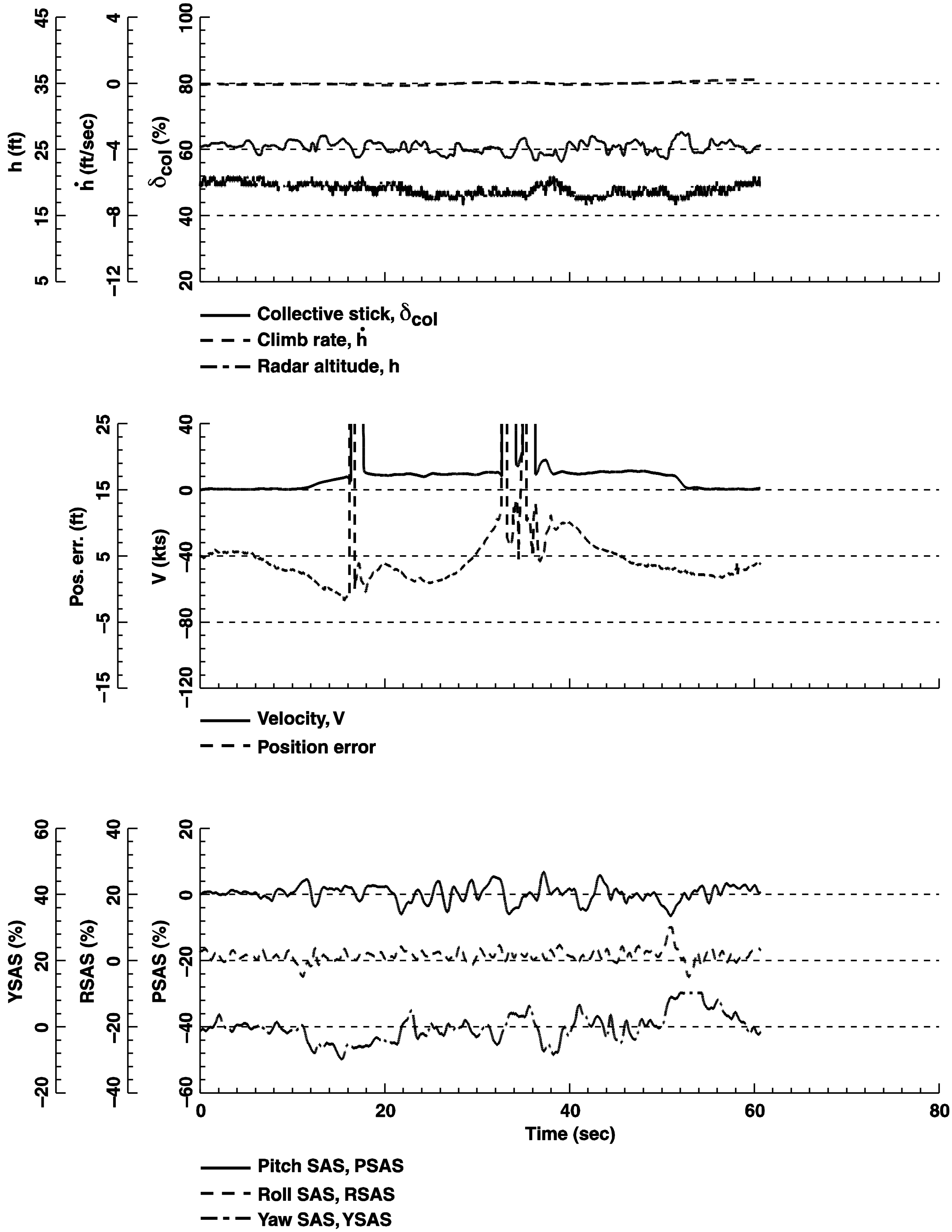
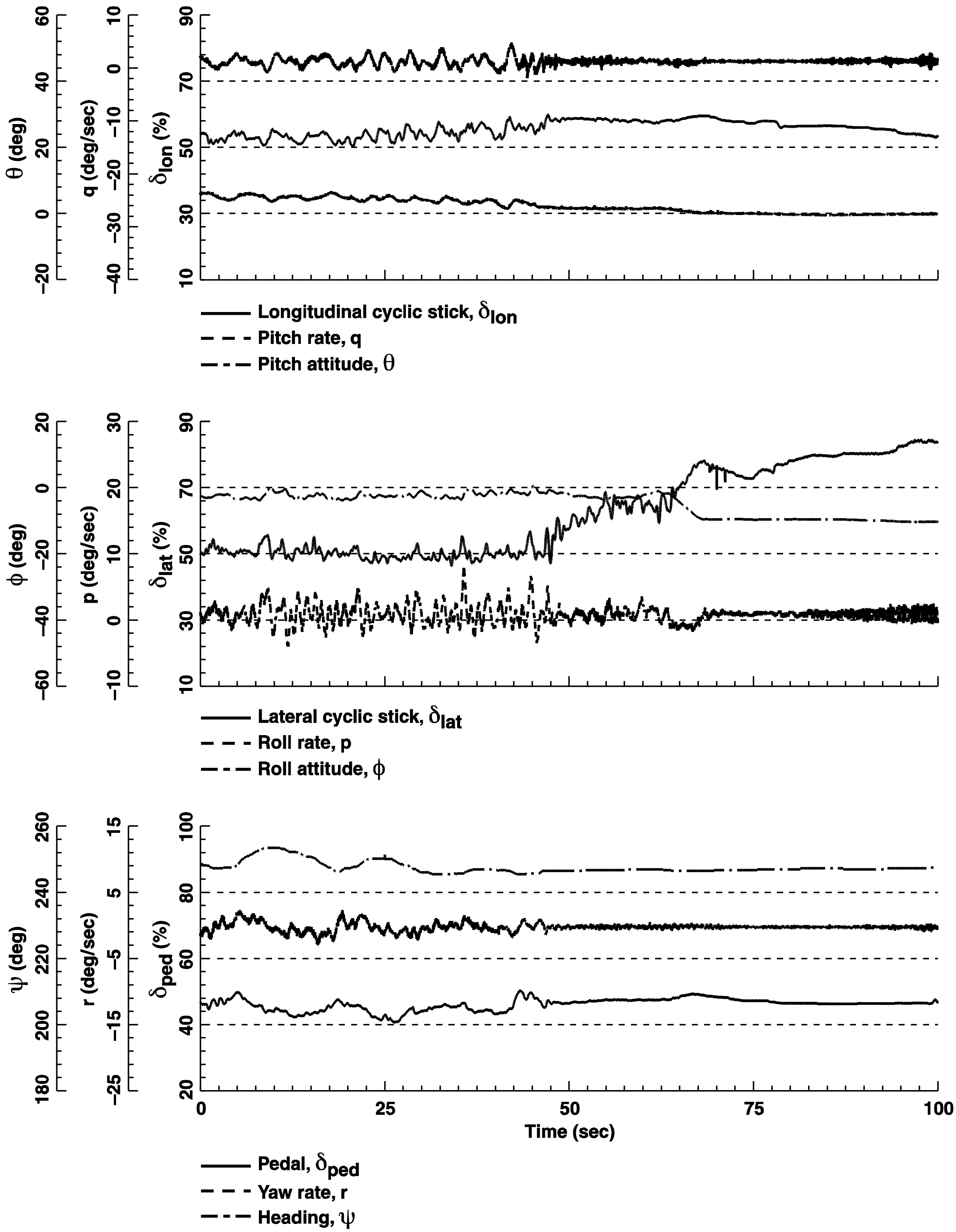


Figure E-85 Pirouette MTE, Flt 207 Rec 6, 3.11.5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q (deg/sec)
δ_{lon} (%)
Longitudinal cyclic stick, δ_{lon}
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δ_{lat} (%)
Lateral cyclic stick, δ_{lat}
Roll rate, p
Roll attitude, φ
ψ (deg)
r (deg/sec)
δ_{ped} (%)
Time (sec)
Pedal, δ_{ped}
Yaw rate, r
Heading, ψ

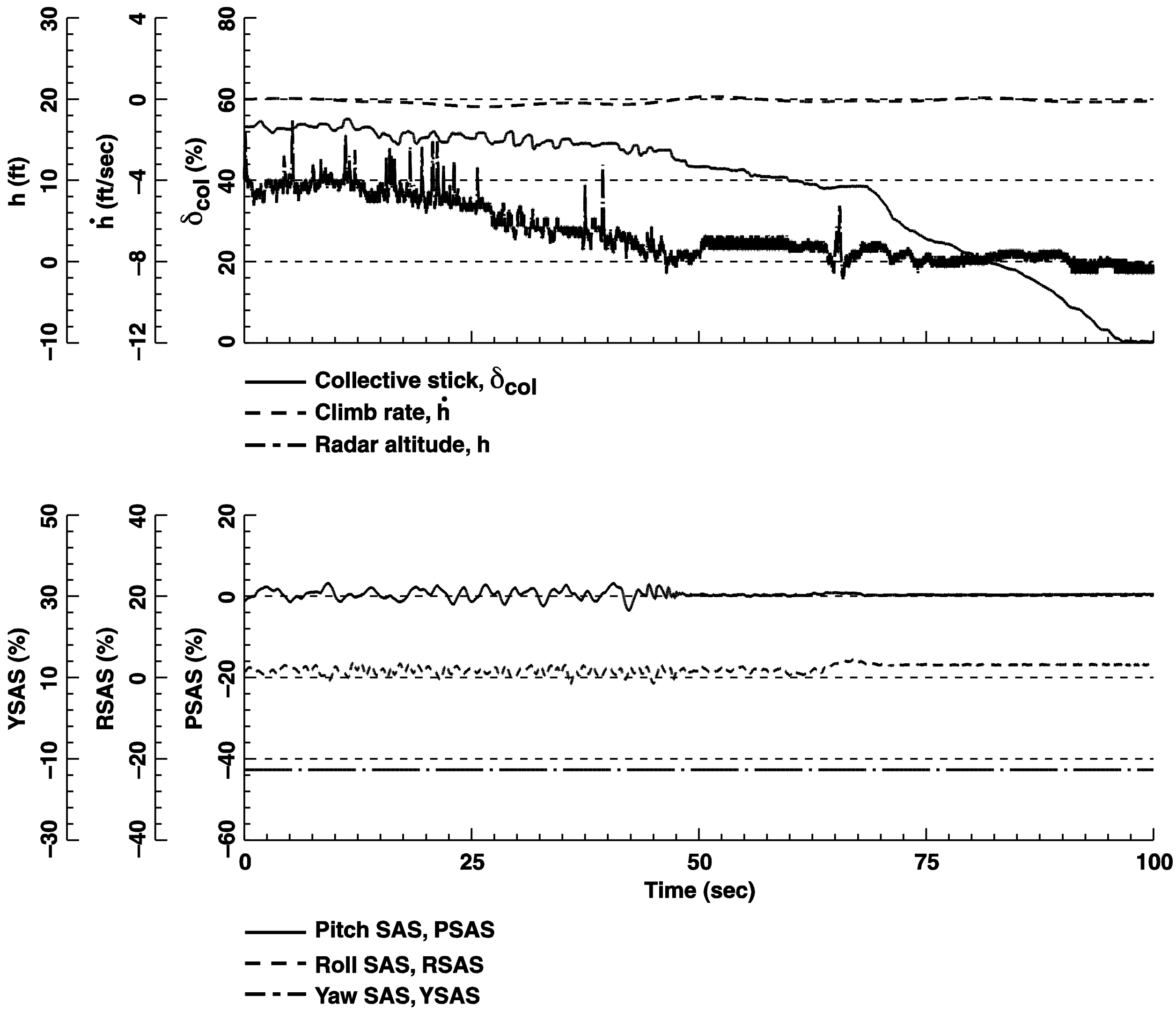
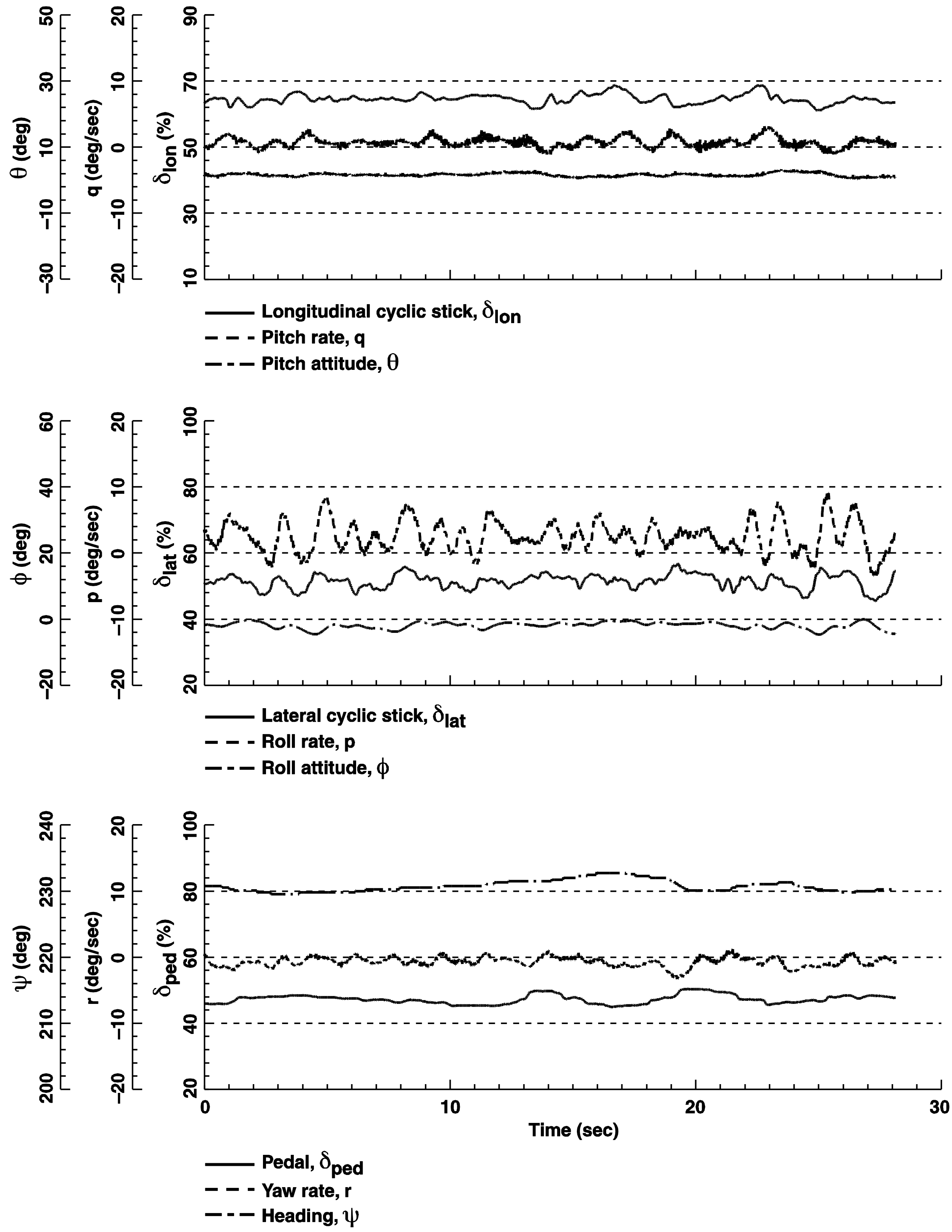


Figure E-86 Slope Landing MTE, Flt 200 Rec 1, 3.11.3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q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, φ
ψ (deg)
r (deg/sec)
δped (%)
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

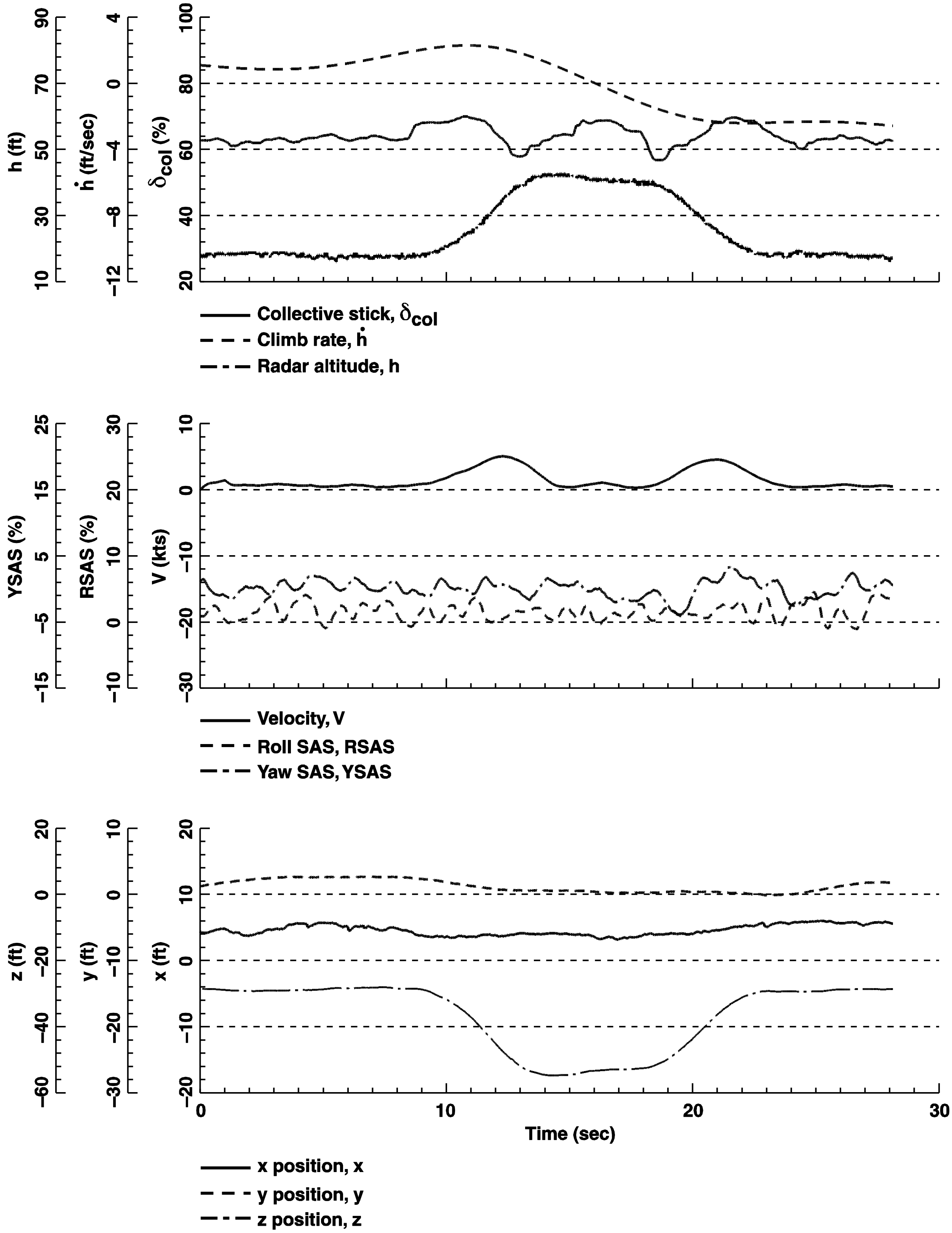
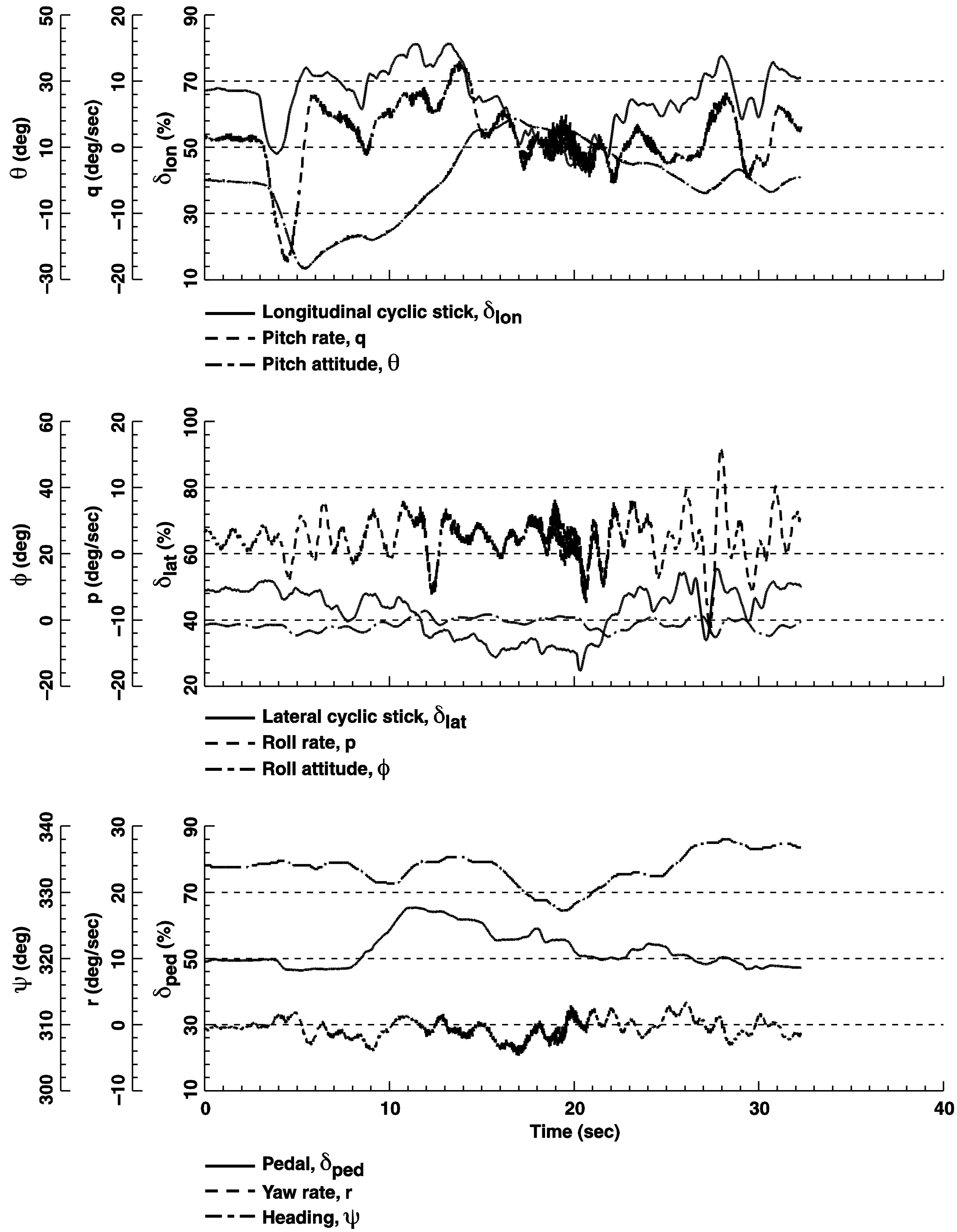


Figure E-87 Vertical Maneuver MTE, Flt 207 Rec 1, 3.11.6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q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, φ
ψ (deg)
r (deg/sec)
δped (%)
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

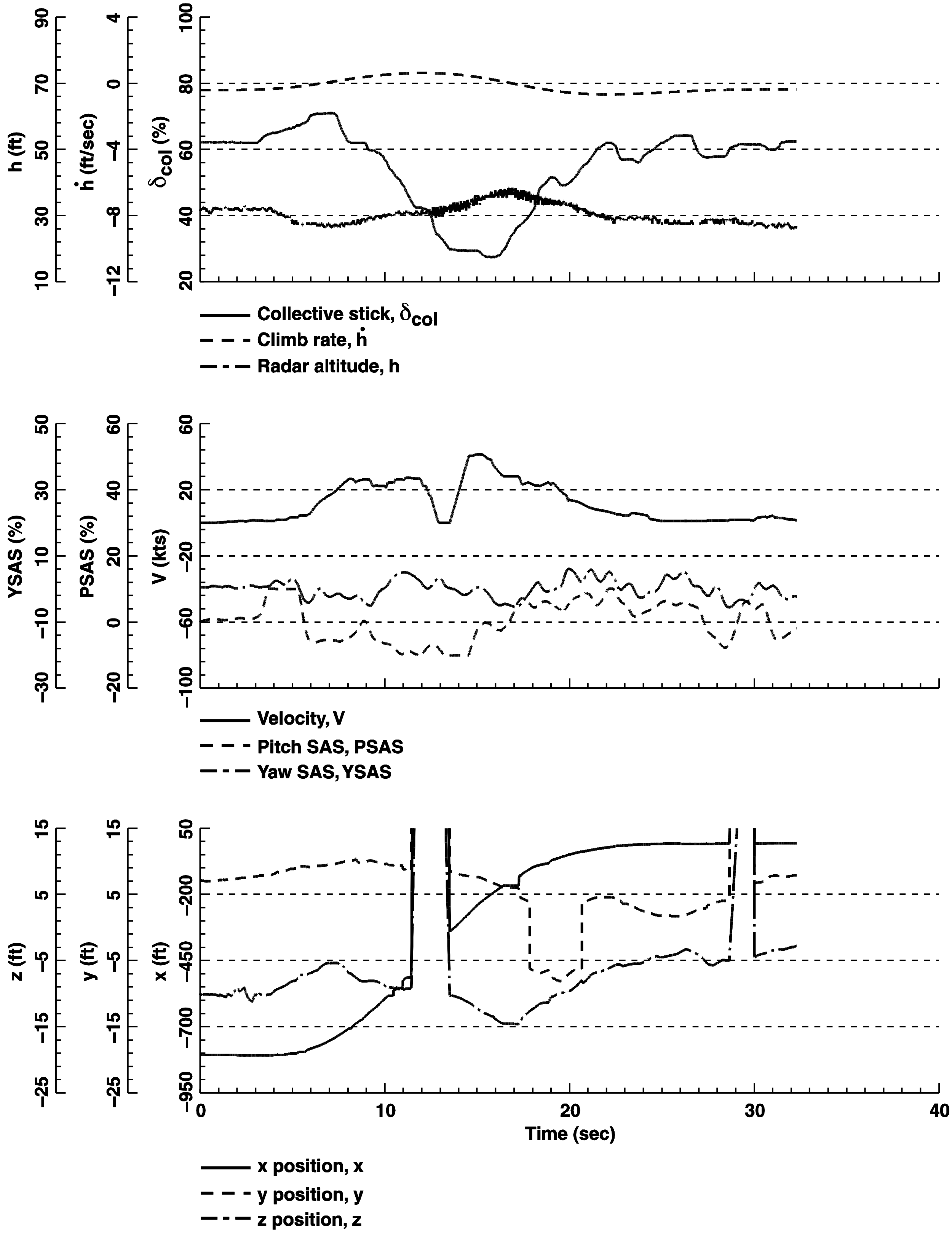
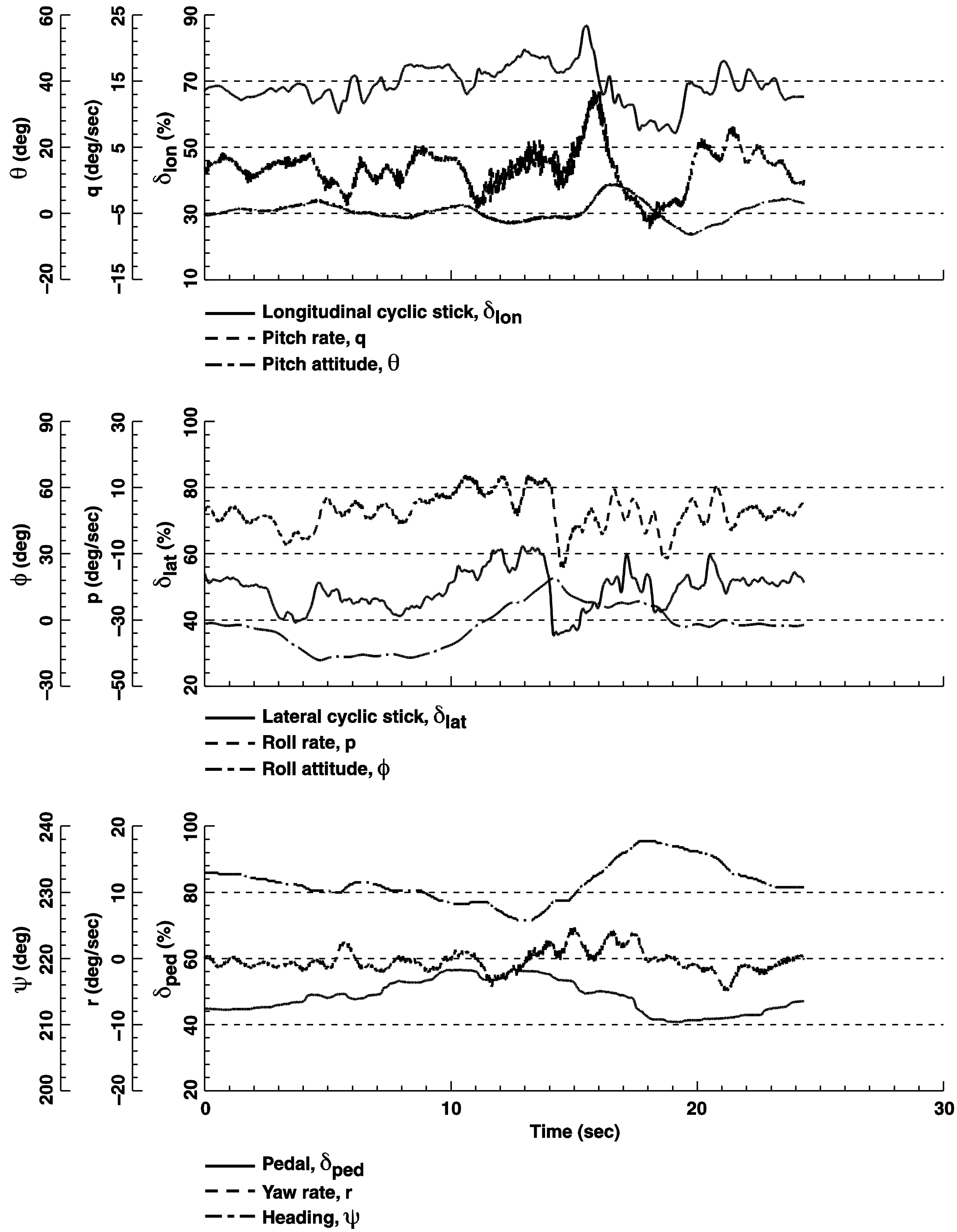


Figure E-88 Depart/Abort MTE, Flt 208 Rec 21, 3.11.7



θ (deg)
q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, φ
ψ (deg)
r (deg/sec)
δped (%)
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

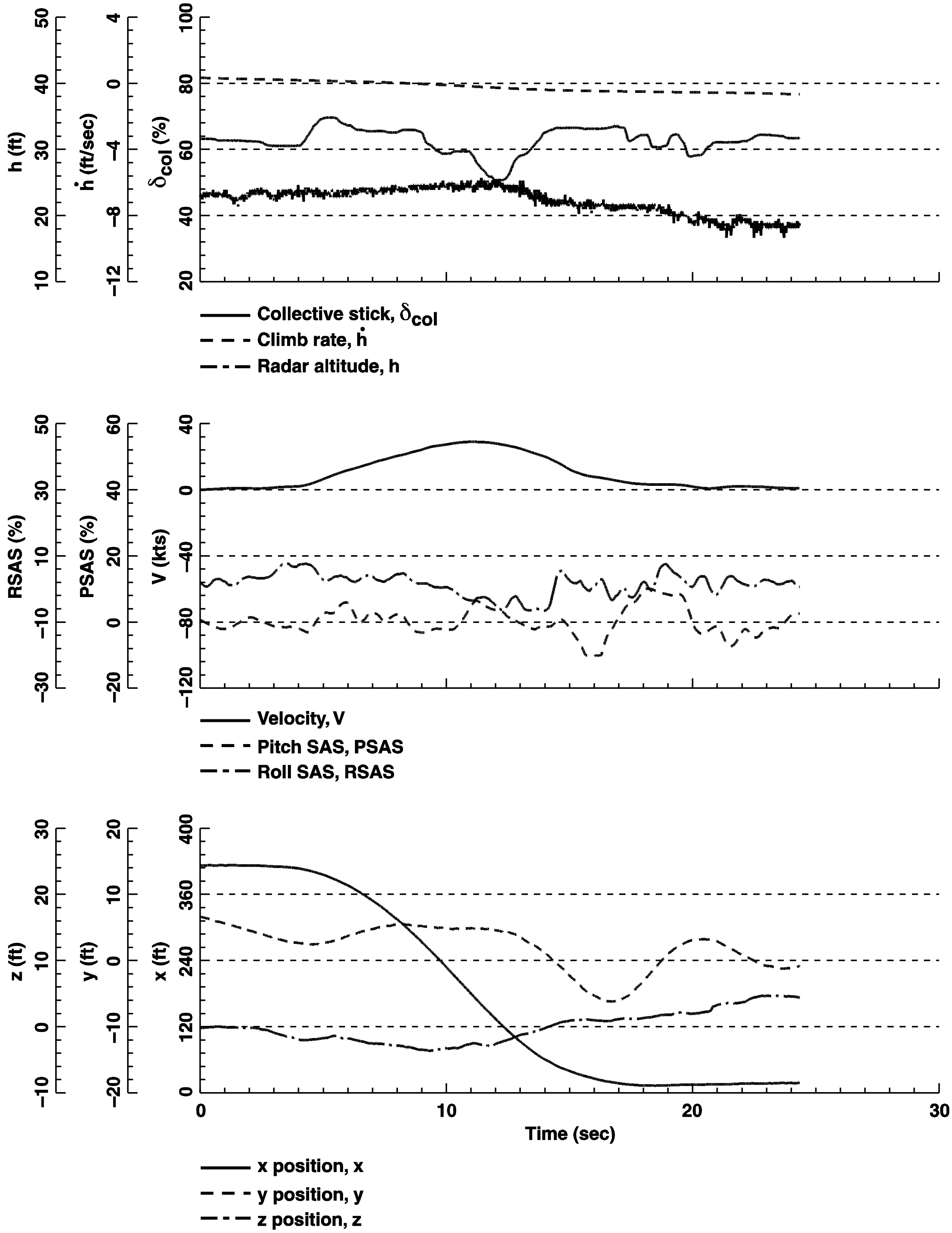
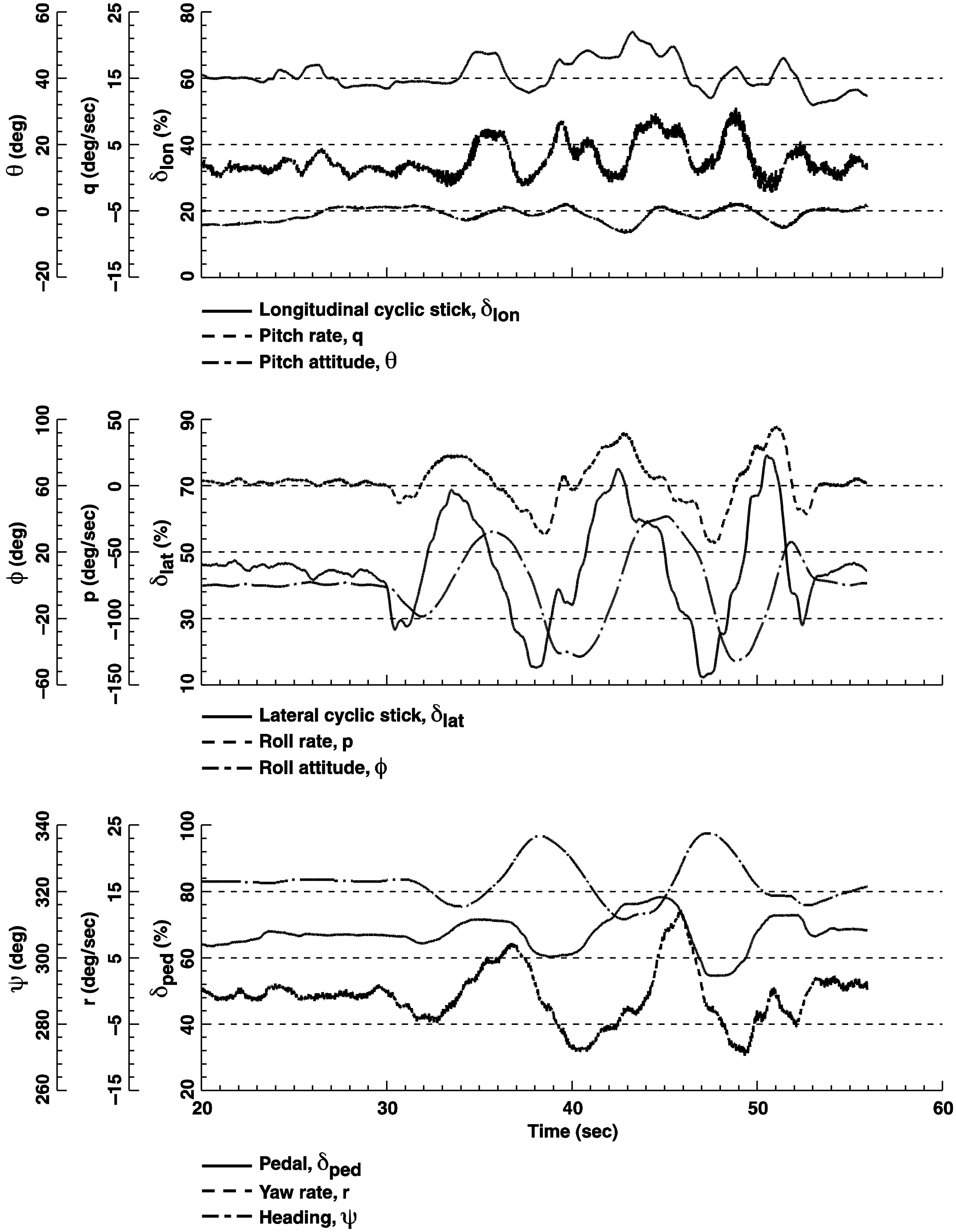


Figure E-89 Lateral Reposition MTE, Flt 209 Rec 19, 3.11.8



θ (deg)
q (deg/sec)
δlon (%)
Longitudinal cyclic stick, δlon
Pitch rate, q
Pitch attitude, θ
φ (deg)
p (deg/sec)
δlat (%)
Lateral cyclic stick, δlat
Roll rate, p
Roll attitude, φ
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r (deg/sec)
δped (%)
Time (sec)
Pedal, δped
Yaw rate, r
Heading, ψ

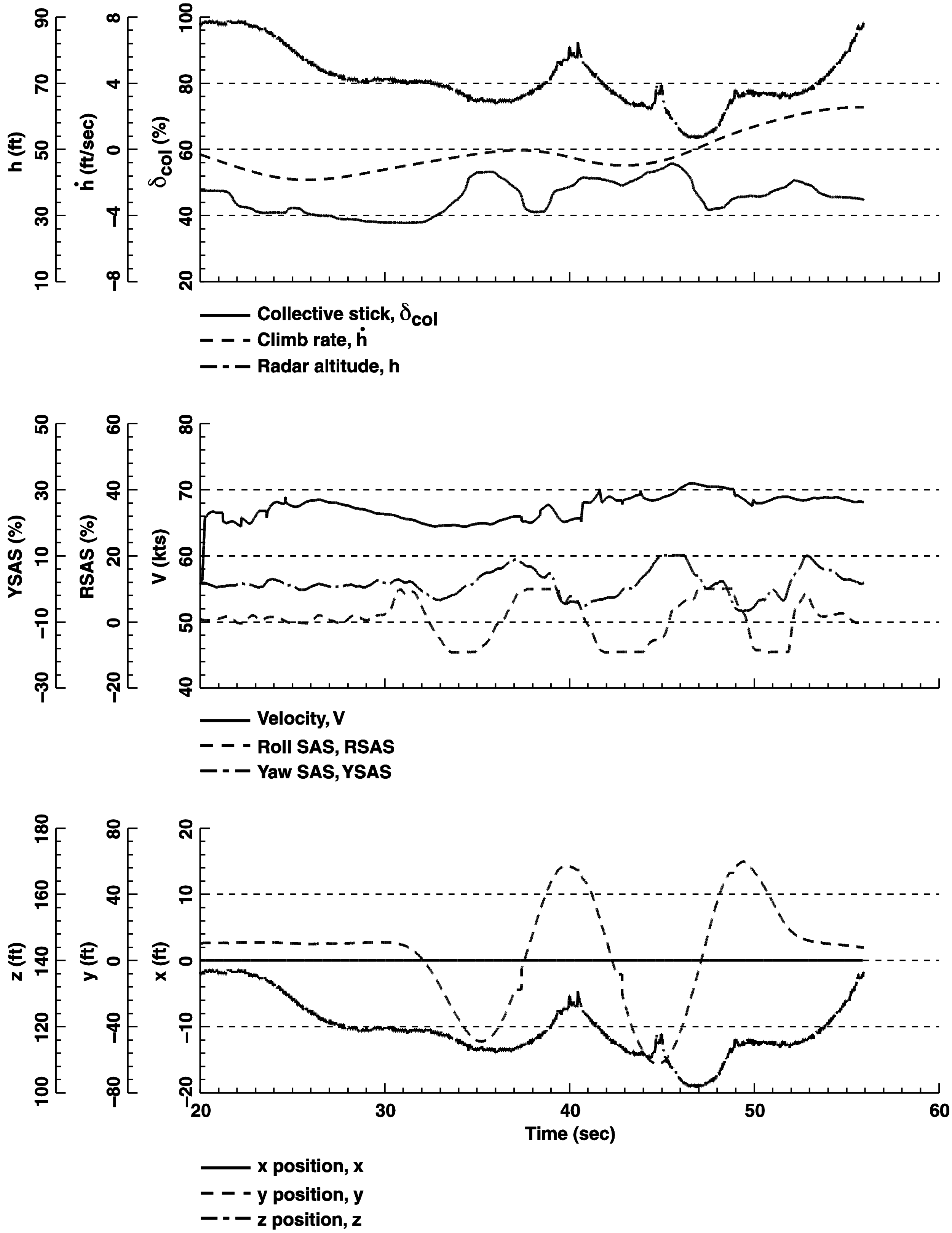

Figure E-90 Slalom MTE, Flt 207 Rec 13, 3.11.9

Appendix F. Pilot Commentary

A formal questionnaire was provided to the pilots to help illicit comments on the task performance, aircraft characteristics, and demands on the pilot, eventually leading to a Cooper-Harper Handling Quality Rating. This questionnaire is provided on the following page.

Using this questionnaire, pilot comments are provided for the following ADS-33 flight test maneuvers, or Mission Task Elements (MTEs):

Hover

Hovering Turn

Pirouette

Slope Landing

Vertical Maneuver

Depart/Abort

Lateral Reposition

Slalom

During the performance of these MTEs, different aircraft configurations and wind conditions were evaluated. Within the response to each question, the replies are subdivided by aircraft configuration and wind condition as follows:

Configuration A - Calm (empty aircraft configuration in winds up to 5 kt)

Configuration A - Light Wind (empty aircraft configuration in winds up to 15 kt)

Configuration D - Calm (external slung load configuration in winds up to 5 kt)

Configuration D - Light Winds (external slung load configuration in winds up to 15 kt)

Configuration B - Calm (internal ballast configuration in winds up to 5 kt)

Configuration B - Light Winds (internal ballast configuration in winds up to 15 kt)

Note that the pilot comments were recorded on an audio recorder on-board the test aircraft immediately following the maneuver evaluation. Subsequently, these audio tapes were transcribed. Unfortunately, there were times when the pilot comments were inaudible to the transcribers or the audio recorder did not work. These are noted in the following pilot comments.

PILOT QUESTIONNAIRE

Task Performance

1. **Describe ability to meet DESIRED / ADEQUATE performance standards.**

2. **Describe aggressiveness / precision with which task is performed.**

3. **If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?**

Aircraft Characteristics

4. **Describe any objectionable controller force characteristics.**

5. **Describe predictability of initial aircraft response.**

6. **Describe any mid- to long-term response problems.**

7. **Describe any objectionable oscillations or tendency to overshoot.**

8. **Describe any non-linearity of response.**

9. **Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.**

Demands on the Pilot

10. **Describe overall control strategy in performing the task (cues used, scan, etc.).**

11. **Describe any control compensation you had to make you to account for deficiencies in the aircraft.**

12. **Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.**

MISC.

13. **Please comment on anything else that may have influenced you.**

Assign HANDLING QUALITIES RATING for overall task.

14. **Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.**

15. **What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).**

16. **For cases with external load, did the load have a significant impact on the assigned HQR?**

HOVER MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: [No audio at beginning] - I failed to meet desired performance standards throughout the training -- each maneuver… [From the ground-station engineers' notes, five data runs were performed; the pilot was able to achieve desired performance on all of these runs.]

Pilot B (data runs 193.8-12 - Config. A calm) HQR=3: Pilot could meet desired performance standards throughout for all tasks on here, on that last one we met all desired from my point of view. Very important on this task is what the cuing markers are, but once we got that sorted out on the first few records, I could maintain desired performance standards. [From the ground-station engineers' notes, five data runs were performed; the pilot was able to achieve desired performance on the last three runs. The first and second runs were adequate performance longitudinally and laterally, respectively.]

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: No audio. [From the ground-station engineers' notes, four data runs were performed. The pilot was able to achieve desired performance on two of these runs, one run had adequate performance laterally, and one run was not adequate longitudinally and directionally.]

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Ability to meet desired/adequate. I felt like I was in desired the whole time, close to the edge during a couple of them, but I never went out. The one questionable one, which is probably the hardest for me to judge, is the heading. So -- but I felt like I was in there the whole time. [From the ground-station engineers' notes, four data runs were performed; the pilot was able to achieve desired performance on the last two runs. The first and second runs were adequate performance laterally/vertically and laterally/directionally, respectively.]

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio. [From the ground-station engineers' notes, four data runs were performed. The pilot was able to achieve desired performance on all of these runs. Time to stabilize was 5-6 seconds.]

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Hover task, task performance. Ability to meet desired/adequate: yeah, I felt like I was in desired. [From the ground-station engineers' notes, three data runs were performed; the pilot was able to achieve desired performance on the last two runs. The first run was adequate performance longitudinally and laterally. Time to stabilize was 8, 7, and 9 seconds.]

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Describe ability to meet desired/adequate performance. I think it was quite difficult to meet desired, especially the fact that it seemed to be the load dynamics underneath the aircraft caused lots of small oscillations that were relatively difficult to counter in a precise manner. So I don't think that it was -- I don't think that we had the ability really to meet the desired standards as it was. [From the ground-station engineers' notes, five data runs were performed; the pilot was not able to achieve desired performance on all of the performance parameters for any of these data runs. The first data run was adequate in heading tolerance, the second run was not adequate in fore/aft tolerance, the third was adequate in height and fore-aft, the forth was adequate in height, fore/aft, and laterally, and the fifth data run was adequate fore/aft and laterally. Times to stabilize were 6-7 seconds.]

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: From the cockpit it looks like we got everything desired. We were, I'll call it sucked twice and we were longitudinally displaced aft of position. Last time it looked real good we were centerline on the cones, although the ground station said we were still out of position. If that was true we were a little surprised. But overall it felt pretty good. The aircraft feels much more stable once you get moving. The response seems to respond quicker. In other words while I'm at the angle all I have to do is put a little bit of reverse cyclic input and the aircraft stops pretty quick. The excursions on the target are a lot less than when we didn't have a load. And the black dot in the middle of the white square is, you can see is barely moving around. Although workload, if there is any, it still seems to be in the collective. Not nearly as quick as before, but when you need to make an adjustment it looks like it's larger, a little delay before it takes effect, so it's pretty close monitoring of the collective.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: We did show, I think within the desired performance standards throughout each one of those maneuvers. We will have to look at the (inaudible) after. If there was a tolerance we were getting close to, it was fore and aft. But I felt as though we were able to achieve desired tolerance in longitudinal.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No audio. [From the ground-station engineers' notes, four data runs were performed. The pilot appeared to achieve desired performance on two of these runs. The other two runs were only adequate in terms of time to stabilize (5.5 and 6.0 seconds).]

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Ability to meet desired/adequate performance. You can meet desired performance standards with work. Adequates are very easy to achieve. Desired a little bit more difficult. And that's primarily due to the lateral cuing out to the 45 through the doorpost. I found myself wavering on heading just a little bit, depending on where I put the cones out to the side. And if I get the cones around the front of the door, it looked like that was the one that was necessary to hit the desired heading throughout. If there was a reason for the heading to vary just a little bit at the beginning, it was because I was sitting back in the seat and having to look around to the right of the doorjamb.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3: No audio. [From the ground-station engineers' notes, three data runs were performed. The pilot was able to achieve desired performance on all of these runs.]

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: The aggressiveness and precision the task performed, the precision was on the edges of desired. It was within desired, but at the edges. In terms of lateral drift, heading and fore and aft drift, aggressiveness was not a factor. The aggressiveness of the maneuver is very low.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: When you get up around the 10 knots, the ability to maintain desired performance during the decel is impacted, I think if you went a little bit higher in terms of the speed that precision would wane based on the existing standards.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: No audio

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: As far as the aggressiveness, it's not really an aggressive maneuver, as far as 8 knots going, that's a real nice, easy speed and the only aggressiveness comes in to how quickly I'm trying to initiate the decel to the steady hover. And if I anticipate not slowing down enough, but anticipate before getting into the point of deceling it works a lot nicer than if I wait until I'm practically over the point to a rapid maneuver, which is more aggressive and much tougher to stabilize.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Aggressiveness, I felt my air speed was good coming in every time. I guess what might be some different aggressiveness levels is if I do more of a slower decel, kind of anticipate a little bit, or if I wait until I'm almost right over the spot and do a more rapid decel. I think my first two were more of a slower decel. The third one I did a little more rapid and felt some more load oscillations but still remained within desired.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Aggressiveness and precision with which the task was performed. It was actually difficult to control the ground speed on the way over, I got lots of changes or variances in my ground speed as I was trying to translate over. And so I couldn't even quite control the aggressiveness, I couldn't keep it down to 6 knots if I wanted to and I couldn't keep it at 8 or 9 knots if I wanted to. So that made things a little bit difficult. And as far as precision goes, it was difficult to maintain precision, mainly because the rates were kind of slow to develop. So as far as fore and aft drift, it seems to not really be accompanied too much by a pitch change. So you don't see the fore and aft drift until you actually begin to translate, at which point it's a little bit late, you have pretty much headed out towards the inadequate territory. And the same thing for lateral, I really didn't see lots of roll changes going on, the aircraft just kind of began to drift laterally and I would have to make an input. A lot of the inputs were accompanied by a little bit of sling dynamics going on, so the aircraft might oscillate here and there, especially in roll. And not really -- those oscillations wouldn't lead to anything, so. That made it difficult to be precise.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: No comments.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Level of aggressiveness, it's not a very aggressive maneuver. The precision of the maneuver in the deceleration is the point where precision becomes an issue. There is some unpredictability as to the final end point because of the 40 degree line coming into the maneuver a little bit of aft stick, a little bit of left stick tends to get you just out of position as you come into the zone. But it's -- it doesn't take very long to get into the zone within 5 seconds and call stable.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Aggressiveness/precision, to perform this task, you could be fairly aggressive with it to meet the five second decel rate on it. The only thing I would say there was some slight tendency to overshoot there at the end. It was while you were trying to maintain the lateral track on the diagonal across the ground, there was a tendency to lose track of the lateral target out in front of view. And due to the fact that it's white out there and black, it's not a very distinguishing cue, you have got to concentrate on it to see it and it's very easy to have it slip right on through the white square.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3: No audio.

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: This would meet desired standards so 3 is not applicable. There were no objectionable oscillations.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Unacceptable oscillations. One of the real detractors in this one is the roll oscillation. That occurs trying to maintain that precision point. I found that there wasn't a lot of lateral drift but there just seemed to be a constant, persistent roll oscillation that is pilot induced but it's in response to the aircraft rolling back and forth, it may be pilot induced, it may be aircraft response. But it didn't affect my ability to achieve desired performance in terms of lateral drift.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: Lateral forward stick to get the flight moving. The ground speed visually looks okay. It's nice when Rick is backing me up and letting me get a flavor for how fast we are accelerating . He held off one time and I think I was around 12. But with a little verbal on ground speed (inaudible) I think I could get that pretty easily.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: I was trying to reach desired, I didn't really notice any unacceptable oscillations. I saw a roll oscillation, that was the only noticeable one.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Question 3 doesn't really apply. Because I don't think I had to sacrifice anything to meet -- just to get an at target adequate.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: I didn't really -- I never reduced my goals to adequate. I kept continually striving for desired there. And I wasn't like so overcontrolling, I don't think that was the problem, because I wasn't controlling myself right out of the desired parameters , I think it was just sling that would take on itself. (Inaudible.)

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: No comments.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: There were no unacceptable oscillations but there was a roll oscillation periodically. Primarily the roll oscillation exists when I was not using trim release. And I used a combination of trim release and feet on and off the pedals for this maneuver and I will discuss those each. They weren't unacceptable, but there tended to be a little bit of a roll oscillation when trim release was not used in the hover position.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: If trying for desired performance resulted in -- there were no unacceptable oscillations that I could see, except maybe those that might be caused by that little bit of overshoot there, prior to the stabilization.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3: No audio.

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: There were no objectionable controller force characteristics. [I performed the maneuver] with trim release and without trim release.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Describe any objectionable controller characteristics. The only objectionable controller characteristic is this, seems to be an apparent disharmony between roll or lateral and longitudinal cyclic control.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: Objectionable controller force characteristics? The only thing I really noticed that I paid a lot of attention to is the collective. And the force is all based on what I do with the friction. But I have to be real real precise on the collective because if I leave it alone too long I start to climb and get out of the box real quick and then I have to lower the collective. I tried to separate and pay attention to foot activity and it's so small that I really can't notice what I'm doing there, it just feels like I'm holding the pedal steady. And lateral longitudinal stick is minor. The biggest workload appears to be in collective.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Aircraft characteristics. Question No. 4. Any objectionable controller force characteristics? None noted.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Aircraft characteristics. Objectionable controller force characteristics? None noted.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: And question 4, any objectionable controller forces? No, there were none.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: No. 4, describe objectionable controller force characteristics. I don't think there is anything wrong with the force. You do feel the load shifting around, primarily when it gets the aircraft started sideways you can feel it swinging. Very little feedback back up into the aircraft. And that might be a mid-term response, maybe, when we were doing the translation, once you get the ground speed going it takes a while for the load to dampen out, but really not an objectionable oscillation of any kind.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Describe any objectionable force characteristics. When I do use against force to establish the stable hover before starting the maneuver and then held that trim all the way in, there was a tendency after the deceleration to get into the zone to need to reset that trim to get everything fine tuned. So there was a tendency to have this roll oscillation in the roll axis. It wasn't objectionable, but it was there, especially if a little perturbation in wind might excite the aircraft.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Any objectionable controller characteristics? I do notice at this weight it appears like you are almost on the verge of translational lift with it. Like there is a constant heading vibration and this feeds back into the flight controls and causes you a little bit of a tendency to overcontrol.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3: No audio.

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Predictability of the initial aircraft response was good. Both in the lateral axis and the pitch axis was less predictable but not objectionable.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Describe predictability of initial aircraft response. I think the predictability of being able to maintain altitude and to be able to get your left lateral and longitudinal position each time was suddenly different. But the ability -- your predictability to get in desired is okay. But which one of those cues and which one of those axes is going to be more difficult wasn't very predictable. It may have something to do with the disharmony between roll and longitudinal cyclic.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: (No comment on tape)

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: No. 5, predictability. Nothing, it's very predictable through the whole maneuver.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Predictability of initial aircraft response. I think the aircraft has good response there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Predictability of initial aircraft response. Today with this, we have got a nice breeze out here, there was almost a head wind and it did make things a little bit less than predictable. With the combination of the wind and the sling load, it was quite difficult to set a ground speed going across the translation part prior to the hover. So. And it seemed to require a lot more forward stick than it has in the past without the sling load. And so therefore predictability was somewhat reduced there for that. Aircraft response was not what I was expecting.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: (See field question/answer #4)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Predictability of initial aircraft response was good. I felt that I could have fairly precise movements of the controls to stay within the zone in a predictable response.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Predictability of initial aircraft response. It's fairly predictable. The response seems to be dampened with this additional weight on board. As opposed to before, where it was a very quick responding helicopter, now it's a little bit more sluggish. So it really makes it more -- makes it easier to handle.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Any mid or long term response problems? There are none.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Describe any mid or long term response problems. There weren't any.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: I don't know about mid to long term response problems. I guess the quickest response a little bit of heave, trying to stay steady. The wind may be having some effect on that.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: And mid to long term response problems, you know, you get a little bit of a right crosswind, I think when I take my eyes off of the hover board to the front and look almost 90 degrees to the right any kind of gusts or with the right crosswind now, it upset it to where almost, I'd say at least 50 percent of the time if I was in the center before I took my eyes off the hover board and looked off to the right reference, and when I looked back to the center, 50 percent of the time I had moved off either left or right, probably just because the small wind moved me off one way or the other.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Mid to long-term response, no problem with that as well.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: I didn't see any mid to long-term response problems.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: (See field question/answer # 4)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Mid and long-term response, I think the roll oscillation is a mid-term response. But it seems to damp out fairly quickly if the trim release is pressed or if the pilot just releases the stick momentarily, eases off the stick with the trim on.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Long term, mid to long term response problems. Again, just that low vibration, it feels like with the heavy load would be the only thing that I could think of as a long-term response.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Objectionable oscillations or tendency to overshoot? There was a tendency to overshoot the lateral.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Describe any objectionable oscillations, tendency to overshoot. Again, the roll oscillation and lateral cyclic oscillation that goes along with that. A tendency to overshoot, really the tendency to overshoot for me was fore and aft; primarily because the cueing is weaker in that axis than in the other axis.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: I didn't see any oscillations or tendency to overshoot. This is question No. 7. Overshoot would be, the only tendency is vertical again.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Objectionable oscillations, a tendency to overshoot. I wouldn't call it oscillations, but there is noticeable, I guess it's damping of roll is much lighter than in longitudinal or any other axis. So if I'm getting oscillations anyway, I wouldn't call them objectionable, but small oscillations are noticeable in roll versus any other axis.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Objectionable oscillations or tendency to overshoot. What I noticed is most objectionable is my third one where I do more of a rapid decel, get some oscillations on the load which gives feed-back, but mostly a lateral roll oscillation. Which is pretty good. Comparing this to sling load/non-sling load, I think I was slower to stabilize because I'm trying to control that roll oscillation due to the load underneath. We reported about 10 degree swings on the load during that maneuver.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: The oscillations were probably due to sling dynamics and acting on the hoof there and it's hard to say, I won't call them objectionable, but they were definitely there and they definitely caused translation of the aircraft, so. I didn't really see any tendency to overshoot. It seemed like we got in the box and did manage to drift out of it every time, so.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: And No. 7, there is no tendency to overshoot. The aggressiveness is not such that it carries you through the hover point.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Describe any objectionable oscillations, tendency to overshoot. I had a tendency to overshoot on the deceleration. I'd then have to come back into the zone, but that was primarily, I think the tendency to be monitoring the longitudinal axis and not monitoring the lateral axis initially during my maneuvers.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: could barely notice anything in the flight control as far as -- oscillations in pitch or roll.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

8. Describe any non-linearity of response.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Describe any nonlinearity of response. There were none.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Nonlinearity of response, for item 8, there are none.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: And I didn't notice any nonlinearity.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Nonlinearity, I didn't notice if that exists.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Nonlinearity doesn't really apply.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Any nonlinearity of response? Yes. Sometimes the ground speed seemed to change almost to step inputs. It was almost -- I could actually feel the aircraft accelerate a knot or decelerate a knot quite rapidly and then steady out on that new air speed. So there was lots of nonlinearities, but they weren't curves they were more like steps. And that was during the translation part of the maneuver.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: (No comments)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: No nonlinearity of response.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Nonlinearity of response, I didn't notice any.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Describe any problems with harmony of pitch and roll, speed control with height control, and with heading hold/turn coordination. I didn't notice any disharmony, but there is more control activity in the longitudinal axis and pedal activity than lateral.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Item 9, disharmony between lateral and longitudinal cyclic seemed to be the big issue. The rest did not come into play.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: No. 9, no problems with harmony.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Question No. 9, problems with harmony of pitch and roll, control speed, I think definitely with roll there is much lighter damped, let's see, there is a tendency to make an input, take the input out, right away, whereas longitudinally I could almost make a steady input and I don't get any kind of oscillation. So a little bit of control harmony difference between longitudinal and lateral, much less damped in the lateral axis. Heading hold, I didn't notice a problem.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Problems with the harmony, controls. (bad audio here) ENGINEER: When you flew over the top of us, we lost transmission. So from about question 9 down through the last one we couldn't copy. So just real briefly, feed that back to us as quick as you can. THE PILOT: Okay. And question #9, (inaudible) negative response. I didn't see any problems with the harmony or the height control, heading control.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Describe any problems with harmony of pitch and roll. This particular time it might have been due to the wind, but it required a lot more pitch input than it did roll input and it was quite noticeable. The amount, the amplitude of the pitch input versus the roll input there. And altitude control was difficult because of the slow rate at which the changes would begin. So you would kind of begin a change and you wouldn't really pick it up until it was accelerated and now you were already plus or minus two feet and you have made your input to respond to it. Heading hold seemed okay, although it almost immediately goes 3 degrees to the right and kind of stays there for the whole thing.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: Harmony, the height control feels a little different, like I said. It's because you put a bigger input in it takes a little longer to overcome the momentum. And then you must reverse and reverse with bigger inputs, but I'd say they were probably like a collective input every, oh, every second or more.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Describe any problems with harmony of pitch, roll, and speed control. I felt as though the roll axis of a little bit, a little bit more sensitive than the pitch axis. There isn't really a control field that way, but there is an aircraft response that seemed lacks harmony, but it doesn't seem to be objectionable. Heading hold, I did feet on and feet off the pedals. Heading hold seemed to be able to maintain desired tolerance if you used heading hold after the initial deceleration. There was a tendency for heading hold during that deceleration, depending on how abrupt it was, to get off heading and approach the adequate boundary. I felt as though with feet on the pedals, though, that I could maintain a very precise heading throughout that maneuver.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Problems with pitch, roll, speed control, height control, I didn't seem to have any problems with that.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Describe any overall control strategy in performing the task. I did the task both with feet on the pedals and feet off the pedals. (Inaudible.) heading retention was better with feet on the pedals than off the pedals. And I felt that the ability to maintain the position was better with trim on than with trim released.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: I did all the maneuvers -- for item 10. All the maneuvers were done feet off the pedals for heading control. What was nice about that was the ability to take away from heading control and just monitor the fore and aft and lateral drift and height control.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: Demands on the pilot. My strategy, I put a little lateral stick to get it moving, lateral and forward, follow those cones in. At the hover cone, just as it starts to slide out of view, that's when I start my decel, shift most of the attention to the board and watch the black box flying into the white and then just a little, quick, minor lateral control changes to capture it there. Then, like I said, it's just maintaining position with flight inputs but mainly concentrating on the vertical.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Demands on the pilot. No. 10. Overall control strategy. As far as the trim system, I did keep my feet on the micro switches the whole time, which could account for my heading deviations. I didn't take them off to see if the heading hold would hold it. As far as the trim release button on the cyclic, initiating the roll to start my 6-10 knots towards the hover point, I would push the trim button and then when I stabilize the trim then decel to stabilize, I would press it again, but it released it, holding down while I stabilized in the trim, once I called stable I pretty well released it. And from that point generally I just plot against the trim while in the hover for my strategy. I tried to use the primary cues off the nose and then off to the -- my 3 o'clock position where the cones were [for] longitudinal position. 45s, because they are -- for quick looks, it's hard to break them out from just the members of the cabin airframe. I didn't use those very much. I'd say through the 30 seconds of hover I may have looked at it twice. So, primarily off the nose and off to my 3 o'clock position.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Describe overall -- demands on the pilot. Again, in doing the task (inaudible.) And as far as scan cues, the most difficult to pick up is probably the fore and aft cue. (Audio cutting in and out.) Within the hover board, that's where my primary focus is, I'd stabilize in there, basically my longitudinal cues and make adjustments, final adjustments from there. (Repeated comments after transmission loss) THE PILOT: Demands on the pilot, overall control strategy. I did keep my feet on the pedals so I flew that like I felt I would fly that normally. As far as visual cues, the biggest one is the longitudinal cue, because once I'm getting the black boxes off the target, that's my primary focus and I know by the way I'm looking (inaudible) to see longitudinally.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Question #10, describe overall control strategy. Mostly it was just trying to keep up with the oscillations of the aircraft, trying to anticipate the large amplitude pitch input and trying to respond to the translations that occurred. That you could not pick up until the aircraft translated. There weren't a lot of attitude changes to go with those translations.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: Demands on the pilot. Pretty light. Longitudinal cue is probably the weakest, but I did have a strong sense there, a sense cue. And I had my feet off the pedals, since we got the FGS on, I figured -- (inaudible) the heading hold, I think I would really do that, too. So this was a foot off thing. And that eliminated any heading oscillation. But it depended on the aircraft system.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Describe the overall control strategy. Initially for the first two maneuvers was to set a good stable hover trim and then not change it, feet off the pedals. And then come into the zone and continue to keep trim release off and stabilize using for (inaudible.) The last maneuver was done with trim release until the stabilized hover was achieved, then trim was released once the stabilized hover was achieved. But feet were on the pedal the entire time.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Demands on the pilot. Overall control strategy in performing the task, cues used. Again, on the vertical cue, use the black box going along the, what appears to be an air conditioner housing until we got over the vicinity of the white square. But there is a tree or something behind that and to me it's a little bit hard to distinguish when the black square started out over, over the edge. Lateral cues, approaching it they are very good in that zone. So the yellow line is very predominant going out to the right. The diagonal cue going out there, it begins, it's interfered with by the doorjamb, you have got to look around the door jamb. This changes your position in the seat, which obviously affects your position when you are looking out front. Scan, most of the attention was actually out to the side along the diagonal trying to determine drift there, with quick glances back forward to see how you were doing vertical. I did notice a little bit of oscillation around the square because of that. And it's just it generally seemed to move around in the square more at this higher gross weight than what I have noticed before in the past. It was more difficult to get it steady on one particular point on the target. It would stay within the white square, but it did seem to drift around.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm ******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Describe any control compensation you had to make to account for the deficiencies in the aircraft. I felt as though the pedal and longitudinal activity were higher than roll because of the coupling issue. And I felt that the longitudinal I was less active there because of the level, difference in level of cuing available in the longitudinal drift than there is in both heading and lateral locations.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Describe any control compensation you had to make to account for deficiencies in the aircraft. There were constant, small collective changes and the -- that I would say were about a quarter inch every one to two seconds. But for longitudinal control, they are very subtle changes after you settle down to the 30-second stable.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: (No comment on tape)

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: (See field 10)

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Any control compensation, I didn't really (inaudible.) My feet on the pedals just like I would fly this thing for a real mission. (Repeated comments after transmission loss:) As far as control compensation, nothing major there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Control compensation. Other than the large amplitude longitudinal cyclic, I didn't really see any control compensation, just continuously trying to make up for the variations in position.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: (See field 10)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Describe any control compensation you had to make to account for deficiencies in the aircraft. The tendency tended to be no trim release until when I got the stabilized hover, then have to reset it after the deceleration. And there seemed to be this roll oscillation that was more prevalent with the trim on than with trim released.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Control compensation. It was, again, it was fairly easy to maintain heading control with the yaw pedals. As far as final end control compensation goes, it was fairly easy to keep the aircraft under control with normal use of controls.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Describe any modifications you had to make to what you consider normal control technique in order to make the aircraft behave the way you wanted. There are none that I would provide for that other than using (inaudible) trim against a stable hover position as opposed to resetting trim, so you don't have to relieve those forces.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Describe any modifications you had to make to what you would consider normal control technique. None. Other than if pilots were flying this maneuver they would probably fly with feet on the pedals but I flew it entirely with feet off the pedals.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: (No comment on tape)

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Modifications to normal hover. I don't really, I don't feel like I compensated for that at all. There weren't any modifications.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: And modifications -- (no audio) (Repeated comments after transmission loss). Modifications, from the way I'd actually fly this. I did make this comment before, but it's not a whole lot different, but I am using the pedals. The one other comment is based on the external load, I wouldn't have a (inaudible) member out in front, so I'm keeping my focus out front and he's directing me to come forward. Versus myself having to check the longitudinal cue out to the right. So it's the only difference in the task and I have to compensate for that by looking out to the right rather than keeping the focus straight ahead.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: And No. 12, describe any modifications you had to make to what you would consider normal. The biggest modification is trying to spend a lot more effort observing the cues and responding to them. Because they are translational cues, they are not attitude cues and it takes a lot to pick them up. And therefore there is not really a lot of excess work capacity there. You are pretty much -- it's pretty much a fully attended operation in that respect. That would be the difference because in the hover task you can pretty much nail it and you can still kind of look around and see other cues or use other cyclics.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: Modifications I made to what I consider normal technique was maybe my foot off the pedals. But I think that may be a more normal if I had remembered that that feature is available. And in this particular aircraft, that's pretty strong.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Describe any modifications you had to make to what you would consider normal control compensation. None. I think feet on the pedals is more mission relatable for this particular maneuver because I think this task is similar to a sling load task where they are trying to keep the nose straight and even have feet on the pedals for that.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: Modifications. There were no modifications that were necessary.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3:

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Please comment on anything else that might have influenced you. I don't have anything there.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Anything else, for item 13, that influenced me. There wasn't really any influences except for the weakness of the cuing between longitude and -- I used the 90 degree cones as opposed to the other cones that are off at a 60 degree angle or so.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: Miscellaneous on 13, still a little bit of trouble with the cuing on the 45 degree angle or 42 angle. One time I had it in front, close by the door and the other, the last time I had it a little behind. That seemed to be better for me, keep the cones behind me, flat posts of the door and then I didn't end up being aft of position.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: Comment on anything else. I think I have pretty well hit on everything.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Miscellaneous, the load oscillations.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Question 13 doesn't apply.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: I don't think there is any other influence other than the mass swinging underneath.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Nothing else influenced me. The wind seemed to be fairly calm today, so that wasn't a factor.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: And I can't think of anything else that might have influenced me.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: Using the Cooper-Harper rating scale, it is controllable. Adequate performance was attainable with a tolerable pilot workload, yes. It is satisfactory without improvement. Yes. I would say HQR 3. Some mildly unpleasant deficiencies, primarily in the pitch to yaw coupling that exists and it causes you to monitor the longitudinal axis more, divides your attention away from the heading hold task.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: Cooper-Harper rating scale. It was controllable. Adequate performance was attainable with a tolerable pilot workload. Is it satisfactory without improvement? Yes. And I would give this an HQR of 3 because I think there are some mildly unpleasant deficiencies. I could give minor pilot compensation is required to stay within the zone, primarily in collective, and that constant roll oscillation is an unpleasant deficiency, but it didn't diminish my ability to meet desired performance.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: I'm going to go over to the HQR scale. It takes a long time. Okay, yes. It's controllable, I got adequate performance even with a tolerable compensation. A tolerable workload? Satisfactory without improvement? Right in here I think I would probably complain a little bit about the vertical heave. But it's kind of in the minor category. I did get the desired. So if I describe the compensation I would probably about a plus or minus a quarter of an inch of collective and probably a little bit more than one second so HQR 4.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: So going to question 14 with the Cooper-Harper. It is controllable, yes. Is adequate performance attainable with a tolerable pilot workload? Yes, it does. Is it satisfactory without improvement? I'd go back in to say that it was -- I would say no on that. I felt like I was getting -- I felt like I was getting desired performance the whole time. I never felt -- I was out a couple times. It was definitely minor but annoying. The higher gain task is in the decel, stabilizing the hover. I wouldn't say fairly objectionable there, as once I get the hover it's, I'd say the aircraft is more easily upset laterally, so it's constant adjustments laterally to maintain my position. Therefore I've got to strip it out but I felt like that was the highest workload. Small inputs, maybe like a quarter inch inputs once every second or two for the minor but annoying categories, that would fit into an HQR 4.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio. [From the ground-station engineers' notes, four data runs were performed. The pilot commented that the maneuver was performed with and without trim release depressed. Also, the pilot commented that there was a low aggressiveness during the maneuver execution. There was a slight tendency to overshoot in longitudinal and lateral position. Mild unpleasant pitch-to-yaw coupling and the external slung load had no impact on the handling quality rating.]

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Handling qualities ratings, when I came up the Cooper-Harper, it's controllable? Yes. Adequate performance? Yes. Is it satisfactory without improvement? No. Deficiencies warrant improvement. I came in for this with a minor but annoying deficiencies and the stabilization to the hover, the roll oscillations constantly defeat that, lateral cyclic to control that with small inputs, quarter to half inch, 1 to 2 hertz on the frequency and subsided, as we see, about 5 seconds. So it's minor but annoying deficiencies. Desired performance requires moderate pilot compensation. HQR 4.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Question #14, is it controllable? Yes, definitely controllable. Is adequate performance attainable with a tolerable pilot workload? I will say yes. Is it satisfactory without improvement? I will say no. And I will say that there are moderately objectionable deficiencies and then adequate performance requires considerable pilot compensation. HQR 5. And of course the moderately objectionable deficiencies are this tendency to translate without attitude changes and therefore any slow rates in which the translation begin and so the deficiencies are the inability to pick those things up, to pick those cues up that you are about to move somewhere. And the adequate performance requires considerable pilot compensation. It does. I think mostly the compensation, it's not so much in the control as it is in the observation of the cues and observation of trying to detect the motion. So HQR 5 for that.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: So let's go to Cooper-Harper. Is it controllable? It took me a while to get to 6 or 8 knots, or 10 knots, whatever I had, but I could get the air speed, I could track in pretty good, I could capture the position within some tolerance. I would say it's controllable and I think I got adequate tolerances. Is it satisfactory without improvement? I think I'm working pretty hard on that, especially in the collective again. I'm squeezing the collective tightly making very small motions on that. I've got very little friction on it, so it's not that a load in the collective, but it's the closeness that I have to maintain and the attention to the vertical heave. So but it still is in the minor but annoying area. And performance requires moderate compensation. HQR 4.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I would say yes. And I would say that I'd give it HQR 3. Minimal pilot compensation required for desired performance. The only thing I don't like is the roll axis and the tendency, that little disharmony between the roll and pitch response that keeps you constantly monitoring the fore and aft drift to stay within desired tolerance, which requires the largest compensation here. So HQR 3 for this maneuver.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape. [From the ground-station engineers' notes, the pilot commented that actual deceleration-to-hover was not difficult. All of the cues and training oneself to incorporate all of these into the pilot's scan is what makes the task difficult. There were no oscillations or predictability problems. Sorting out the visual cues was the problem. The aircraft is not difficult to hover. Achieved only adequate performance with the critical sub-phase being the longitudinal axis. The pilot commented that an HQR=5 seems rather harsh . . . and it could be a training issue/problem. This last comment is the reason for the asterisk next to the HQR in the header.]

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: As far as Cooper-Harper goes, is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? Yes. Fair, some mildly unpleasant deficiencies. Mainly the drift around in the box that causes you to concentrate more on that box than I believe is necessary. I think minimal pilot compensation required for desired performance. An HQR=3 on that. End of comments.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3: No audio. [From the ground-station engineers' notes, the pilot commented that the response was very predictable. There was a tendency to "bobble" in the roll axis. The other axes were fine. The pilot used heading hold during the performance of this maneuver. The vertical cues during the translation over to the hover point were inadequate, i.e., the vertical cues are not picked up until at the hover point. There was some control compensation in the roll axis and a little tendency to have a pilot-induced-oscillation (PIO) during the deceleration to hover.]

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm *******************

Pilot A (data runs 186.1-5 - Config. A calm) HQR=3: What was the critical subphase of the task? I think the critical subphase of the task is actually capturing the final heading because you don't have great altitude to use to get into the position and so you focus on the altitude and lateral and longitudinal capture, you tend to overshoot a little bit. The load does not have any impact, there were no excessive swinging or load dynamics that were apparent during the entire maneuver. That completes my comments.

Pilot B (data runs 193.9-12 - Config. A calm) HQR=3: What was the critical subphase of the task? The critical subphase was the deceleration to capture the position hover point.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.10-13 - Config. A Lt winds) HQR=4: Probably, the second part of question 14 is there -- question 15, pardon me, the critical subphase, probably control of altitude? ENGINEER: I want to affirm what I hear, and the compensation in the collective. THE PILOT: Yes. The collective, I could feel it in my arm, the muscles would get tight after a while they get a little bit fatigued. Even though it's very small, it's got to be very, very precise. To the point that I don't even pay attention to the workload in longitudinal or pedal. Not that it went very far, I mean I was always pretty much in the middle of the square but I could see it starting to move and I had to make this real small collective and then be ready to reverse in that direction. Heading hold, altitude hold, was great.

Pilot D (data runs 192.1-4 - Config. A Lt winds) HQR=4: The critical subtask, I'd say again the, just the stabilize in hover I guess would be where you had to watch the most. There was probably higher workload during the decel, the stabilizing. It wasn't -- it wasn't saturating the pilot by any means.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: The critical phase is that stabilization to a hover where I'm seeing the most -- highest pilot workload.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: Question 15, the critical subphase, I think this particular case it was not the decel but it was kind of two critical subphases. The translation was quite difficult to maintain a steady speed so you could get a nice, smooth decel, and the maintaining position was difficult. The decel itself wasn't particularly difficult.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4: And No. 15, the task is vertical and it's the collective input but at a lot slower rate than when we didn't have the load. I would say the collective input every second or so.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.11-13 - Config. B calm) HQR=3: The critical subphase for the task, I think is the deceleration phase. Everything after that the aircraft seemed to be fairly controllable and easy to maneuver in the stable hover.

Pilot E (data runs 208.1-4 - Config. B calm) HQR=5*: No comments on tape.

Pilot F (data runs 209.1-4 - Config. B calm) HQR=3: The deceleration of five seconds was probably the most critical. The main reason for that, it seemed like everything was excited at once. You are trying to get the square, the black square in the middle of the target, lined up on the lateral line, yellow line and cones going out to the side. And on the diagonal. So everything was sort of -- all the axes were excited at once. And to get those straightened out in the five seconds was probably more difficult than the rest.

Pilot G (data runs 204-.1-3 - Config. B calm) HQR=3

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Calm ******************

Pilot B (data runs 186.21-24 - Config. D calm) HQR=3: No audio.

Pilot D (data runs 195.8-10 - Config. D calm) HQR=4: Yes, very significant. Once I start my decel the load is continuing to give some oscillations, plus or minus 10 degrees and I think feedback into the aircraft control system from there. That's all.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.32-36 - Config. D Lt winds) HQR=5: And question 16, yes, I think, anyway, that the external load probably had a significant impact on the assigned HQR. I think that was probably the cause of the translations without attitude change, a lot of the difficulty in picking those things up. And that's all I have.

Pilot C (data runs 188.36-38 - Config. D Lt winds) HQR=4:

HOVERING TURN MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio. [From the ground-station engineers' notes, four practice runs were performed prior to the three data runs; the pilot was able to achieve desired performance on all of the data runs. The times to complete the turn were 13, 14, and 13.5 seconds.]

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Item 1, desired performance standards could be attained, although heading was the limiting factor in this one for -- in terms of (inaudible). Time was not a factor. Fore and aft drift didn't appear to be a factor. But heading, capturing that final heading and stabilizing on it was the limiting performance standard.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: For this maneuver, desired performance standards could be achieved. We had a couple adequate excursions, I think the first two maneuvers on this card where the pilot's ability to figure out where that line was and where you would come out during the maneuver for the left-hand turns in terms of the fore and aft cuing. So once we got that worked out, got that sight picture down, performance standards for desired were able to be achieved.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: It looks like we were able to get the desired. The first one was the best of all. The second one ended up with a little bit downwind, we had a crosswind blowing on us. The last one was pretty good again. The hover position seemed to be all right. And I'm not using any cones for that, it's just the center line, the black lines between the concrete blocks and stuff like that, the overall environment in close to the aircraft for position. But 45 degrees prior to the hover marks I find myself looking up, and then kind of lean into the position.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Okay. It felt like we met desired except for heading capture on the left turn.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: This is the right hovering turn. Ability to meet desired/adequate, I felt like I was in the desired the whole time, and I was thinking adequate on longitudinally, primarily.

Pilot D (data runs 192.8-.11 Left - Config. A Lt winds) HQR=5: Desired versus adequate performance. Longitudinal axis I was just with adequate, everything else was desired.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Commenting on hovering turns with external load, both right and left. Task performance: Describe the ability to meet desired/adequate. And going to right I felt like I made desired every time. Going to left I fell into adequate maybe once or twice, I felt like my last one was in, so given the average I think I was desired.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: These will be comments for the hover turn to the right with the load. We did it four or five times there. We are hovering in a left crosswind to start of about, I think it was 16 and we end up with the same wind on the right after we complete, so the aircraft is 8 degree bank to begin with to the left and ends up a few degrees to the right when we complete and that shows up a little later in some force problems. The whole thing is not too tough, except visual cuing of longitudinal position leaves a little bit to be desired. Once the runway passes underneath our -- actually it passes underneath the nose, reference points are lost. In other words I'm looking at the three cones, 180 degrees from where I'm going to end up with, and the centerline off to the right. As I make the right turn there is a period there where I have no longitudinal cuing until I'm pointing at the target again, I have the centerline in view.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: It's hard to meet -- ability to meet desired and adequate performance standards. I think the real trick here is to be able to capture longitudinal/lateral and then the heading as you come around in the last phase, some are desired, some are on the edge of adequate. I think for the most part based on what I have seen, there was always one parameter that was right on the edge of adequate performance standards or right on the edge of desired and adequate for this maneuver.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: Comments on the right turn. I would say that generally speaking the performance is right at the upper edge of adequate. I find that as much as I would like to think that the turn can be made smoothly I find that it's kind of a ratchety turn for me. It's not clear to me that I am turning around the mast, it's not something that I think of necessarily as the way to turn the aircraft. So to some degree that in itself is a descriptor in the maneuver that needs in my case some practice to assure that I'm actually doing that. What I see instead is that I am turning the aircraft around, I'm finding about halfway through I assess where I am on the line and then continue the turn and try to come up on the line as I finish the turn. It's hardly being done smoothly over a point. I find it very easy to overshoot. I'm trying to keep the speed up to make sure that we get the time, but again it's a matter of being able to smoothly take the yaw input out to end up on position. I find that on average my overshoots have probably been, in the practice runs were in excess of 10 [degreees]. I think here they were more in the order of four to six on the runs that were for data.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: Looks like we're getting desired performance on everything except longitudinal. And that is a question. The times when we showed it, I guess run No. 3 it showed me out aft, that was the best run of all to me. If I had looked down the line I would have said I was right on. What this is telling me is I'm not a very good estimator of longitudinal position. I think that -- I look down the line and I can be convinced that I'm on the line with some degree of dispersion. I could be aft or forward. And I'm not -- I think I have a tendency to look at the line, I've come up with a visual picture which is acceptable to me but which is incorrect. So I'm happy being slightly aft as opposed to being up on the line and I suspect physiologically that accounts for the amount of turn that you have to put in your body to see the line. So if you are slightly aft and you convince yourself you are on and you actually have put less body work. So I suspect there is some loop there that is causing me to be happy with it when in fact I'm aft. Okay. Overall I guess I would say that you could get desired performance even though we do have a couple of adequates in there.

Pilot F (data runs 209.5-8 Right, 209.9-.12 Left - Config. B Calm) HQR=4: Ability to meet desired/adequate performance standards. I think it is possible to meet desired performance standards with some training and practice on it. And just being sharp on the skills.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight. [From the ground-station engineers' notes, four data runs were performed in each direction; the pilot was able to achieve desired performance on all of these runs. The times to complete the turn were 12.5-13.5 seconds to the left and 13-15 seconds to the right.]

2. Describe aggressiveness / precision with which task is performed.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Describe aggressiveness/precision with which the task is performed. I think we did up to moderately aggressive, precision could still be maintained. We will talk about why. As you increase the aggressiveness I think that precision will go down fairly dramatically because of the control coupling. And some oscillations.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: If trying for desired performance resulted in unacceptable oscillations, the oscillations were annoying but acceptable and desired performance could be achieved so item 3 doesn't apply.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Aggressiveness, that's about -- it feels a little low on aggressiveness because of turn rate, but, you know, for a heavy aircraft, it's probably fine.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Aggressiveness, it felt the same as before or I could be a little bit more aggressive. We are in a, I'd say 5 to 7 degree left wing down into the wind and then I want to put the left pedal in to right the aircraft, get the moment arm out of the tail rotor. And then it's a nice, flat turn around in the wind line. I mean into the target. I just kind of hang on until most of the turn is out of the way. Look across cockpit to see the target coming and then try to anticipate when to lead with the opposite pedal. But the tendency, I think all three of them, was to overshoot in the yaw.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Aggressiveness, fairly aggressive maneuver, but I would consider it moderate just because there is -- it's pretty easy to get the pedal turned in the minimum time but still not a highly aggressive maneuver. I felt like I was getting into the desired, so as far as high oscillations or anything like that, I would stay within adequate. I felt like if I reduced the aggressiveness I could stay there.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Aggressiveness of the task, targeting the 15 seconds was not too much to ask for. I think that's what I was targeting every time, so I never missed or reduced the aggressiveness.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Describe aggressiveness/precision of maneuver. My first one to the right did not meet the time required. I was a little aggressive and made the time required on every one after that.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: (See field 1)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: Describe aggressiveness and precision with which the task was performed. The aggressiveness with which the task could be performed were -- it's not an unusually aggressive maneuver to stay within the time standards, but the precision with which to capture the final heading and maintain other parameters is difficult because on the predictability of the yaw response to a given pedal input, when it's going to take effect. There appears to be some other coupling that's involved as you have to make a large pedal input to get stopped in time, there appears to be some pitch to roll or some yaw to roll coupling that gets you in trouble in terms of roll oscillations to meet your lateral standards.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: Aggressiveness and precision, I don't have any sense of aggressiveness here again I think with 15 seconds it seems to me that you can, once you are comfortable with the maneuver, it's not a maneuver that needs to be rushed. In fact once you have the style down, you can actually do it in 15 seconds quite nicely, I think. The precision in my case I think is suffering, from again coming through it exactly the way the task seems to be flown and the smoothness, I do think it's a task that will improve with practice.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: I see no sense of aggressiveness in this task at all. In fact aggressiveness in my experience degrades the overall performance. It's very important to have a smooth directional input, otherwise the correcting at the end to get it on, whether I was overshooting actually kind of destroyed the smoothness of the maneuver. So the high priority is on putting a smooth input in. There is no reason to rush the initial onset. I think that a nice, smooth onset at the count of 3 with a slight acceleration still gives you nice time and gives you a smoother task.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Aggressiveness and precision with which the task can be performed. It seems like the more aggressive you are, in other words the faster that you want to do the maneuver, the more tendency there is to overshoot at the end. Once you get it established going either left or right, get the turn established it's stopping the turn that becomes critical. In order to do it quickly and abruptly. There is definitely an overshoot of the yaw at the end with a very high gain. It feels like feedback in it. I did notice that going between the left and the right there was a difference and I think this is primarily due to tail rotor effectiveness as you go around and how the wind is hitting it. When we are making turns to the right, due to the wind being out of the north, we were getting 4 knots, I could feel the wind acting on the tail, resisting movement of the tail during the initial 90 degree turn. Once you got past the 14 heading, it seemed like the wind was more effective upon the tail in turning the nose around. So you were able to pick up a little speed there. That would have an adverse effect upon because there would be more of a tendency to shoot

-- overshoot on the other side, just because of like the pendulum effect of the nose of the helicopter. So you had to take that into account. Going the other way, going to the right, it felt like once you put a control input in there in, you could almost hold it there. Going to the left, nose to the left, you could hold it in there and it seemed like it picked up a fairly constant rate as you turned back around. This allowed you to go ahead and divert your attention to the outside and pick up the visual cues on the outside. Jumping back to when you turn to the right, it feels like you have to put in a lot of pedal and then be prepared to take it out once the wind starts affecting the tail.

Pilot G (data runs 205.5-8 Right, 205.1-.4 Left - Config. B Calm) HQR=4: No tape for this flight.

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-.18 Right - Config. A calm) HQR=4: Unacceptable oscillations, one oscillation that gets coupled in here is there is a subtle roll oscillation that's tied to the pedal inputs to capture the heading and it distracts from your ability to look at that heading and capture it. But it's not objectionable, it's just -- it's an annoying problem with this aircraft.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: If trying for desired performance resulted in unacceptable oscillations, the oscillations were annoying but acceptable and desired performance could be achieved so item 3 doesn't apply.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: I don't remember any unacceptable oscillations, there is a little bit of the old Blackhawk roll with pedal, but it's compensated for easily with lateral input.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: (No comment on tape)

Pilot D (data runs 192.5-.7 Right - Config. A Lt winds) HQR=5: I guess I'm saying I didn't lower requirements to do that.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: I guess the next question because of that feeling, because I felt like I got in desired every time, I don't think I ever was out of the adequate means, but possibly, one question I didn't go with was if I would have taken a little more time, not spent the 15 seconds, but scan longitudinal axis, made a few more adjustments, I may have -- I would have made longitudinally desired, but not for the time limits, not for the aggressiveness of it, I don't think.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: Desired performance, fell out of adequate. I think I could -- once I -- probably without many practices once I -- excuse me, once I perfected the maneuver a little bit, I was able to hit the desired without compromising anything.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: (See field 1)

**************** Configuration B - Calm ******************

Pilot B (- 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: I think that the desired performance resulted in unacceptable oscillations only in the fact that trying to stay less than 5 degrees of overshoot, if you had to make a large pedal input to do that, there were some roll oscillations that got induced and the pilot couldn't react. So there was a tendency for some PIO at the tail end of the maneuver, but it damped out fairly quickly, as soon as the pedals stopped moving and stabilized on a heading. Did going to adequate performance alleviate the problem? I think that that would alleviate the problem, in fact it did. On a couple of the -- I don't think it was -- I would call it objectionable only in that I couldn't meet desired performance with this oscillation in terms of lateral.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: For any oscillations involved, they are directional. And it's not really an oscillation, it's more of a correction.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No. 3, I don't see any oscillations.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: It seemed like there were some, what I consider unacceptable oscillations in response to question No. 3 there at the end of the maneuver. Because there was a little bit of overshoot on heading and it seems like you were fighting it with the yaw pedals.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Item 4, objectionable controller force characteristics. One of the comments I will make with the pedal forces is that pedal forces appear to be a little bit high to do this fine tuning. If you can get right on it, get the oscillation under control and set the heading, you can capture easily within desired. But a subtle oscillation in roll as you capture the heading makes a difference in your ability to precisely get down and the control forces don't help you diminish that oscillation.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Objectionable controller force characteristics, again I think there is still a little bit of force in the pedals making it such that fine tuning is a little bit more difficult to attain here in terms of predictability of capturing the final spot.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: On No. 4, I don't notice any control force characteristic problem. I don't know where it fits but the pedal feels a little low on responsiveness when you try to capture the heading for my right turn. That's probably the hardest part is the heading capture via pedal.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: No force problems on No. 4.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: The only thing noticeable there is once in awhile maybe it will come out in predictability, but the pedal, whether it's actually getting the micro switches depressed or not, sometimes feels like I have to -- it's not real predictable in my pedal inputs.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Aircraft characteristics. Objectionable controller force characteristics. None noted there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Aircraft characteristics. Objectionable force controller -- controller force. No.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: No. 4, describe any objectionable force characteristics. Controller force. I do have some forces into the slip and if I trim with the left wing down then I end up with a lot of forces to the right. When I'm complete I had to warm it through here but I release the forces I get a stick jump out of that. The next one I did with the force trim button depressed all the way around. But in that case if I change -- my grip changed. I think I would tend to want to do that with the force trim system working. But then the force changes from one side to the other pretty significant.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: Describe any objectionable controller force characteristics. The controller force characteristics, the only ones there was good correlation between how much pedal and how much rate was required to stop the airplane, because there is a time delay associated with the pedal input and when the tail rotor actually takes effect.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: Aircraft characteristics. No objectionable controller force characteristics.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No. 4, no objectionable controller characteristics.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Objectionable controller force characteristics. There weren't any.

Pilot G (data runs 205.5-.8 Right - 205.1-.4 Left - Config. B Calm) HQR=4: No tape for this flight.

5. Describe predictability of initial aircraft response.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Predictability of initial aircraft response. The predictability of the rate in the initial response is fine. The predictability of capturing the heading is difficult in this particular task. It's not unacceptable, but it is -- makes this task meeting desired more difficult.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Predictability of initial aircraft response. Predictability is poor because of the little bit of time lag, as well as the pedal oscillation, you are not quite sure where you are going to end up and how much that next oscillation is going to take, where it's going to take you.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Predictability, I think that was a little bit low on that. Because I put a, must have been a two to three inch left input one time and then a couple small ones to correct for it. To capture heading.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Predictability of the initial response, everything is pretty predictable.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Question 5, I'll go into that a little more. Sometimes I feel like I'd initially put in a pedal input that's not really slowing me down, this is the discussion of the capture phase, so I will put in a much larger input, which will kind of go into a momentarily kind of a yaw PIO and yaw coupled with roll, I guess.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Predictability of initial aircraft response. No problems with predictability and in this way, unless I'm getting better flying the aircraft, I thought it was easier to stop the left pedal turn than it was to stop the right pedal turn. Maybe that's some of the wind effects coming into play with that as well, staying in the right crosswind.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Predictability of initial aircraft response. Was very predictable.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: Initial response, the aircraft is a little sluggish to get moving in yaw, but I think we know that sensitivity is a little bit low. But I can do this timing around. Position maintenance is okay until the taxiway passes underneath the nose and I start looking at the fence. Once I see the target I can make the appropriate corrections to get the target on centerline. And I have to be a little aggressive on the right lateral stick or any lateral stick because the wind is going to keep moving.

**************** Configuration B - Calm ******************

Pilot A (data runs 206.14-16 Right, Left 206.17-19 Left - Config. B Calm) HQR=4.5: Predictability of initial aircraft response. I thought the first response was predictable, but as the turn comes around the initial response to stopping the aircraft was not predictable. And that made the task more difficult.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: Predictability of initial aircraft response, I think there may be something one could discuss here. I don't typically think of doing these kinds of tasks for precision, where one is doing something other than just barely turning the aircraft around a spot that it in fact is comfortable with. So here I find I tend to be a little bit ratchet and the directional control getting the speed down, an intentional rate down, I'm thinking of a nice, smooth turn.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No. 5, predictability of initial response. I'm finding now that with a little more practice, I find that the onset of the maneuver is actually more controllable or is actually being controlled more nicely by myself. I can put a smooth input and I get more time to estimate whether it's going to be the appropriate amount of pedal or not. If I go to the left it's been easier than going to the right, perhaps a matter of practice.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Predictability of initial response of the aircraft. For most control inputs it was good and fairly predictable.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

6. Describe any mid- to long-term response problems.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Mid and long term responses, I think there is a mid-term response problem in that the pedals, if you let go of the pedals right after you capture, do the oscillations, they will sit there and wander as you cannot fine tune that final heading just by releasing the pedals quickly after you get to the desired heading.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Mid to long term, I think some mid-term response problem is getting the oscillation and yaw down to where you can let heading hold finally take over. Where you finally decide to do that makes a big difference whether you meet desired or adequate for the conclusion of the maneuver.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: No mid to long term response oscillations.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: No long term response problems.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Mid to long term response, I wouldn't consider it that. No problems there.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Describe any mid to long term response problems, not applicable.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Mid to long term response, no problems there.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: (See field 5)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-.19 Left - Config. B Calm) HQR=4.5: Mid to long term response problems. I think there is a mid-term response problem in the yaw to roll coupling when you have to make a more dramatic pedal input.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: No sense of mid term or long term response problems.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No mid or long term response problems other than perhaps sliding aft.

Pilot F (data runs 209.5-.8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Mid to long term response, no.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

7. Describe any objectionable oscillations or tendency to overshoot.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Describe any objectionable oscillations or tendency to overshoot. There is a tendency to overshoot in the heading as you increase the aggressiveness. The objectionable oscillation is trying to settle down on that final heading with your sight cues. You can have lateral cuing in this one, but they are really not great heading cues for this particular maneuver that allow you to readily outside the airplane look and discern your heading. You are really relying primarily for heading response on the gyro.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Objectionable oscillations, there really wasn't objectionable oscillations, but -- well, objectionable oscillations in the yaw in terms of that final capture. I didn't feel as though the left turn was as bad as the right turn in terms of that oscillation. There was a tendency to overshoot going to the left, it didn't seem to be as bad as going back to the right. It may have something to do with rate, but from here it appeared as though that was clearly definable.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: I had a tendency to overshoot, with that rate on the aircraft you have to put a good sized pedal input in to keep it from overshooting. But then that's probably only one overshoot and then a few small iterations on the pedal to settle down.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: And no -- yeah, there is a tendency to overshoot. And that's the same thing, large pedal to stop and the aircraft feels like it's got a little momentum, carries it through, then some iteration on the pedal to send left.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Objectionable oscillations and tendency to overshoot. Yes. I think I was putting in a fairly large pedal input to stop my rotation, which has caused me 1, 2, 3 at least three to four overshoots in the yaw channel during my stabilization phase.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Objectionable oscillations, I didn't see any really, there. Tendency to overshoot.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Objectionable oscillations, tendency to overshoot. When I was trying to rapidly keep the turn in and then stop the decel I had some yaw oscillations that caused problems on a couple of the ones to the left, that sent me out of -- I think the second one sent me out of the desired into the adequate range. So controlling the yaw oscillations required some control strategies that lead my decel time more than just coming up to the point and making a decel once for the maneuver. Also while stabilizing, once I'm at my desired point, I started my decel, that's where the roll oscillations start to kick in and kind of a little bit in longitudinal, this time, so there is kind of some cross axis primarily roll, but also some longitudinal oscillations is causing longitudinal cyclic corrections.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: (See field 5)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: (No comments)

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: The only tendency to overshoot that I see is in the heading response. I never undershoot, I always overshoot.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No objectionable oscillations or in this case tendency to overshoot.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Again jumping back to the heading vibration that I'm feeling with the extra weight in the helicopter is probably the only thing that would be objectionable. It feels like you are right on the edge of translational lift with it and there is a constant vibration, deep vibration, that is coming back into your control inputs.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

8. Describe any non-linearity of response.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Nonlinear response, there really isn't any nonlinearities.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: No nonlinearity of response.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Nothing felt nonlinear.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Nothing is nonlinear.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Nonlinearity of response, there is a point where and sometimes it is obvious if I'm not pressing down on the micro switches where little inputs, not do anything, not do anything, and then once the micro switch gives, I get a little bit of a jerky motion. So I consider that a nonlinearity.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Nonlinearity didn't really apply there, either. I think as long as I keep the micro switches depressed I had no problems with that but I have to make sure they keep depressed through the maneuver.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: Nonlinearity of response, not seen here.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: There is no linearity.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: Describe any nonlinearity response. I didn't see any nonlinearities.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: No sensitivity or nonlinearity of response.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No nonlinearity of response that I'm aware of.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: There was no nonlinearity of response.

Pilot G (data runs 205.5-.8 Right, 205.1-.4 Left - Config. B Calm) HQR=4: No tape for this flight.

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Harmony of pitch, roll, speed control and height control, I didn't really notice that too much on this maneuver. The winds are calm today so I didn't have much coupling in the heave axis, so it didn't seem to be a problem there.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Harmony of pitch, roll, speed control, I don't think there were any harmony issues that played a role.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: No. 9, harmonious. I felt a little bit of height control issue there, I was going to comment on that. But it was overcome, I think, by capturing the heading. But I think I did okay on the altitude. I wasn't watching the rad out [radar altimeter].

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: No. 9, harmony is okay. Heading, hold/turn coordination. Everything is okay in the turn.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Harmony of pitch and roll, it's not really noticeable. The heading hold/turn coordination doesn't quite apply with this maneuver.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Problems with harmony, again that does not really apply.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: Problems with harmony of pitch, roll, speed, no problems that, heading hold not a factor here and I will talk about that in my strategy.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: No harmony problem on 9. There is the force build up from left to right during the turn.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B calm) HQR=4.5: Describe any problems with harmony of pitch and roll, speed control. I think that there is a -- the harmony is between yaw and roll that those two start interacting with each other and the yaw is not directly apparent unless you stop one axis from moving, which is what I did.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: And nothing for No. 9.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: No sense of difficulty as far as control harmony goes. I still think that there is, as far as I'm concerned -- I'll tell you in miscellaneous.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Harmony of pitch and roll, speed control, height control. Height control on this, which I will get to the cues, you have got to start off initially using the radar altimeter since there is no target out in front. And it looks like there is a tendency as you go left, I particularly noticed it going to the left, to increase altitude. I didn't notice so much in going to the right. But it did seem like we increased a few feet and ended up high at the end. Heading, turn coordination, no problem with that. The only thing heading, heading hold, once you get back around, the overshoot tendency requires you to make pedal inputs to get it back to the 232 heading.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B calm) HQR=4: No tape for this flight.

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

*************** Configuration A - Calm ******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Demands on the pilot, overall control strategy in performing the task. I would pick up and at the 90 degree point I would pick up the line and pick up the altitude cues from the board that allowed me to take those things out by the time I got to my initial capture. I thought the cues were adequate for this task for that.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Overall control strategy. The control strategy in this one and the other one which I didn't previously mention was if you can get around in a reasonable amount of time, you still have your 15 seconds left, it gives you time to stabilize on the point at the other end, the more time you have to do that the more you can fine tune those last pieces. Once you are in the stabilized environment, the cuing is good. So my strategy was to get around quickly in the initial response and then make that initial deceleration in the end in time so I had plenty of time to get stable at the other end.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Overall strategy was to put the pedal in, trying to hold what appears to be constant rate, pick up the ground cuing rather than the cones, look to the right about 45 degrees out and then you can kind of play the two targets coming together.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Overall strategy, much like the right side, although the cuing seems to be almost even better, because the aircraft swings level to make the turn. But again looking up about 45 degrees ahead of time for the heading and at the target to see when I should capture. And even then position feels okay.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Demands on the pilot. Overall strategy. I think I started a nice, easy yaw rate but also I know that to meet the times in this case, the time to complete the maneuver within 15 seconds, I felt like I had to dedicate almost five full seconds just for the stabilization phase, at least. So the turn had to, the turn took up more than two-thirds of the maneuver. So in some ways I felt rushed to get the turn going for that. (Inaudible) cues. A real interesting thing there. As far as my longitudinal position throughout the turn, I had very little. I'm trying to somewhat guess where I need to end up and rotate about the mast which, which is very subjective for the small tolerances we have. I can see where basically where I initiate the turn where I'm supposed to be longitudinally and where I spot and then in the middle I kind of have to guess in between the two points where I'm at, even when I'm perpendicular, heads down the runway, I see the center line, but I shouldn't really be on the center line yet, I should be slightly to the left of it. So as far as my longitudinal position throughout the turn, there really aren't very many cues.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Demands on the pilot. Overall control strategy in performing the task. I think really the point of the cues, I didn't feel like the longitudinal cues were necessarily -- anywhere I needed them to be. And basically when you really got to flying I guess you've got to scan off to your right as well as straight ahead. But I felt in order to make the task within 15 seconds I pretty much fixated on the hover board until I got it stable there. And I felt if I took the other second or two to glance off to my right to get exactly in longitudinal position I would have been outside the 15 seconds for desired. So it's more fixation on the board, longitudinal cues weren't really great for me there. The 45 cues were virtually nonexistent because they are kind of going in and behind the airframe and I can't pick those up. So to be able to take a look out to the right to see those cues just took extra time that I was trying to get the 15 seconds I didn't make.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D Calm) HQR=5: Demands on the pilot. Question No. 10, overall control strategy. I concentrated in on getting my position right as I'm going through the turn. Once I roll out on heading, I'm not trying to set the heading hold, in order to hold my heading, I'm active on the pedals in the loop the whole time. As far as the cue scan, similar to the hover my primary focus is on the hover board with the (inaudible) to the right a little more than normal. For turns to the left I'm able to pick up those longitudinal cues a lot earlier on, which is enabling me to position as I am finishing my last (inaudible) degrees of the turn. Coming from the right, hover turn to the right, I'm not able to do that. So I'm having to hit the hover board and then crosscheck over to my longitudinal cues. So a little more head movement going to the right than to the left.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt winds) HQR=6: Control strategy, let me think about that one. The strategy is look real hard at the cones and the center line and then look kind of like over the right shoulder to see where I'm going in order to maintain position. So like you said, laterally I'm doing okay, longitudinally that last 45 degrees, I need 45 degrees to end, I don't have good enough cues to stay longitudinally. And the displacement cones look pretty close when you are 40 feet up in the air. So that is not good cuing there.

**************** Configuration B - Calm *****************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B calm) HQR=4.5: Describe the overall control strategy in performing the task. Make the initial input to start the rate, try to maintain a constant rate as you come around and then lead with pedal about 10 or 15 degrees prior to the desired heading to try to get it stopped. Then focus on heading and longitudinal and typically coming around there wasn't real good ability as you came through the 90 degree point to have a good feel for where you were going to end up longitudinally or laterally on the visual cues.

Pilot E (data runs 208.5-8 Right - Config. B calm) HQR=5: And demands on the pilot. Overall control strategy performing the task. Again, it should be a nice, level turn. This should not be a complicated task at all. Again, my sense is put the control input in and then trying to sense how the aircraft is turning. It's actually a pretty constrained space, so whether it turns around the seat or the mast, it's not a whole lot of distance difference. Again I have yet to figure out exactly how that is being done. My sense is to put the control input in and try to make it as smooth as possible, realizing that it doesn't have to be -- it's not really a hard driving turn to make 15 seconds, so I'm trying to smooth it out and end up with a nice deceleration into the end hover point.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: Again, a very smooth onset, as much as possible, just right the turn, I don't take it too fast so you don't have to put too large of an input in at the end. The most difficulty I find is in getting the -- to come out of the maneuver without having drifted laterally so that I don't have to reposition myself laterally when I come up on the end target. That would again, (inaudible) lateral displacement is very easy to see. The fact that you have a longitudinal displacement for me is much harder to determine.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Overall control strategy in performing the task. Having to turn around the center of mast required a little bit different control input. I found myself putting in a pedal input to get it started going left or right and then pulling a little bit of aft cyclic. This also could have contributed to the height control as we went around. I didn't move the collective what I felt to be very much, if at all. But just maybe that little bit of aft cyclic going to left, when we went to the left, caused some of the height change. The same technique was used going to the right, you pull a little bit of aft cyclic, so you felt like you were turning more behind you rather than over your seat. Let's see. Cues used. Going to the right there are no lateral cues out there to see how you are doing. You have got to pick up on the visual cue, the black square on the air conditioning duct and have it try to -- and usually by the time you get turned around, the black square is fast approaching the white square. So there was a slight tendency to overshoot into it, because you don't realize how fast it's moving until it's slipping across the white square. At that point you try to pick up the lateral cues staying in the diagonal or the yellow line, and the columns on the line and it tends to divide your attention between the white square and the line. I felt this was a little bit taxing as far as cues go, trying to keep track of all these things. Plus the fact you are trying to get stabilized out on the heading. I did find going to the left it seemed like the pickup of the cues was much easier, because you are able to go around and start picking up the lateral cues as your nose was passing over them, so you could start sorting those cues out, getting lined up on the line both in the fore/aft longitudinal position. And then you would just, once you had that wired, you could go ahead and divert your attention to the horizon and pick up the black square and the white square. It seemed like those, there was more time to focus on each one of the cues as you were going to the left. But again, that was a problem I had -- one problem I had going that direction was height control. I'm not sure, you know, just what was feeding into that because the difficulty there, but I did think the cues were better going to the left than to the right.

Pilot G (data runs 205.5-.8 Right - 205.1-.4 Left - Config. B Calm) HQR=4: No tape for this flight.

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Describe any control compensation you had to make to account for deficiencies in the aircraft. I had to keep my feet on the pedals and get rid of that oscillation before I could let heading hold take hold. And depending on where I was in those oscillations and release the pedals made the difference whether I made desired or adequate.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Describe any control compensation you made to account for deficiencies in the aircraft. The control compensation is really getting rid of that oscillation before you release heading hold. That's the compensation that was most prevalent. And then making sure that you are in the zone fore and aft at the 90-degree point was very important in whether you could meet the fore/aft tolerance.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Compensation was mostly on pedal on the capture. And I would guess two to three inches one time application followed by, you know, maybe plus or minus a quarter one or two times a second to settle in on heading. And then once you are there, it's fine. So the capture seems to be the hardest part.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: No. 11, control compensation for deficiencies in the aircraft is the large pedal to stop the yaw rate.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Compensation that I'm making for this. I think it's basically in the capture phase. When I try to capture I'm putting in a larger pedal input which I immediately have to follow-up with a couple other inputs, I'm also in a constant oscillation and trying to damp that out. So it's mostly in the pedal inputs, I'd say one large input of one inch followed by two to three smaller inputs of smaller amplitude, half inches, possibly.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Describe any control compensation you had to make to account for deficiencies in the aircraft. Again, I don't feel like this task was any major problem of the aircraft, I don't think I could get the tolerance because of my cues. Because it took longer to scan all the way out to my 3 o'clock position.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: Control compensation. Did not notice anything significant as far as control compensation goes. Possibly the difference between my going to the left, my second and third runs was on the second one where I exceeded the heading parameter. I kept the turn in, just about at the point and then decel down. Corrected the last one, I probably the last 45 degrees of my turn I slowed down just a little bit so my decel to capture the hover was (inaudible.) I don't think it compromises the task any and I would probably do that in a real situation. I'm not going to try to make a turn in and then see how mild I can make the decel. So I think it's an optimal way to fly the task.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt winds) HQR=6: Control compensation, I don't know, there is a little bit of combination of all of them. I told Chris if you could measure the forces in the stick I think I would squeeze in a cyclic, if you try to make appropriate size inputs but not overdo it, because the whole thing is pretty tightly constrained. So it's a combination of lateral for the forces with the wind and longitudinally for displacement. So the work is in the stick in both axes.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B calm) HQR=4.5: (No comments)

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: I think as far as 11 is concerned, I have a tendency to not be able to pick out the exact point the aircraft should arrive on at the end of the turn. If this turn is done correctly, there should not have to be any movement of the aircraft longitudinally, it should end up in the right place. I find that I'm always ending up a little bit short and then having to move forward.

Pilot E data runs 208.8-10 Left - Config. B Calm) HQR=4: No particular control compensation.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: Control compensation, I can't think of anything. The only control compensation that I felt like I had to do was in the activity of the yaw pedal on coming out on the final heading. There was definitely some activity in the yaw pedal in trying to get the heading sorted out.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Describe any modifications you had to make to what you would consider normal control technique. I think a pilot would keep his feet on the pedals during this capture maneuver, or have difficulty just by keeping his feet on the pedals, staying within the desired tolerance. So my tendency was to get it down, try to minimize the oscillation, let the heading controls take over for the rest of the stabilization.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Describe any modifications you would make from what you consider normal control technique. None. Although I would again mention that pilots will keep their feet on the pedal for this and not release heading hold and I think they would really hold it to that 5 seconds to maintain that heading reference with the weak heading cues on the course, it's debatable, since I was releasing heading -- releasing the pedals once I reduced the oscillations, what I thought was normal, letting heading hold take over from there.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Any modifications from normal. I think it's just be ready for a large pedal input opposite the direction the aircraft is going.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Modifications, the only thing I could do is probably lean a little bit earlier, but I don't know if I can anticipate when that should be.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Modifications I would consider normal control technique, I don't see anything here. I think I flew this as I would an initial representative task.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Modifications you had to make that you would consider outside the norm technique. I can't really speak of any there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: (See question #11)

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt winds) HQR=6: Modifications, I don't know. Maybe I would turn the trim system off. Not hold the button in, but turn it off, to make the turn. I'm not quite sure we can fly it that way.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B calm) HQR=4.5: Any modifications you had to make to what you would consider normal control technique. I don't think there were any.

Pilot E (data runs 208.5-8 Right - Config. B calm) HQR=5: And nothing for No. 12.

Pilot E (data runs 208.8-10 Left - Config. B calm) HQR=4: And no particular modifications.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B calm) HQR=4: Modifications, I sort of talked about. In the normal control technique, again, most the time turns are being about seat of your pants as opposed to employing behind you. The only modification, control modification was just sort of the aft cyclic control to get it to start rotate where you were going into your speed around the mast.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B calm) HQR=4: No tape for this flight.

MISC.

13. Please comment on anything else that may have influenced you.

*************** Configuration A - Calm *******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Miscellaneous, there was nothing, anything else that influenced the task. The winds are calm today. I didn't notice the wind to play a role.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Anything else that influenced you. Again I want to comment for this task is that there is no great heading cues out in front of us to really take heading outside the cockpit, it's really relying on coming back in to make sure on the reference heading.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Miscellaneous. The miscellaneous, I think the things that might influence what's going on, I think it could be the wind, going from wind on the left to wind on the right. So going from a left bank to a right bank, basically.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: And I don't think I have any miscellaneous. Except the height, like in hover I was noticing the collective, but this one the collective is not an issue, it all seems to be just keep the turn rate going and then the biggest workload then is heading capture.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: And no other real comments that I haven't mentioned already.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: And any other miscellaneous cues, miscellaneous comments, nothing else that I haven't spoken of already.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: Miscellaneous, nothing going on there.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt winds) HQR=6: And miscellaneous, No. 13, I think the thing that really influenced us was the wind changed from one side to another. 16 knots.

**************** Configuration B - Calm ******************

Pilot A (data runs 206.14-16 Right, 206.17-19 Left - Config. B Calm) HQR=4.5: I don't think anything else influenced me. The winds seem to be relatively calm, so the rate could be fairly constant all the way around.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: Miscellaneous, no extra comments there.

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: Miscellaneous, I think the difficulty I have is still in doing a turn about the mast. I think if I knew how to do that and do it smoothly, all of this stuff would sort itself out and you would be getting better ratings off of me. But somehow I find myself working and cross controlling the aircraft to put the cockpit where I think it should be as opposed to where I think the aircraft wants to be naturally.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: (No comments)

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

*************** Configuration A - Calm ******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio. [From the ground-station engineers' notes, four practice runs were performed prior to the three data runs; the pilot was able to achieve desired performance on all of the data runs. The times to complete the turn were 13, 14, and 13.5 seconds. There were some minor but annoying deficiencies and the critical phase of the maneuver is the "roll-out" onto the correct heading.]

Pilot B (data runs 193.13-.18 Right - Config. A calm) HQR=4: Cooper-Harper rating, it is controllable. Adequate performance was attainable with a tolerable pilot workload. Is it satisfactory without improvement? I would say -- I'm kind of on the fence with this one. I think that I will give this a 4 because I think no, it's not satisfactory without improvement for this particular aircraft because I think the annoying deficiency is the roll oscillation. Two things: The predictability of capturing the heading on the end and the coupling of the roll response with the heading in the initial capturing that makes desired performance attainable but I think there is a fair amount of workload associated with capturing that final heading, stabilizing things down. And I don't think it's a minimal pilot compensation issue. So I'm going to give this HQR 4 for the right-hand turn. That concludes my comments.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: Cooper-Harper rating scale. It was controllable. Adequate performance was attainable. Is it satisfactory without improvement? I would say, in this direction I would say yes, the mildly unpleasant deficiency in this particular direction is again the yaw oscillation that I felt the ability to capture, but that oscillation was less and my predictability was a little bit more improved over going the opposite direction for this particular task. So I will give this direction an HQR of 3.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: Okay. HQR. It's controllable. Adequate performance is attainable and the workload is tolerable. Satisfactory without improvement? I have to think about that one a little bit. If I say no, it says minor but annoying, desired performance requires moderate compensation. That would be probably heading capture, from the turn. If I said yes to this, it would mean fair, some mildly unpleasant, minimum compensation required. Let me get back to this question, then. Is it satisfactory without improvement? I would probably say no, it's not satisfactory without improvement and the no is on the heading capture. Requiring the large pedal input, probably because the aircraft feels less responsive, followed by the small ones, one or two a second, that requires moderate compensation. But I did get desired. That's a 4.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: Adequate performance is attainable. Is it satisfactory without improvement? I'll say no. And it's probably the same category as going to the right. Minor but annoying. Desired performance requires moderate compensation. And the compensation is the one time large pedal input followed by maybe two to three iterations on the pedal to settle down on heading. And that's a little distracting to the position maintenance, although that was okay. 15 -- that answers 15. It's all on the heading capture. ENGINEER: I didn't hear the number. THE PILOT: 4.

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: Question 14, coming down, is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I'll give that a yes as well. Is it satisfactory without improvement? That's in the no category there. Deficiencies warrant improvement. I felt I was working as hard as I could to get the points but I was still just getting adequate in the longitudinal. So it's moderately objectionable deficiencies. Part of that may have to do with the cuing system for me to see my longitudinal, because I would go through a turn, and as soon as I'm able to look right and see the hover board, that's what my focus is, to be able to stabilize on that. My only -- at that point my real longitudinal cue is off of my 3 o'clock position, which I don't tend to look at until I get fairly locked on the yaw and roll channels, my front lateral channels, and then I will happen to glance over for longitudinally. So possibly the cues give some problems there. But I feel like the highest workload has still got to be in the pedals. So maybe it's because I'm concentrating so much on the pedals I sacrifice longitudinal. So HQR 5 is where I seem to end up.

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: Going down the Cooper-Harper scale. Is it controllable? Yes. Is adequate performance attainable with tolerable pilot workload? Yes to both of those. Is it satisfactory without improvement? I'd say no. But again I felt -- I don't know, it's interesting, this task, if I went to compensate for the visual cues, I think my performance would have fallen out. Whereas I did accomplish my visual cues, I ended up out of the tolerance I feel because of that, more than the aircraft handling qualities. So maybe I flew the task wrong, I'm not sure. But I guess I come back to -- so without saying probably an HQR 5 category. Adequate performance, considerable -- requires considerable pilot compensation. That's where it falls out.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: Handling quality ratings, question 14. Okay. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? You know, I'm going to say no there. There is a tendency for the yaw oscillations and then when I stabilize load in hover the feedback of the oscillations in load are causing the slight (inaudible) workload and a little more significant lateral workload to control those oscillations and stabilize in a hover. I probably also needed the collective a little bit, but I'm not thinking about that as much. So I think I was in the overall where I -- I'd say 30 percent of the ones I went into adequate, but the rest I felt I was in desired so four out of six of the runs. So I'm going to go ahead and say that I was in desired, minor but annoying deficiencies required moderate pilot compensation. And again the areas where that exist, lateral (inaudible) control oscillations, longitudinally as well and then capturing the hover, little things to control the yaw oscillations that give you a rapid stop. ENGINEER: Did you say that was HQR 4? THE PILOT: I felt it was but then I was on the adequate on quite a few of them. I'm not going to go with a 4.5, let's call it a 5. ENGINEER: Okay. And that applies for both directions? (No reply)

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt winds) HQR=6: Cooper-Harper. Is it controllable? Yes. Is adequate performance attainable? You were saying I was getting adequate longitudinally, I would get adequate there, my question is it tolerable or not. I'm going to answer yes for now. Say is it satisfactory without improvement? I would say more than minor but annoying. I'm talking about longitudinal position maintenance or capture at the end. Nominally objectionable or very objectionable but tolerable, considerable compensation or extensive? I think I'm going to have to go in the very objectionable but tolerable and call it extensive. That's the longitudinal position maintenance in the turn. And I think part of that is I don't have a good cue of where I am.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B calm) HQR=4.5: Cooper-Harper rating scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would say yes. Is it satisfactory without improvement? I would say no. And I would say that this is HQR 5 which is moderately objectionable deficiencies, adequate performance requires considerable pilot compensation. I don't think that's necessarily true for the HQR 5, so I'm going to call this a 4.5 because I think you can achieve adequate performance with a moderate pilot workload, but it takes a lot of compensation to get desired performance. So I'm going to call this HQR 4.5.

Pilot E (data runs 208.5-7 Right - Config. B calm) HQR=5: Cooper-Harper rating. It's certainly controllable. Adequate? Yes. Is it satisfactory without improvement? I'm not getting desired performance. (Rest of comments are missing. HQR comes from run log.) [From the ground-station engineers' notes, the pilot commented that: he was generally at the upper edges of desired performance; it's hard to assess turning about the mast; there's a yaw overshoot of 4-6 degrees; once you have a "style," it's not difficult; there's a tendency to be ratchety in heading control - always overshoot final heading; and it should be a nice maneuver, but pilot is having trouble and not consistently getting desired performance. HQR=5.]

Pilot E (data runs 208.8-10 Left - Config. B calm) HQR=4: Going to handling qualities. It's certainly controllable. Adequate it is. Desirable, I would say that it is. Okay. I think what I will do is I will take that back and I'm going to an HQR of 4. Because what I find is even though I could get desired performance, I end up having to do a lot of secondary controlling to do that. If I had this thing all figured out, I would be able to make one nice smooth turn and end up on the numbers. But the aircraft is always displaced, so that when I come out of the turn, I don't have the cockpit where you expect to have it. So that always resolves in some lateral -- an additional lateral input, an additional longitudinal input, which in my mind starts to drive the compensation up. Because now you are trying to estimate the value of the input and what it's going to give to you in terms of response and whether you will make it in terms of the 15 seconds or not. So that's what drives it out of a level 1 into a level 2. The rating is 4. End of comments.

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B calm) HQR=4: Using your Cooper-Harper scale. I would -- let's see. Controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? No. Minor but annoying deficiencies. Desired performance requires moderate pilot compensation. HQR 4. What was really easy or easier going in one direction was more difficult going to another direction.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B calm) HQR=4: No tape for this flight. [From the ground-station engineers' notes, the pilot provided the following comments: pretty much desired throughout; there's unequal pedal forces to start and keep going - not objectionable; tendency to overshoot final heading; objectionable lateral oscillations at final heading capture; height control excellent; cues acceptable - better to the right; deficiencies are coupling into pitch and roll; and the critical sub phase is the heading capture at the end. HQR=4 for both directions.]

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

*************** Configuration A - Calm ******************

Pilot A (data runs 186.7-13 Right - Config. A calm) HQR=4: No audio.

Pilot B (data runs 193.13-18 Right - Config. A calm) HQR=4: Any critical subphases? The subphase obviously is capturing that final heading in this particular maneuver. That's it.

Pilot B (data runs 193.19-23 Left - Config. A calm) HQR=3: And critical subphase of the task again is capturing that heading and get rid of the oscillation before you release the pedals for this task.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.14-16 Right - Config. A Lt winds) HQR=4: No. 15, what was the subphase. The subphase that led to all that was the heading capture. That's it.

Pilot C (data runs 188.17-19 Left - Config. A Lt winds) HQR=4: (No comment on tape)

Pilot D (data runs 192.5-7 Right - Config. A Lt winds) HQR=5: (No comments)

Pilot D (data runs 192.8-11 Left - Config. A Lt winds) HQR=5: And the subphase of the task has to be the hover task because through the turn I think I can get established smooth, it's just capture that hover at the end and get my positions, heading, laterally as well as longitudinally and the altitude. The one that's toughest to get is longitudinally because of the cues, I think.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: The critical subphase, it's definitely stabilizing in the hover once the turn is complete.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt winds) HQR=6: (No comments).

**************** Configuration B - Calm ******************

Pilot B (data runs 206.14-16 Right, 206.17-19 Left - Config. B calm) HQR=4.5: I think the critical subphase of the task is capturing the heading at the end of the turn and knowing exactly where you are at that point in terms of the position over the precision hover location.

Pilot E (data runs 208.5-8 Right - Config. B Calm) HQR=5: (No audio)

Pilot E (data runs 208.8-10 Left - Config. B Calm) HQR=4: (No comments)

Pilot F (data runs 209.5-8 Right, 209.9-12 Left - Config. B Calm) HQR=4: I did notice, again, the heading control at the end was probably the most difficult phase, to answer your question 15. Phase of all the maneuvers. I would say the final heading control for that portion. End of comments. ENGINEER: So the 4 applies to both left and right? THE PILOT: That's affirmed. There were deficiencies in both that I tried to, you know, height control, even though the rate could be done, going to the left the height control seemed to be off. If any one was easier than the other, going to the left was easier than going to the right.

Pilot G (data runs 205.5-8 Right, 205.1-4 Left - Config. B Calm) HQR=4: No tape for this flight.

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Calm ******************

Pilot D (data runs 195.11-13 Right, 195.14-16 Left - Config. D calm) HQR=5: And for external load, again the oscillations are what really feeds back and causing the higher workload. Comments complete.

**************** Configuration D - Light Winds *************

Pilot C (data runs 190.23-28 Right - Config. D Lt Winds) HQR=6: External load, did the load have an impact? I don't think load was the problem there I think it was more of a wind change from one side to the other. Complete. ENGINEER: I didn't hear a number on the rating, I heard the comments. THE PILOT: It was 6.

PIROUETTE MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: We could meet desired performance standards, but we were bouncing between the limits of desired throughout the task.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: These are comments on the left pirouette. Desired/adequate performance standards met. Two trials we had at least busted into the adequate tolerance and two trials met all desired performance.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: This was pirouette going to the right. Question No. 1, task performance, describe ability to meet desired/adequate. On all of them I felt I was within the desired, except for my second run where I crept forward during the decel. And actually went out of desired on that one, but within adequate. Also on the first run, the initiation felt like the heading get off, up to 10 degrees may have been out of the desired for the initial initiation of the maneuver.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Task performance, question No. 1, desired/adequate. I felt like it was well within the desired for most the ranges. I saw myself go out on altitude once but I know you say it was in there the whole time. It was within about a foot. Also I think on one of the runs, I can't remember if it was the first or second run, I think I was slightly out of the heading.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: Comments on the pirouette with no load to the right. The first two felt a little easy and I was getting a little cocky and I tried to get a little quicker on the third one and then lost my altitude tolerance and a little bit on the position. But that's because of feeling good about the maneuver. And basically the altitude was within probably a couple feet and it looked like I stayed inside the desired tolerance all the way around. There is a little bit of wind blowing today, but it doesn't feel like it's too effective -- I mean it doesn't influence anything too much. Most of the workload is, as you would probably expect, I guess, in lateral and in longitudinal. And they are kind of like little pulse inputs mainly to keep the aircraft going and not stop and very minor corrections longitudinally to either keep from drifting too close or drifting out. And that's where all the attention is, is in the longitudinal-lateral control. Altitude felt fairly easy.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: Pirouette to the left, no load. We have 16 knots of wind. We started with the nose into the wind. And a couple places where we had problems with adequate as the wind -- as we were flying to the left, when the wind was broadside to the left we had about 12 degrees of bank angle. As the aircraft goes around and gets the wind on the tail, the bank angle washes out a little bit, the nose drops a hair. A tendency to get drifted toward the circle and then after that, maybe it's compensation or whatever, we get blown out of the circle that [is] past the adequate performance and probably in the last fourth to a third of the pirouette and that was very repeatable all three turns. Wind input, yes, but probably some visuals and the fact that the direction I'm going I really can't see, I have to look at the lines coming out from underneath. So it's not as strong a cuing environment as it was when I went to the right.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: It was pretty close to the other maneuver. I think on my last -- the first one was okay, the second two, I think I missed the turn or I ended up creeping forward a little bit, just during the deceleration. So again I'm right on the edge of desired, so I still call it desired, but I did creep forward where I wasn't as happy as I thought I could have been. I thought I could have been a lot better (inaudible.) Maybe we just had a breakdown in the end. So going down the list, (inaudible) performance was desired.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Pilot comments on pirouette with the load, both left and right. Let's start with question #1 for the task performance. Ability to meet desired/adequate. I went into adequate on every run on at least one parameter. I'd say the biggest one is the stabilization in the hover, I think 5 seconds is -- was just not there. So adequate there. Also through the turns to the left I found myself going out of the position; possibly due to the visual cues. And altitude for some reason on the ones to the right, maybe that was just getting used to the maneuver, because I had no problems with that going to the left.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: These are pilot comments on the right pirouette. Describe ability to meet desired/adequate performance standards. It appears as though, to me the perception on this particular maneuver was that if you tried to stay right on the 45 second margin, you got into a handling qualities routine where it seemed to be difficult to maintain a constant rate of speed. There appeared to be slowing down and speeding up in the lateral translation that required a little more attention. If you got a little more speed on the airplane, the lateral control didn't seem to be as difficult and -- nor did heading control. And so you could focus more on altitude maintenance and fore and aft drift. If the speeds got down to 40, 37 seconds, we noted the last one in this, the pace seemed to be much faster and the handling qualities from my point of view got better.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: I don't think that I could meet desired performance standards no matter how hard I worked on this particular one. One parameter all the time was out of desired tolerance in the adequate band.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight. [From the ground-station engineers' notes, five data runs were performed; the pilot was primarily able to achieve desired performance but there was some excursions into adequate - predominately heading with some adequate excursions on altitude and longitudinal position. The times to complete the maneuver were 50, 43.5, 40, 40, and 40 seconds.]

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight. [From the ground-station engineers' notes, five data runs were performed; the pilot was able to achieve desired performance on all runs. The times to complete the maneuver were 45, 44.5, 42, 42.5, and 43 seconds.]

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Ability to meet desired/adequate performance. I'd say to meet desired is probably pushing it without extensive practice at it. There is an awful lot of things going on. Of course wind conditions will also have an effect upon it. I think that's partially what was causing some of the trouble going to the left versus going to the right. And we will talk about that later on.

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Describe the aggressiveness/precision with which the task was performed. I could increase the level of aggressiveness and get around within the time standards, but the limits of which desired tolerance were starting to be getting right to the margin and occasionally exceeding it.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Describe aggressiveness/precision with which task is performed. I couldn't be very aggressive on here, I had to back off on the task in terms of longitudinal control, really focus coming through the wind line on the outside, because the longitudinal cuing was very weak because of the cross cockpit viewing. I don't believe you could do this task with any standard by looking at one -- the task is behind you, with any level of precision at all. The aggressiveness was only as aggressive as I need to be to get around the course in the, within the desired time.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: As far as aggressiveness, I think it was moderately aggressive throughout. I felt like I was tracking around to make the 45 seconds of the time. Not trying to increase, but just stay within that pace.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Aggressiveness/precision, I think I was just as aggressive equally to the left as to the right. I'd pace myself for the 45 seconds, not trying to increase that any, but well within the 45 seconds.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: (See field 1)

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: Aggressiveness and all that seemed appropriate.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Describe aggressiveness. I actually think I was pretty aggressive. Partly -- I felt like as we were getting low on fuel we didn't have much time left, so I kind of kicked in the maneuver, I was probably pushing myself a little harder than I would have been, you know, first maneuver of the day. So I thought I was pretty aggressive with it.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Okay. Aggressiveness/precision with which I performed the task. I made it around the circle within 45 seconds every time. And then -- so I think the level of aggressiveness was there. I wasn't making the five seconds stable to hover but I don't think that's the level of aggressiveness, I think that that was totally the flying qualities of the aircraft.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Describe aggressiveness and precision with which the task is performed. This particular task, as the aggressiveness was increased a little bit, I felt as though the handling qualities was a little bit better than at the -- right on the 45 second margin.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Describe aggressiveness/precision. I increased the -- tried to increase the aggressiveness, but in the first 90 degrees turn as the aircraft is turning, the first 180 degrees of turn, as the aircraft is turning the tail rotor into the wind line, this is a very difficult task. Because there seems to be a lot of roll perturbation. It's very difficult to stay on speed as you are coming through the wind line. A lot of yaw excursion, a lot of roll excursion. And there is a lot of -- seems to be, I didn't notice it as an oscillation, but seems to be a lot of abruptness as you come around the turn, it feels like turbulence in the aircraft. Describe aggressiveness/precision with the task. It's very -- evenly increasing the aggressiveness, even at the lowest levels of aggressiveness the precision of the task is very difficult.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: The aggressiveness. It helps in this to be fairly aggressive, because that tends to make your maneuver smoother going around. You are not fighting it getting momentum going. Once you have your momentum going, it's easy to keep it up going around.

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: If trying for desired performance resulted in unacceptable oscillations, there were no unacceptable oscillations.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: There were no unacceptable oscillations, item 3.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: As far as, desired, there were no negative oscillations except for possibly during the recovery portion and there was a tendency for roll oscillations, I believe, during the deceleration going through the stabilized hover.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: As far as the oscillations, the only problem I see there at all with the right is the recovery phase. Once I start the decel to the stable hover. But again I also went out of altitude once, but otherwise within desired.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: I really didn't notice any unacceptable oscillation, there may be a little bit associated -- similar to the slalom, in that when you put a lateral control in you get a little bit of tendency to overshoot. Although these inputs are a lot smaller so they are not as noticeable.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: (No comments)

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: It looked like there wasn't a whole lot of problems, it was a nice, smooth pattern around to try and hit the desired, I didn't have to sacrifice anything just to get adequate.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: As far as reverting to adequate to prevent oscillations, I don't think that's the case because I pushed for the desired and aggressiveness through the turns, so there was no -- I wasn't compromising anything there.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: If trying for desired performance resulted in unacceptable oscillations, there weren't any.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: I didn't notice that there were any unacceptable oscillations, but there tended to be again, this turbulence, this erratic nature of the aircraft that's similar for low speed aircraft characteristics between 15 and 20 knots in this aircraft, that seemed to be much more noticeable to the left than to the right coming into the wind line.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Let's see. If trying for desired performance resulted in unacceptable oscillations, there are a few oscillations in heading that I experienced all the way around. Mainly because you are having to crosscheck, double check back and forth between the view, the view out the side of the cockpit through the doors and back to the front. And your picture is changing the whole time that you are going around.

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Objectionable controller force characteristics, item 4, there were none.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Item 4, no objectionable controller force characteristics.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Aircraft characteristics. The only objectionable thing that I noticed is in part of this was letting the heading get off is to actuate the trim micro switches, get the heading hold off, seemed like maybe a little more of a push, just depressing the micro switches enough we are in the stable hover.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Aircraft characteristics. 4. Objectionable controller force characteristics. I didn't notice, maybe I'm finally getting used to the aircraft a little more doing that maneuver, but I noticed the pedal compensation is great if you take the heading hold off, so no objectionable force characteristics.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: No. 4, I don't really notice any force problems.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: No. 4 is no controller force problems.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Aircraft characteristics. Describe objectionable controller forces. None noted there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Okay. Aircraft characteristics, No. 4. Objectionable controller force characteristics. I would say I don't see any objections there.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: There were no objectionable controller force characteristics, provided that I used trim release. When I had trim release not depressed, trying to do it against force, it was a very difficult task to do in that situation because of the constant change in control inputs fore and aft and the activity in cyclic makes the controller forces, makes you fight it a little bit more. Especially as the wind changes around the azimuth on the aircraft and the actual trim position that you are trimmed for changes.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Objectionable controller force characteristics. I didn't feel as though there were any objectionable controller force characteristics.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Objectionable force characteristics. Controller force characteristics. None.

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Item 5, predictability of initial aircraft response was fine. But the heave axis seemed to be the least predictable of the control forces for this particular maneuver.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Item 5, predictability of initial aircraft response. Again, collective application predictability: if there was a predictability problem it was in terms of height control and initial response because of the collective time delay.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Predictability, everything was predictable. I felt possibly a tendency to go into the roll oscillations during the recovery is the only area where I would say was not quite predictable, basic overshoots there.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Predictability, I think the (inaudible) was very predictable through the maneuver.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: No. 5, predictability, that was pretty good. I was expecting wind to catch the tail but it didn't bother me very much. A little bit of left pedal to help keep the nose going left as the aircraft is going right.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: Predictability, I'm not sure if we can predict it, if you had the same wind every time and did it about three times, we just saw that it was the same. But you have a changing attitude as you go around the circle. I think some of that wouldn't help anyhow to the left, because this aircraft does bank with wind to the left. Or flying to the left.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Predictability of aircraft response. Again, not noted there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Predictability of initial aircraft response, again, I was getting the response I wanted with no adverse effects. I'd say that's (inaudible.)

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: (No comments)

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: But in terms of predictability of initial aircraft response, as we went into the wind line, there is no predictability as to what I was going to get. It was constant correction during the first 180 degrees of turn in roll, heading altitude maintenance as the aircraft turned left into the wind line.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Predictability of initial response, it's very predictable.

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Describe any mid or long-term response problems, there were none for item 6.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: No mid or long-term response problems for item 6.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Mid to long-term response problems, no deficiencies noted there.

Pilot D (data runs 191.7-.9 Left - Config. A Calm) HQR=5: Mid and long-term response, no problems there.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: No. 6, no long term response problems.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: I don't see any long term response problems, No. 6.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Describe mid to long term response characteristics. Nothing as well there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Mid to long term response, no problems there.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Describe any mid or long term response problems. I didn't see any.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Describe any mid or long term response problems. No mid or long term response problems.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Long term response, none.

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Item 7, there were no objectionable oscillations. But there was a tendency to overshoot. So on the capture point in terms of initial alignment that made getting right on the heading -- getting heading control and the roll control more difficult to use the entire five seconds.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Item 7, no objectionable oscillations. Again, a tendency to overshoot at the recovery point, largely in this case because you have to watch the recovery point come through your scan underneath the airplane, then go back outside to the left hand as opposed to the right hand.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: I think any objectionable oscillations, I think during the recovery it's easy to get into some kinds of roll oscillations.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: No. 7, objectionable oscillations or tendency to overshoot. Yeah, I think it goes back to the decel, returning to the stable hover phase where I guess more so in this maneuver besides getting the roll oscillations down, they weren't as great as just a vertical oscillation through the microcontrollers through the collective channel. And I will talk about that just a little more than this.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-.31 Right - Config. A Lt Winds) HQR=5: No. 7, there was nothing really objectionable on oscillations.

Pilot C (data runs 188.32-.34 Left - Config. A Lt Winds) HQR=8: Objectionable oscillations, I don't think there is a tendency to overshoot, the problem was just staying inside the limits.

Pilot D (data runs 192.28-.30 Right - Config. A Lt Winds) HQR=4: The objectionable oscillations or tendency to overshoot, somewhat in the recovery from the decel to the recovery phase of it, there is a little bit of a tendency, probably to go through oscillations, not necessarily overshoot my mark, you go through oscillations in roll as I try and recover.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Objectionable oscillations. Yes. Primarily in the phase of the stabilization to hover, roll oscillations were present and also primarily going to the left, maybe because I was more aggressive with trying to maintain the vertical I managed a couple of vertical oscillations as well where I felt myself pumping the collective to compensate.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Describe any objectionable oscillations or tendency to overshoot. There is a little bit of oscillation in roll as you settle down from the maneuver into the stabilization into a hover. But that wasn't objectionable to me, it seems to damp out after two cycles.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Objectionable oscillations, tendency to overshoot. Again, this turbulence that I've already described.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Objectionable oscillations or tendency to overshoot. The only thing I can say is there is a tendency to overshoot on your heading as you are going around, because you are changing it all the time. And if the wind happens to hit your tail in the wrong position, it's going to increase your tendency to overshoot on heading. And at the end it looks like, I get the feeling there is a tendency, depending on how aggressive you are on your deceleration, there is a tendency to bobble at the end. You have a tendency to overshoot on your altitude.

8. Describe any non-linearity of response.

**************** Configuration A - Calm ******************

Pilot B (data runs 193.1-.3 Right - Config. A Calm) HQR=4: Item 8, nonlinear response, I didn't note any.

Pilot B (data runs 193.4-.7 Left - Config. A Calm) HQR=5: Nonlinear response, there were none.

Pilot D (data runs 191.4-.6 Right - Config. A Calm) HQR=5: I wouldn't call it nonlinear, question No. 8, linearity of response.

Pilot D (data runs 191.7-.9 Left - Config. A Calm) HQR=5R/6L: Nonlinearity, I didn't see any of that.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: And everything felt pretty linear.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: And I don't have any description of nonlinearity. Cross-coupling is probably what we are talking about. Wind influence.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Nonlinearity of the response, I thought everything was pretty well linear.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5: Describe any nonlinearity of the response. Nothing to note there. It was linear as far as I could tell.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Describe any nonlinearity of response. I didn't feel as though there were any.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Describe any nonlinearity of response, I didn't notice any.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Linearity of response is okay.

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Item 9, harmony of pitch and roll, speed control, height control, the harmony seemed to be fine. However, the -- if there were any problems with harmony at all it would be in the heave axis with the other controls because of the amount of total control movements that are required for this.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Item 9, there were really no problems with control harmony for this maneuver except as commented previously in the heave axis.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: And No. 9, problems with the harmony, the only thing I noticed in the last portion of that were heading hold, it felt like you had to work a little harder to get the heading hold off initially until I get the maneuver initially, get the nose pointed towards the center, but after that no problems at all.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Describe the maneuver with harmony of pitch and roll, speed and height control, it really feels like once I'm in the turn again I increase, slowly increase collective demand. Once I come out to the decel, and especially once I put in a little bit of a side flare to recover for that, there is a tendency for the aircraft to balloon. So I lower the collective and then as soon as the aircraft starts to decel again, quick collective increase, there is a tendency to overshoot, I think, at that point to the point where the initial -- lower the collective, increase the collective (inaudible) by an overshoot, so I immediately have to take part of that collective out.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: The harmony between, I call it pitch and roll, they seemed pretty good, because like I said, I had to put little inputs in all the time and the nose reacted, but it was always about the same it was always about a 45 degree input. Height control, except when I kind of increased the aggressiveness myself, I kind of lost altitude. That was a real short time around the circle.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: No. 9, yeah, I think the height control, I was not anticipating the height, either, and I don't know where -- what the influence was, but when I get the tail around into the wind that's when I was seeing about 19 feet which is probably still in adequate, but I couldn't stop that from occurring.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Describe the maneuvers in harmony of pitch and roll. No problems there. Speed control, I thought that was fairly easy around. Height control, I didn't notice anything, there was a tight three foot tolerance, (inaudible) a couple times and again it comes into that recovery phase where once I put in a flare, unload the collective and as I go wings level again I start to settle so I have to increase collective, probably about a 1, 2, 3 collective input, increase an inch, decrease an inch, increase a half an inch, the compensation for that.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Okay. Problems with harmony of pitch and roll, speed, height control and heading hold/turn coordination? Again, everything was pretty well smooth throughout, I wouldn't say there were significant comments on that.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Disharmony between pitch and roll and speed control. I felt as though fore and aft in roll there is a better response than there is in vertical because of the delay in the rotor spots. And I think that that predictability in the vertical axis being a little bit of a time delay and a little bit less precise, makes the vertical axis more challenging to maintain. There is a lot of collective activity.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Harmony of pitch, roll, speed control and height control. There seemed to be not any disharmony in terms of control functions in this particular one except for again this delay in the vertical axis as compared to the instantaneous response you tend to get in the pitch and roll.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Pitch and roll control are fine. Speed control, again, it becomes a factor of wind. It looked like going to the right, the right turn is a little bit easier to maintain a speed, [a] specific speed going around the circle. It didn't seem like the wind was hitting it as much. Going to the left it was like you were battling the wind a little bit with resistance during the first, oh, about 135 degrees on today, and then once you got through that it looked like it was pushing you along. I noticed that once we got around to about the 230, 225 point on the circle, it looks like it became very smooth during that last bit of the arc. In fact, probably during the last 90 degrees of the arc, it was extremely smooth.

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Overall strategy was to use the bucket for height control and use the lines for heading control and establish a, monitor the heading position and height through peripheral vision while monitoring the lateral cues.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Describe overall control strategy. I tried the first one to look out using the fore and aft cues out my door, the right side door, for the task and found that untenable. So the remaining three maneuvers were done looking out the left hand door to monitor fore and aft cues. But the cues were weak. Took the -- you had to develop your own sight picture with the instrument panel and the door post to keep you within tolerances going around, but they were far ahead of the airplane, so you really had no idea at any point in time exactly where you were due to cuing.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Demands on the pilot. I think over al strategy, I felt if I started off at a little slower pace to get comfortable in the turn, once I got a third of the way around the circle, even a quarter of the way around the circle, I felt I could accelerate a little more from there. Start off a little slow initially and keep a nice pace up going all the way around. Maybe I could have slowed down during the last quarter and that would have helped the recovery, but I couldn't keep my speed steady until I hit the decel point.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Demands on the pilot. Overall control strategy to perform the task. Similar to the right. Start out a little slower but then keep the speed up through the whole circle. As far as pilot cues, I noted for the ride I could almost pick a 45 degree position just with my eyeballs. Going to left I felt I definitely had to make about a 60 degree head movement to be able to keep my scan up. Look to the left and then look to the center. And I did use the direction the aircraft was moving for my primary scan fore and aft cues.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: Describe the overall strategy. Kind of hang on, bank aircraft maybe 5, 10 degrees and from there on just keep the nose pointed at the pole and watch the yellow lines come through and be real quick to compensate for any kind of a drift. There is no room for anything else, you have to pay particular attention to that task and anything else would be distracting, that's probably what happened to me by decreasing the time around the circle.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: Overall control strategy was, I think I was behind in most stuff. See what's there, try to compensate for it, as soon as I do I have to handle the next event. So if I've got height, position, speed, bank angle, that's about four things and you have got to divide your attention among all of those, but you can't do them all at once. So that's where everything gets a little bit out of control.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Okay. Demands on the pilot. Overall control strategy. I used the bucket in the far ring around to keep it in there for height. Just looking out to my left for longitudinal cues to go through. There is a tendency, I think I focused in on the bucket and the height as I came to a stop, which gave -- lent to my tendency to drift forward in the forward desired edge of the circle.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Demands on the pilot. Overall control strategy in performing the task. To the right again it's visual cues are a lot better from my position, that's not much of a problem. Going to the left, I was having to search around the cockpit for places where I could actually look out and see the visual cues. And in some cases I could not see the inner yellow line at all. And what I cued on was, I see the red line through the co-pilot's chin bubble and so I used that as a cue to offset from that I know I stay in desired. But around the circle I could not see the altitude, so I think that's where I was drifting out of the adequate about 270 degrees through the turn. The visual cues just weren't there. Where I could actually see through the co-pilot's windshield and his side window were far enough out that it wasn't very good for my relative position, where I was at. I never tried to use the right side to correct for which, I felt like that would have -- I would have dropped something else if I would have done that.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Describe the overall control strategy in performing the task. Really it was to monitor kind of a 45 degree angle. Most of my attention was outside with constant surveillance to the right. I felt as though altitude hold and heading hold maintained more of my attention than did fore and aft drift, because of the attention required in those areas.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Describe overall control strategy. Control strategy was trying to get it stabilized, I could initially in the right turn, you can get stabilized on a lateral translation, but in this left turn for the first 180 degree turn it didn't appear as though you could ever get stabilized on a constant translation until you came through the wind line and you started going with the wind. And then you could stabilize on a constant translation. So I was trying to maintain this translation and I was unable to do. That was the strategy.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Control strategy, cues used. Major cues used is bucket on top of the post, getting it within the -- attempting to keep it on to the two center circle arcs and (inaudible) trying to keep it within the four lines, someplace between the two outer four lines. There were points on the circle where you had a tendency to gain altitude in the -- this is especially true in turns to the left. Around the 180 to 270 point, it really looked like it wanted to gain altitude. Scan, turns to the right it was -- primary scan was out to the right to maintain the pilot's seat position in between the two center lines with the brief scan out to the front. The majority of concentration was out the front with glances out to the side. Out to the front you are getting heading and height. Out to the side you are getting longitudinal position. So it was -- I'm not going to say -- it was split primarily between the front and the side with the more on the front than the side.

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Control compensation, most activity was in the longitudinal and heave axis, the lateral axis, once the rate was established, didn't require a lot of monitoring to keep going around in time. I would say that the longitudinal control activity was every second throughout the maneuver, but corrections were made difficult for the compensation because of the constant scan between altitude and longitude and you didn't really notice the longitudinal cues fore and aft until after you were already near one of the boundaries and had to make a large correction to get back in.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: No. 11, control compensation you had to make for account for deficiencies. This particular case, coming out of the wind line after the tail went into the wind line and coming through the wind line, very sensitive height control wise in fore and aft -- fore and aft control wise because your cuing is degraded. So your initial focus in the fore and aft cuing caused the height control to go bad and if you focused on the height control it was very, very difficult to stay within the longitudinal boundaries.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: I talked about the control compensation, possibly easier control inputs initially, but no per se compensation. I would say during the decel to recovery to the stabilized hover possibly there I was getting into a little roll oscillations coordinating with the pedal as well to keep the nose pointed towards the center and I guess a plus or minus half inch of the roll two or three times to stabilize and corresponding with small inputs I'd go up to a quarter or half inch till the oscillation subsided and also a little bit of coordination with the collective there as well to keep from climbing during that portion of the maneuver. It felt like as I initiated the decel I'd have to lower the collective initially to keep from climbing and then increase the collective just as I was stabilizing in the hover.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Control compensation, again, it goes back to the recovery phase. The greatest portion is in that collective where I feel like during the recovery I lower the collective about an inch. Once the aircraft rolls back towards the wings level and starts to settle, immediately pulling in another inch of collective and -- until I have to take about half of that out for the stabilized hover.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: (See field 10)

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: And control compensation, once you see something going out, your inputs have to be fairly big to get back, even though you know you have already blown the criteria.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Control compensation, I can't say that there was anything really that fits into that category. I guess maybe the altitude control went to the collective pumping, but that's the only thing that falls in that category.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Control compensation. I can't say that I have anything there as far as controls, just how I would use my visual cues.

**************** Configuration B - Calm *****************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Control compensation, collective was a very active control, as was fore and aft. There seems to be a lot of sawing in fore and aft in keeping the aircraft settled.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Control compensation you had to make to account for deficiencies in the aircraft. Constant lateral, constant fore and aft, constant pedal changes in the first 180 degrees turn. A lot of work-load trying to just maintain, even to stay within adequate tolerances.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Control compensation, I can't think of any. The only thing I can -- is that with the heading, you could not keep it on one central heading, it was sort of like keep it within the band. Keep it within the 10 degrees, that you would go -- if you start around the turn you put it on one end, you let it slide through to the other side to make a correction to bring it back around. It's just you couldn't pick out one number or one particular point on the wind screen to keep it there. That would make the workload too high. But it was possible to keep it within the plus or minus 10 degrees for the majority of the time.

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Describe any modifications you had to make from normal control technique, I would say none.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Describe any modifications you had to make to what you would consider normal control technique. Not really normal control technique, but one axis significantly suffered because of having to cue on that environment coming through the wind line and having poor visual cues in the longitudinal axis. So either height control or fore and aft cuing suffered during that portion.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Any modifications you consider from the normal. I don't really see anything there.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Modifications that I had to make for the normal response. I don't think there are any. If I had to do that maneuver, that's how I'd fly a real mission pirouette if that was a real mission task.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: I don't think I would make any modifications.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: On No. 12, I don't know what to suggest for modifications. Maybe slow down a little bit.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Modifications from what I consider normal, I don't really see anything there as well.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: And modifications, to how I would do this maneuver, I'd say the modification is for this aircraft I if I were to fly a (inaudible) maneuver like that, I would pass the controls to the other guy.

**************** Configuration B - Calm *****************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Describe any modifications you would make to what you consider normal control technique. Again, this is a very difficult task because of the multi-axis workload. But I don't think there is any modifications from normal control technique.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Describe any modifications you had to make to what you consider normal control technique. Trying to go faster and slower and it didn't appear to make any difference. So no real modification that affected the performance.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: (No comments)

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm ******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Item 13, there weren't any real additional factors other than the fact that the wind were primarily 3 to 5 knots on a 240, and as the tail turned into the wind, longitudinal and height control became more of a factor and that seemed to be where the limiting condition was.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Comment on anything else that influenced you. I will note that on the -- the wind sock flipped 3 to 5 knots for the first three maneuvers. On the last one it looks like it's dead calm out here. So that may have influenced the quality of the task.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Miscellaneous, no comments for the miscellaneous section.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Miscellaneous, again, I don't really see any strong comments there as well.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: I don't think there was anything else that influenced me, either, on No. 13.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: And No. 13, miscellaneous, I think we already covered, I think a little bit of influence of the wind.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: Okay. Comment on anything else that may have influenced you. And I don't see any other comments for that.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Miscellaneous, I think I pretty well hit on anything. Nothing on that.

**************** Configuration B - Calm *****************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: I think the only thing else that influenced me is the winds. The winds are really flip top today, but still as the tail comes around changes to trim point in the aircraft require compensation constantly as you go around the circle.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: No comment on anything, I don't think there was anything else that influenced me.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: (No comments)

Assign HANDLING QUALITIES RATING for overall task.

14. **Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.**

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: Using the Cooper-Harper rating scale. It was controllable. Adequate performance was attainable with a tolerable pilot workload. It was not satisfactory without improvement. Moderate pilot compensation was required, primarily in the longitudinal and heave axis to maintain desired performance, so I would say it's HQR 4 under these wind conditions.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: Cooper-Harper rating. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? No. It's adequate performance requires considerable pilot compensation. I think it's -- I think there is enough to give it a 5 rating here. Although we were able to meet desired on the other tolerance, I have to go with the other three that pilot compensation has to be maintained -- it has to either in height or longitudinal control, have to stay on it all the time to stay within desired because of the poor cuing.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: Cooper-Harper rating scale, I would say even though there was two cases -- No. 1 on the heading. (Inaudible.) Okay. So for the pilot decisions: Is it controllable? Yes, I thought it was controllable. Is adequate performance attainable with a tolerable pilot workload? Yes. I would say adequate was [achieved] every time, it was tolerable workload. Is it satisfactory without improvement? As I mentioned, I went out of the desired a couple times. Do deficiencies warrant improvement? I will have to say -- in fact I might say with tolerable pilot workload even the desired, I think during the recovery phase there may have been some higher workload there. I guess I'd have to say that since I did go into the adequate range a couple times not really objectionable deficiencies was probably the case, looking at over at HQR 5, adequate performance requires considerable pilot compensation. And with that what goes into play mostly is during the initiation of the maneuver and then the recovery to the hover for those two phases I felt were the most difficult. So HQR 5.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: Flipping over to the Cooper-Harper. Coming in, is it controllable? Let's just say yes. Is adequate performance attainable with a tolerable pilot workload? Yes to that as well. Satisfactory without improvement? I would come in to the no category. And for me I felt like I went into adequate on the one recovery phase and that's probably where the most objectionable deficiencies come into play there. I would say that it is moderately objectionable deficiencies, maintain the adequate does require considerable pilot compensation to the order of moving the collective an inch followed by initial pulling an inch back in on the collective, a tendency to overshoot because of that, and then back out. As far as how quick I'm doing that, one second for each input. That's why I'd call it an HQR 5. Just to add a little more on the comment to the cuing, I had to, again it was more head movement required and I was looking over to the left side with the cross members of the cockpit, it was more difficult to see the circles, so the cuing wasn't as great for that. I don't know, it goes back to the, actually aircraft field of view, probably, before that. But part of the movement, I think it increases the pilot task, or it increases workload, I don't think it's beyond the optimum level where his performance is starting to degrade, but it's up to the higher workload category, I think, because I think of that cuing of the head movements.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: So we will go to the Cooper-Harper scale. The pirouette is controllable. We got adequate performance. Is it satisfactory without improvement? I have to think about what I'd like to change here. Is it satisfactory without improvement? Let me say no. So now it's minor but annoying, moderately objectionable or very objectionable but tolerable. It's probably better than moderate. So we are kind of looking at minor but annoying. But let me look at the demands on the pilot. Moderate compensation, considerable compensation, it's almost like considerable compensation because the lateral-longitudinal inputs are pretty small but they are pretty intense to keep everything going right. But it's really kind of minor but annoying. In other words I got desired but I worked a little bit hard. Let me put that on -- I will say HQR 5. And that's a combination of the lateral and the longitudinal control. Which is about, you know, plus or minus an eighth of an inch in both axes. Probably a couple of seconds.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: Go to 14. Is it controllable? Up in the left it says adequacy for the selected task. So we are talking about controllability of the task. And I'd say yeah, it's probably controllable but we have problems with adequate. Both adequate performance and tolerable workload. I'm going to say no to: is adequate performance attainable with a tolerable workload. And then is controllability in question? That's where I think the task comes. And I think controllability of the task probably is in question and I'm pretty worked up with three or four things to do at once. So it's probably considerable compensation required for control. HQR 8.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: And let's go through the Cooper-Harper. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? Again I guess, I think the collective pumping there is pretty active. For altitude control. Deficiencies warrant improvement? I'd put it in the minor but annoying category. I could get the desired but I worked pretty hard in the collective. While I'm trying to put in my flare and take it out is fairly predictable, but I guess the worst case is the collective, the bigger input, followed by the two secondary inputs to maintain. And the HQR was a 4.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Going into the handling qualities rating scale. Flipping out Cooper-Harper. Okay. Entering initial maneuver. Is it controllable? Yes. Is adequate performance attainable with tolerable pilot workload? Yes for adequate and it was tolerable pilot workload. Is it satisfactory without improvement? No. Deficiencies do warrant improvement. According to this category, maintaining adequate, -- going to the other side here, I'll assign two different HQRs here for the left and the right. Going to the right, I'd come in with moderately objectionable deficiencies. Primarily the phase that we are talking about, going to the right, is the decel stabilization to hover. Multiple overshoots in roll causing quite a bit of lateral cyclic action there. Pretty rapid frequency, at least a few hertz frequency. Inputs, I'd say (inaudible) amplitude. And come up with HQR 5 on that one. Going to the left, is it controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? No. Warrants deficiencies. And on that one I give it very objectionable but tolerable deficiencies. And that -- two phases. I'd say if I separate the phases, I work up -- actually due to visual cues I'd make it a fore and aft longitudinal movement, I'd say much greater going to the left than going to the right because I'm searching for my position more than I was going to the right. So therefore during the actual maneuver around the circle I'd go with an HQR 5. Moderately objectionable deficiencies fore and aft movements. About a 1 to 2 hertz half inch amplitude continuous see-saw motion. When I separate that and come back to the actual stabilization to a hover, I'd say it's more, more objectionable in that category. (inaudible) roll, again lightly damped oscillations, I'm trying to fight that as well as some collective inputs corresponding to make my height, probably at least three to four collective up/down movements trying to capture the altitude. So moving on to very objectionable in that case and over to HQR 6.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: Using the Cooper-Harper rating scale, I do want to comment, the first two maneuvers I felt as though I was verging on adequate and perhaps going into the adequate boundary fore and aft and in altitude. That was my perception. So-- but as the speed went up improved. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would say yes. Is it satisfactory without improvement? I would say no. I would say that there are moderately -- I achieved desired performance with a considerable compensation. Adequate performance I think could be attained with moderate compensation. So I want to give this one today a 4.5 rating. I think there is a distinction between there in terms of the workload. I think there is annoying deficiencies, but I don't think they are dramatic. This primarily has to do with the multi-functions, not deficiencies in the airplane but a workload issue. So I'll give it a 4.5 rating.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: Cooper-Harper rating scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would say that no, it's not. You can achieve adequate perform -- well, I take it back. You could achieve adequate performance but it wasn't with a tolerable pilot workload. So I would say adequate performance not attainable with maximum tolerable pilot compensation. HQR 7 doesn't really apply in that case. But adequate performance requires extensive pilot compensation. HQR 6. That seems to be more applicable here. So I would say from an extensive pilot compensation standpoint, you could do that and achieve adequate performance. So I'm going to give it HQR 6, even though the first block leads me into 7 through 9. The descriptions really don't apply, so I'm going to say -- give this one an HQR 6.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight. [From the ground-station engineers' notes, the pilot was primarily able to achieve desired performance with some excursions into adequate. The times to complete the maneuver were within desired. The pilot commented that: it was not very aggressive nor very precise; reducing the aggressiveness helped; some pitch oscillations were noted; very predictable; control harmony is good; cueing was sufficient, but radar altitude update was a little slow; pilot fought against cyclic trim; compensation in collective and pedals;

couldn't achieve desired performance; heading control problems, not smooth, a little unpredictable lateral/directional; critical sub phase is throughout the circle, the start/stop is easy. HQR 5]

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight. [From the ground-station engineers' notes, the pilot could meet desired, within the adequate every run; precision was "iffy"; cueing is weak directionally; unacceptable oscillations are a function of wind axis; predictable in height, longitudinal; some unpredictability in lateral and directional response; pilot did not use trim release on cyclic; it is not that much more difficult to the left; deficiencies in lateral axis and some in yaw. Critical sub phase is the start (heading control) HQR 5]

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: Cooper-Harper rating. Doing the right turn first. Controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? No. Minor but annoying deficiencies. Desired performance requires moderate pilot compensation. HQR 4 on that. And that's primarily due to the -- how the wind was affecting our tail as we went around.   For the turn to the left: Controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? No. Moderately objectionable deficiencies, adequate performance -- desired performance -- make that a HQR 4.5. Doing it cross cockpit was not as big a deal as what I thought, in fact it was almost easier to maintain reference to the line to the cockpit and then a quick glance back out front. There wasn't as much head turning involved with it as there was with the turn to the right.

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm *******************

Pilot B (data runs 193.1-3 Right - Config. A Calm) HQR=4: What was the critical sub phase of the task? It was inserting the tail into the wind and changing your wind direction as you went around the pirouette, largely being the difference. As well as the visual cues that you used to maintain the pilot compensation. The cue seems to be very good for the altitude, using them between the lines. So that made a big factor whether I could meet the high tolerances.

Pilot B (data runs 193.4-7 Left - Config. A Calm) HQR=5: What was the critical sub phase of the task? It was coming through the wind line from aft and then forward into a headwind made a big difference in height and fore and aft control.

Pilot D (data runs 191.4-6 Right - Config. A Calm) HQR=5: And that kind of covers the sub phase. Like I said, the entry and then the decel to stabilization in the hover were the two areas. Particular reasons, the entry for the heading, get the heading hold picked off and pointed straight, which is a little more minor, and then the more moderate compensation was during the decel to recovery phase with the, again combination of lateral fed in with pedals.

Pilot D (data runs 191.7-9 Left - Config. A Calm) HQR=5: And critical sub phase, I'd have to go with the decel to recovery to the stable hover.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.29-31 Right - Config. A Lt Winds) HQR=5: No comments.

Pilot C (data runs 188.32-34 Left - Config. A Lt Winds) HQR=8: And No. 15 was, the most critical is probably longitudinal position that drives it that way and I think it's workload, followed by height and followed by bank angle.

Pilot D (data runs 192.28-30 Right - Config. A Lt Winds) HQR=4: And of course that falls into the critical sub phase, it is the deceleration to (inaudible) hover and capture.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: If I come back to the next question, 15, critical sub phase on the right was definitely the see-saw stabilization. To the left the most critical was definitely the decel to stabilization but also critical was, I think I'd get tired about three quarters of the way around the circle and my longitudinal position falls out. Primarily I did that through the visual cues.

**************** Configuration B - Calm *****************

Pilot B (data runs 207.5-8 Right - Config. B Calm) HQR=4.5: The critical sub phase of the task I think is throughout the pirouette is the sub phase because as you change wind direction it constantly requires your attention.

Pilot B (data runs 207.9-12 Left - Config. B Calm) HQR=6: The critical sub phase of the task, first 180 degrees of turn that made it very difficult to maintain any constant translation or constant heading variation.

Pilot G (data runs 205.17-21 Right - Config. B Calm) HQR=5: No tape for this flight.

Pilot G (data runs 205.22-26 Left - Config. B Calm) HQR=5: No tape for this flight.

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.30-32 Right - 209.33-36 Left - Config. B Lt Winds) HQR=4R/4.5L: And the most critical part, phase of it would be the aggressiveness level at the end of the maneuver during the decel. If you don't require the five second decel, it's fairly -- fairly smooth at the time to roll out and get the thing stopped. If you throw a five second decel in there, that's when you are going to start to get the bobble into it. So that would be the first sub critical phase. The second is any time the wind is swapping on your tail and you start to get more lift out of the tail, then that becomes the critical point. End of comments.

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Calm ******************

Pilot D (data runs 195.2-4 Right - 195.5-7 Left - Config. D Calm) HQR=5R/6L: Okay. For cases with external load, did the load have -- (inaudible.) There is something wrong with the radio. Okay. In question 16, for external load, did the load have a significant impact on the assigned oscillation. I would say yes, especially in that decel phase where I felt a pretty good oscillation of the load. I don't really feel it around the circle, other than just (inaudible) consciousness, but during the decel phase I'm really feeling some oscillations on the load, which is, I think, kind of jerking the aircraft around, it may be causing some of those roll oscillations and making it difficult to stabilize. That is all.

SLOPE LANDING MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: Okay. I think we did desired performance on all three [data runs]… both in terms of positioning and heading capability.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: We were able to meet desired. I felt like we were able to meet desired performance standards. However, it did require a spotter in the back for wheel position. As far as the cone cues out front, they were somewhat relevant, but they came to be obscured slightly, so they didn't provide much lateral information in the pilot's position. The cues out to the right, the two cones out to the right were unusable. In fact, I didn't even refer to them. When I did, I found myself getting off longitudinal and lateral position out the front of the helicopter.

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: I think the precision is certainly satisfactory, I would not say it is at all aggressive. I don't think the task lends itself to being aggressive. Actually, it mitigates against being aggressive.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: It seemed like you were with (inaudible) spotter in the back you were able to be fairly precise in doing the task. And in the desired heading, lateral longitudinal (inaudible) position. As far as aggressiveness goes, I think with more familiarity of the maneuver, an individual could become more aggressive. With the time constraint that was put on the maneuver, (inaudible) desired performance goes.

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: If trying for desired performance resulted in unacceptable oscillations, they did not.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: If trying for desired performance resulted in unacceptable oscillations, the only oscillation that I noticed was in letting down after the right main gear has touched down and when you (inaudible) [lower] the collective down, there is a tendency, a slight oscillation between cyclic movement and collective movement. It sort of gave an up/down lateral motion, lateral rolling motion to the helicopter.

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: Aircraft characteristics. No objectionable controller force characteristics.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Objectionable controller force characteristics. There really wasn't any. Utilizing the trim release did not produce any kind of aircraft jump like I was anticipating. It was very calm, sort of seemed to be washed out when the cyclic moved to the new position but the actual helicopter would not move.

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: Predictability of response is satisfactory.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Predictability of initial aircraft response. It was really predictable.

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: No mid or long term response problems that I could see.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Any mid to long term response problems. No, except for maybe that lateral roll once you decrease the collective.

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: No objectionable oscillations or tendency to overshoot. The only ones I see that are even oscillatory occasionally at initiation of the touchdown and also the initiation of the lift off there is a slight amount of uncertainty as to where the lateral cyclic should be, but it's not at all objectionable. That's pretty typical.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: No comments.

8. Describe any non-linearity of response.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: I sense no nonlinearity of response.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: No nonlinearity of response.

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: And I sense no harmony problems; harmony of pitch, roll, speed control is not an issue. Height control is acceptable. And heading hold in this case seems to work out quite nicely. I don't see deviations of more than a couple of degrees around the initial set down heading. I don't think it's critical that you be right on 243 or 245, I think you can pick whatever heading there you like to stabilize the aircraft and then start your measurement of variation from that point.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Problems with harmony of pitch and control, speed control, no, there was none of that. It seemed like it was fairly easy to hold the heading. I didn't get as much feedback on rudder or tail pedal movement into the rolling movement, that's what I anticipated, it was fairly calm. Of course the wind condition out here is dead, so a (inaudible) in a higher wind condition is a little more adverse wind conditions directional wise, you might get more disharmony.

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: (See field 9)

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Describe overall control strategy in performing the task. Again it was the forward cues that were eluding use. We did use the lateral box (inaudible) the time it went out of cube. The spotters in the back were able to put the right main gear into the box. It was really kind of fixating on the two cues out in front or even a clump of grass that might be next to the cues. It was very hard to (inaudible) lateral cue.

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: I don't see any (inaudible) what I actually see are pretty normal and consistent control inputs for degree of slope. I'll say what I don't like, including the leveling of the tip path plane as part of the task. I think it's inappropriate for a slope landing if you are really concerned about the ability to keep the aircraft on the slope, there is no reason to give yourself a downslope vector.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Control compensation to account for deficiencies, there really wasn't any.

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: Describe any modifications you had to make to what you would consider normal control technique. I see none here.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Any modifications, none.

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: Obviously the tricycle cue (inaudible.) On the ground I'd say are key to the task. Very serious control input, the decrease in collective is very important. I saw what I thought was a considerable difference between the first trial maneuvers and actually doing the task. I think the position on the slope gave us roughly 15 degrees for the first (inaudible) whereas, the actual data runs were more like 12 or 13 at the most. The (inaudible) degrees of extra tilt make a considerable difference when you are already out 12 or 13.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: Comment on anything else, I can't think of any right now.

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: Cooper-Harper scale. Okay. The aircraft is obviously very controllable. Adequate performance? Yes. Satisfactory without improvement? I didn't see any deficiencies that warrant improvement, from what I could see. That makes it satisfactory without improvement. That raises to level 1. I would indicate a 3, minimal pilot compensation required for desired performance. I could obviously get desired performance. It's not that the task is not without workload, but the workload is very defined. The task requirements are defined. And the issue is not the handling qualities as much as it is the precarious position of the aircraft and the desire to maintain the state of the aircraft and control it around a very narrow limit. And the aircraft provides you the handling qualities with which to do that. Even though the amount of work involved is actually fairly high. I think that justifies a handling rating of 3. I would say that all three landings and takeoffs were roughly equivalent. I didn't see any significant difference between the three. And I think the HQR of 3 applies to all three equally.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: As far as HQR goes, was it controllable? Yes. Adequate performance attainable? Yes. Is it satisfactory without improvement? Perhaps some people would say no, deficiencies warrant improvement. And I would say there is minor but annoying deficiencies. Desired performance requires moderate pilot compensation. That's primarily due to the aggressiveness of the task and it's very benign, you could take all day in getting it down on to the ground. If there is any kind of sling conditions or if there is any kind of speed, (inaudible.) The challenge would decrease.

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm *******************

Pilot E (data runs 200.1-3 - Config. A calm) HQR=3: The critical subphase of the task, entry, steady state, whatever, or major determining factor in the overhaul handling qualities rating. I'd say I think the issue is always from the point where you have the right gear on the slope, it's not at all difficult to maintain a low attitude, but then the coordination to make sure that you get the left wing down without sliding the right or getting yourself a heading change to tail rotor inputs is probably where it's critical. I think to be honest the handling qualities rating is actually given for the whole task. I find that the whole task requires a fair degree of work. It's not a matter of compensation, it's a matter of overall workload, which I think is pretty consistent across the task. There is a fairly exciting level that goes with the task, there is a certain degree of uncertainty which goes along with being on a surface, which if this were asphalt it would be different than when you are sitting in loose dirt.

Pilot F (data runs 200.4-6 - Config. A calm) HQR=4: What was the critical subphase of the task, EG entry, steady state. Probably the subphase of the task, it wasn't so difficult getting it over the spot, and even getting the first right gear down on it. It seemed to me like the most critical was getting the left gear down and then getting the cyclic centered. You just don't know how much cyclic you are going to take out. That probably degrades the HQR. It was a big question how much slope angle you had out there and without really knowing or saying that you don't know ahead of time, you have got to be very careful in lowering the collective and considering the cyclic. That's the end of comments.

VERTICAL MANEUVER MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: The last two performance standards that I did meet desired I think is a function of this being an hour, almost two hours into this flight doing this maneuver. So with that caveat I think you can meet desired performance with this standard.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: The target comes in, and then just intuitively you push down on the collective and the thing just stops right in the block. Maybe one little correction, pedals just kind of hanging on. There is no torque compensation required and laterally I'm staying in good shape. The fence line is a real strong cue for longitudinal with an occasional glance over to the cones.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: I flew three tasks. I was able to get desired. The first one was adequate with heading and longitudinally.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: We were able to meet desired performance standards in all parameters. However, the bottom edge of the altitude and the aft of the longitudinal drift were at the edges of desired.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: I think two out of the three I missed the desired into the adequate. One due to the time and the other one due to fore and aft drifts in heading.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: Position control seems like it's very easily done. Ground control says we keep showing a little off centerline, but that's not too readily viewable. I can move around and have two or three places that seem pretty acceptable or very accurate up here and I can throw in about almost a ten-foot error. So, but anyhow, from this perspective, everything in desired, it looked pretty good.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Describe ability to meet desired/adequate performance standards. All maneuvers were done in desired performance standards there. There might have been a sight pick tour problem for the aft standard, but I think within the tolerances. The movement up and down was within that plus or minus band.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: Again, there is a lot of variability in the way that the task is flown. I find that the last run was actually well done and very comfortably flown. It looked to me like it was actually as good as it could have been. In terms of longitudinal in spite of the fact it was on the limit. I felt that torque application, just general smoothness of the maneuver was actually quite good. Taken across the three runs, I would say that the performance probably was degraded into the adequate range by virtue of the fact that there were a number of things that continued to stick on the adequate border.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: I think you can meet desired performance with a little work in most of the parameters. The most difficult one, it looked like, was the longitudinal, and that was primarily due to the lack of a definitive cue out there. Again, I'm fighting the door support for the position of the lateral cones. And when you get up high like that, it's difficult to pick out the yellow line out to the side of you. The array of cones that are out there are unusable at the high height position, up position.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR.)

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: And the Level of aggressiveness and precision plays a role here. The more aggressive you are in the vertical ascent, the more difficult it is to capture that upper box precisely. The rest of the control activity doesn't seem to be that bad, although at the top of this maneuver the cuing is weak in terms of making sure your fore and aft drift is gone because of the altitude.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: (See field 1)

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Aggressiveness of maneuver. I think I increased in amp from the first one on, being able to pull more torque, but the aircraft would (inaudible) light state. The aggressiveness depends on how much power margin you have, how much torque available you have, the difference there. And we have plenty in this configuration.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Precision in terms of altitude seemed to be dependent on how well your initial capture was so that that wasn't always adequate. We will talk about that in terms of predictability. Aggressiveness, the maneuver did not seem overly aggressive. However, you are into the torque limit, 115 percent torque was the highest one I saw and it seemed to be continuously there to meet the 13 second timing.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: I think I was just not quite to the desired in aggressiveness and I hit that with a second two. So I was really trying for desired aggressiveness.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: (See field 1)

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Describe aggressiveness/precision with which task is performed. Most of them were right on the desired, aggressiveness of 15 seconds, but the last one was done a little more aggressively with a little anticipation for the descent and it could still be done within desired tolerances.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: Aggressiveness, the most complicated thing here for me is the torque application. It's very hard, in my mind, to keep the aircraft level and go for the time and get a good smooth torque application. The torque application is always somewhat less than it could be because I'm always concerned I'm going to over torque it. And I don't feel like I have the time to look inside, to crosscheck it, because by the time I can see it, I'm already at the upper limits. So that really complicates the deceleration at the top and stabilization on top of the -- at the top marker. So it ends up being more torque application, I feel, with one quick crosscheck that is not long enough to actually ascertain the stabilized torque value. All the aggression is in the vertical axis. Precision, of course, is in the roll axis. I'm very insensitive to directional control, unfortunately, and I seem to be, continuing to be somewhat insensitive to the longitudinal, even though I think we are doing a better job of staying on the line.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Aggressiveness and precision. I think you can be fairly aggressive with the power because with this extra weight it seems like the helicopter is really dampened out very positive in its positioning at the end of a particular power increase, so that you don't have a lot of overshoots coming out at the end. You suck in a lot of power and there is not too many -- there is very few oscillations, if any, in the collective control on hitting the top position or bottom position point.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Unacceptable oscillations, item 3 doesn't apply.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: (See field 1)

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: If trying for desired, adequate, unacceptable oscillations, I never had to dip down to target adequate for any oscillations or any requirement like that.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: If trying for desired performance resulted -- there were no unacceptable oscillations, so that's not a consideration.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: So therefore I didn't think I had to sacrifice, question 3, for the adequate performance.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: (See field 1)

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: If trying for desired performance resulted in unacceptable oscillations, there were no unacceptable oscillations. So that's not applicable.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: No oscillations for item No. 3.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Desired performance resulted in unacceptable oscillations, I didn't perceive or see any oscillations in the maneuver.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: 4, objectionable controller force characteristics, none.

**************** Configuration A - Light Winds *************
Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: (See field 1)

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Aircraft characteristics, describe any objectionable controller force characteristics. And none noted there.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: There were no objectionable controller force characteristics.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Aircraft characteristics. Objectionable controller force characteristics. None noted. I think the primary controller is in the collective and for my friction that I normally fly with, it felt fine.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No objectionable controller force characteristics.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: There were no objectionable controller force characteristics.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: No objectionable controller characteristics.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Objectionable controller force characteristics, none.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Predictability of initial aircraft response was good, except there is always a little time delay in terms of capturing heading with the initial collective response. So there is a little weakness in predictability, but over time you can compensate for that. There is some compensation at the top in terms of leading your collective reduction.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: Very predictable aircraft. I get the rate going, it will stop right on the -- as soon as you move the collective, it just follows it.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: No. 5, describe predictability of initial aircraft response. Again there is no problem there. I think the initial response is the aircraft is predictable, it just depends on how much torque I want to feel, how safe I feel pulling that.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: There was predictability of initial aircraft response. The predictability was good in terms of longitudinal -- or lateral drift and heading response. However, the past drift was not predictable each time, depending, marginally on your initial conditions, as well as how often you were in a certain parameter and how much attention you can pay to the longitudinal axis as opposed to heading. I felt it was easier with the feet off the pedals since the pedals were taking care of heading for me, to prevent the longitudinal drift and that the overall results, I believe, will show that drift was minimal during the feet off the pedal type maneuvers. Predictability also at the bottom end, predictability at the bottom was not very good in terms of capturing the heading because torque was a concern at the bottom.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Describe predictability of initial aircraft response. I think I'm getting a good pull coming up and it's predictable throughout for collective. I'm not making a lot of overshoots to do that.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No. 5, predictability of initial response, you can tell the aircraft is heavier than when unloaded. But it's pretty much pull the collective, wait for the box to come in, reverse the collective, the thing just nails and the excursions and heights are minuscule. I have feet on the deck, so I'm not worrying about heading. And the lateral-longitudinal stick requirements, I kind of wasn't even paying attention to them, because they were whatever is necessary to kind of stay in position, but the work was in the vertical, so we were paying attention to the collective activity. And even at that the aircraft was very responsive to the left hand. Pull the collective it comes, push the collective it stops, lower the collective it starts again and again the same thing with like very short time constant in vertical. So the aircraft is very predictable.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Predictability of initial response. A little bit of time delay in the collective application, which you would expect with the rotor, apply the collective, you get an initial response fairly quickly but the predictability to stop, it takes a little anticipation to stay within the desired band.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: I think the predictability of the initial aircraft response is good. The torque response of the aircraft is good. No unusual heading excursions as a function of the heavy collective input.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Predictability of initial aircraft response. It was good. It seemed like, again, the power, the application of collective was very -- you could do it very positively to a definite position and at the end, even if you happen to overshoot it a little bit, you can correct and get the helicopter back into the position that you needed it. I did notice during the descent it looked like, even though it was fairly positive in the vertical axis, like there is a slight drift to the right as we were coming down. I don't know what precipitated that, but it did look like it was very consistent throughout each of the maneuvers. And this is something that had to be compensated for to keep the target in the middle of the screen or keep the targets on top of each other.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Any mid or long term response problems, none.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: No mid to long term problems.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Any long, mid to long-term response problems. None noted there.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Mid to long-term response problems, none.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Mid to long-term response, no problems noted there.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No real long-term response problem.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: No mid- or long-term response problems.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: Mid- to long-term response problems are not -- I'm not sensitive to.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Long term response, none.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Any objectionable oscillations, none. Tendency to overshoot was at the top. That's because of the time delay and your anticipation of your collective reduction is a function of your aggressiveness.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: No. 7, no oscillation or tendency to overshoot it.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Objectionable oscillations or tendency to overshoot. None really. In the vertical maneuver I feel like it's pretty accurate as far as predictability to capture the height once I get up there.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Objectionable oscillations or tendency to overshoot. No objectionable oscillations but there was a tendency to overshoot the final altitude hover point.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Objectionable oscillations or tendency to overshoot. Again, I don't see any problems with oscillations in this maneuver. The load rides very nicely on this one.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No tendency to overshoot. Maybe when I went up, that might have been a little cause for a drift down, because again the cues kind of go away and this frame in the door is a little troublesome for the angle that you see. Other than that it feels real good.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: No objectionable oscillations or tendency to overshoot.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: No objectionable oscillations.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Objectionable oscillations or tendency to overshoot. Again, I didn't see any on that. It looked very stable in all the positions, both top and bottom.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

8. Describe any non-linearity of response.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Describe any nonlinearity. There wasn't any.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: It's just as linear as it could be.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Describe any nonlinearity. And again nothing there.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Describe any nonlinearity of response. None.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Describe any nonlinearity. No problems there. Well, I guess if you call it nonlinear, but there is a point of change in the momentum to get the load going vertically. Which takes somewhat of a initial collective pull, until you get the torque up in the transient range, 115 to 117 was what I routinely saw and I let off on that after a couple of seconds once the aircraft actually starts moving. So if you call it nonlinear, just change the momentum (inaudible) anything, but it's not really a control problem.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No nonlinearities.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: No nonlinearity of response.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: No nonlinearities that I'm sensitive to.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Any nonlinearity of response? None.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm ******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Harmony of pitch, roll and speed control, that's not applicable here. There weren't any.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: Harmony of pitch and roll, like I said the collective, Sikorsky did their job in mixing it, because the collective to yaw and collective to pitch and roll all had a -- you can't see it from the cockpit, it's just hold on.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Problems with the harmony of pitch and roll, speed control, height control or heading turn coordination. And again no serious problems there.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Describe any problems with harmony of pitch, roll, speed control, height control, heading hold, none.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Any problems with harmony of pitch, roll, speed control, height control, heading/hold, no problems noted there.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No. 9, I didn't see anything unharmonious, either.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Describe any problems with harmony of pitch, roll, speed control, height control or heading hold/turn coordination. I didn't think there was any disharmony. The aircraft seems to handle in this configuration fairly well in terms of harmony between the control inputs.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: (no comments)

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Problems with harmony of pitch and roll, speed control, there was none as far as that goes. Height control, just since that was basically the maneuver, it was -- seemed to be very positive with the amount of collective that you would put in.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm ******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Overall control strategy to perform the task. Really the control strategy was to make sure you had a good hover position within the cues or within the performances. I think what they were going to want to look at is where does the guy start in the adequate band within the desired tolerance band, if he starts on the aft, from his aft position he's only got one feet on the aft from his start. Then he progressed three feet fore and aft from that point because that (inaudible) plays a big role in whether or not you achieve the standards on this maneuver.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: No. 10, once you get comfortable with it, overall strategy is just hang on the controls and pull the collectives and lead just as the box comes into the white, kind of reverse the collectives and the box will stop right on target.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Demands on the pilot. This is where I would like to talk about control strategy. Except for the first one where I did have my feet on the pedals, the second and third one were in desired for heading, I had my feet pretty well off the pedals. Micro switches not depressed. So heading hold was engaged. I was just letting the aircraft work for me, which I guess is a plus for the aircraft. I'll go back and say it's not the way I'd actually fly the aircraft. A lot of times in a hover I would probably depress my feet there, but at the same time it may be a real question whether even if I was pulling up an external load or vertically out of a defined area or even coming up with troops on a spy rope down below me, probably isn't as critical to the tolerances that we are looking here. So maybe I compensated by keeping my feet off the pedals, but maybe the tolerances are too tight realistically. There is some questionability there. Anyway I kept my feet off the pedals for that maneuver.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Describe overall control strategy for performing the task. I did the first one feet on the pedals, two feet off the pedals, final two feet on the pedals. And the overall strategy was to capture the heading and monitor that first through an additional collective application, monitor torque and go back outside and capture the parameters. So there was some divided attention here, however that was significantly reduced with the feet off the pedals. Come inside, check torque, change longitudinal position, that was the important part of doing the task precisely.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Demands on the pilot. Overall control strategy. I went with going on cue with my feet actively on the pedals. I didn't try to do this using heading hold only. I did deviate in heading the second run and was pretty close to the edge on the first run. But I think that's how I would fly the actual maneuver operationally.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: I had a good strategy, I keep my feet on the floor and I'm going to pull a chunk of collective and don't be too concerned about it. I don't have a torquing problem, my co-pilot is watching that. So it's give it a handful of collective, get the vertical climb going and reverse the control and nail it on altitude.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Describe overall control strategy. Really was to get a very stabilized hover position and then not making any inputs to the flight controls, just a pure collective application.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: Okay. Demands on the pilot. Again, the idea of this task is really to be in the old elevator shaft where you get the aircraft very stable and level and just apply a nice, strong collective input which drives you straight up the chute without having to dither around longitudinally and laterally. I find that if I haven't got the aircraft stable, I will probably drive it out of one of those bounds. And so part of it is how well you set the maneuver up and how stable you are to start with, I believe.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Overall control strategy. It was basically getting lined up in the initial position, attempting to get lined up longitudinally with the outside cues. And then pulling in what felt to be like a couple of inches of collective until you had a feeling of vertical acceleration. Once you had that feeling of vertical acceleration going, and depending upon the amount of that feeling would depend on how aggressive you wanted to be in the vertical axis, you could modify the response to collective accordingly. And it, again, it seemed like it was very positive in the end of responding to the collective input. The lateral cues, again, were probably the weak point and this is primarily due to the cones being lined up along the door jamb and just not being usable without having to look around the door jamb. When I looked around, that of course threw all the visuals, picture off out in front of me.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Describe any control compensation you had to make to account for deficiencies in the airplane. I didn't feel there were any real control applications, but it made it difficult in the fore and aft cues, as you went up you could fine tune yourself up there, the cuing was poor so it's difficult to know whether you drifted fore or aft vertically. All the rest, the cuing was great, there wasn't any problems or real control compensation, I think the ability coupling in the heave axis in the other axis was objectionable.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: I didn't make any control compensation required for any other deficiency in the aircraft. Again we are wings level here with wind on the right.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Describe control compensation you had to make to account for deficiencies. And that was the real one there. Feet on the pedals is very difficult to remain heavy within the tolerances, as I found out my first time I did the FTE. So I accounted for that by not depressing the micro switches.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Describe any control compensation you had to make to account for deficiencies in the aircraft. Largely there was longitudinal required with collective input provided could monitor the cuing in the longitudinal direction.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Any control compensation, I don't see anything there.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: So on No. 11, I don't really see any compensation requirement.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: And then there was some very slight cyclic control compensation as you went up, a very minor amount. Both feet on and off the pedals, there didn't appear to be -- require -- any pedal application required. With feet off the pedals it was just as easy to do as feet on the pedals because there was no input required.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: No. 11 (tape ends here - see HQR below)

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Control compensation, none.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: No modifications to normal control technique. I had my feet off the pedals for all of this entire maneuver, which made heading control not enter this task. I think if you have heading control in here, it would increase the workload associated with this task.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: And I don't think I would modify anything on No. 12.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: And that would kind of lead in to question 12 as far as me meaning the way I normally fly the aircraft because of that.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Describe any modifications you had to make that you would consider normal control technique in order to make the aircraft behave. No modification to the control technique, but longitudinal cuing plays an important role as to whether you can do this task precisely.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Describe any modifications I had from how I would conduct the maneuver under normal conditions. And I don't have any comments for that as well. I feel like I did it normally.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: Modifications, I don't think I can come up with a modification for the climb. There may be something on position, but I don't know what to recommend there.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Describe any modifications you had to make to what you consider normal control technique. I don't think there was any for this maneuver.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: no recording tape.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Modifications you had to make, none, considering it was a normal technique.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: Please comment on anything else that influenced you. Again, I think at the end of a two hour flight trying to do this precision and task affected my scan a little bit and may have affected the ability to get on the last couple, to maintain desired.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: No. 13, I don't think there was any other influences.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Miscellaneous, nothing else to add.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: no comment.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Other comments is just to (inaudible) for this external load weight. Torque is a big consideration for defining my initial aggressiveness of the maneuver. And mentally that's a big factor in how I perform in this maneuver.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: I don't see any influences except positively, and that's the quickness of the collective response and the fact that it's got good heading hold.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Nothing else influenced me. There is a little tail wind today, so getting in a stabilized hover position seemed to be a little erratic down at 19 feet, but it didn't seem to be a problem during the ascent or descent.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: no recording tape.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: Comment on anything else that might have influenced you. None.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 below for HQR)

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

**************** Configuration A - Calm *******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: I'm going to give this, is it controllable? Adequate performance was attainable? Yes. Is it satisfactory without improvement? I will say yes. Some mildly unpleasant deficiencies only in that the predictability of capturing that top end heading was a little bit difficult. It would be nice if you could go up there and release the aircraft and it would stabilize and maintain that performance, but I had to lead, I had to do my own leading and use that cuing and focus on that axis. So I will give it HQR 3 for this task.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: I will go to Cooper-Harper. Controllable, adequate performance is attainable and this time it's satisfactory without improvement, I would say yes. So we have highly desirable, negligible deficiency or unpleasant, some mildly unpleasant. I think I'm going to eliminate HQR 3 right away. So it comes down to highly desirable or negligible. And both of those have the same workload. So I put the input in, wait till I get the altitude, reverse it, make one adjustment. That one adjustment probably keeps me in an HQR 2.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: Cooper-Harper scale. It is controllable. Adequate performance with tolerable pilot workload is a yes. Is it satisfactory without improvement? And I would say yes. I don't see any real problems there. The heading hold is nice for holding the heading. Longitudinally I think it's more of a cue thing but if you work hard to maintain that, I think it actually falls into a good, negligible deficiencies. Pilot compensation not a factor for desired performance. I take that back. Minimum pilot compensation required for desired performance. If I scan off to the longitudinally -- maybe because of the cues or maybe the aircraft tended to drift fore and aft as I did that, some minor -- minimal pilot compensation, so I will call it HQR 3.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: Cooper-Harper rating, it is controllable. Adequate performance was attainable with a tolerable pilot workload. It is satisfactory without improvement. Yes. And HQR 3. Minimal pilot compensation required for desired performance. Largely that compensation was required in monitoring torque and monitoring longitudinal drift position. And altitude position on the final capture.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Cooper-Harper rating scale. Okay. Is it controllable? Yes. Adequate performance attainable with a tolerable pilot workload? Yes to that as well. Is it satisfactory without improvement? No. I felt I did hit adequate on two out of the three, so I think it falls into the category of moderately objectionable deficiencies. Primarily it's just the heading is the biggest thing that comes out. Again I didn't try to use the heading hold for this maneuver. And I don't think you necessarily would for a vertical maneuver. So that's where I felt it the most. And the aggressiveness kind of goes back to my power available on the aircraft and considerations were not over torquing the aircraft. It's not an oscillatory matter, but I think the heading goes off as I increase collective, obviously, and it's not oscillations but I just have to -- that's something else to feedback and correct for. And it's a pretty tight tolerance to have to -- I'd almost question the tolerances on this one, but it's a pretty tight tolerance to have to worry about the heading to that accuracy where it's not -- I'm more worried about torque in this maneuver, I think. But regardless, moderately objectionable, HQR 5.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: Go to Cooper-Harper. I think I'm going to jump up to: is it satisfactory without improvement? Because I think the answer there is yes. We got all the other answers. So we are talking about pilot compensation not a factor, it's always a little bit of a factor but is there anything I would do to make it better, workload? I think more on the vertical axis. So, excellent, highly desirable, negligible deficiency or fair, some mildly unpleasant? It would be hard for me to come up with what that unpleasant is, unless I factored in a (inaudible) for a position, but I think I'm going to go with a good, negligible deficiency, which is a 2.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: Using the Cooper-Harper rating scale. It was controllable. Adequate performance was attained with a tolerable pilot workload. Is it satisfactory without improvement? I would say yes. And I would say this was HQR 2. There is -- pilot compensation is really not a factor for desired performance. The only compensation that's really required, the negligible deficiency is a little anticipation at the top for collective application, but that's about it. So I will give this HQR 2.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: no recording tape.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: As far as HQR goes, controllable? Yes. Adequate performance attainable? Yes. Is it satisfactory without improvement? No. Minor but annoying deficiencies to moderately objectionable deficiencies. Make it a 4.5. This is primarily due to the lateral cuing in that there was not a definite lateral cue in order to be able to determine your drift fore and aft as you were coming down.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight)

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm ******************

Pilot A (data runs 186.14-.20 - Config. A Calm) HQR=2: (no audio this flight)

Pilot B (data runs 193.24-.30 - Config. A Calm) HQR=3: The critical subphase I thought was capturing that heading at the top and not being able to really look at your fore and aft drift except when you came within about 20 feet of the ground.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.20-.21 - Config. A Lt Winds) HQR=2: And No. 15, that's all on vertical. The others, I guess if I were to rate heading and position and all that it may be even better but the workload is in the vertical.

Pilot D (data runs 192.12-.14 - Config A Lt Winds) HQR=3: The critical subphase of the task, I tell you it's got to be or the most critical is, I'd say it's in the initiation, possibly in the initiation or middle of the ascent of the climb and the descent and when I'm working at longitudinal position, it's critical to scan at that point and make corrections early. I can't wait until the heading, the altitude (inaudible) to do that otherwise I would be out of the tolerance. I've got to do it right in the middle of the maneuver, which means I'm looking at the board, then as I initiate the maneuver I've got to keep track of my longitudinal position right then in the middle of the climb or descent.

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: What was the critical subphase of the task? For me the critical subphase was both the stop at the top and the stop at the bottom in terms of altitude maintenance.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: Critical subphase of the task. I would have to say that that is establishing the climb. Because the -- I think that's where my heading is going to initially drift off and that's where I'm mostly concerned about the torque, is initially establishing the climb, the initiation of the phase is the most critical. And that's where I see the problems I think.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: No. 15, the subphase I'm talking about is vertical and the others don't seem to be of issue.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.1-.4 - Config. B Calm) HQR=2: What was the critical subphase of the task? I think the real critical subphase of this task for this iteration was merely the top maneuver in getting -- actually two, the top maneuver anticipation and then making sure you had a good stabilized hover at the start.

Pilot E (data runs 208.11-.13 - Config. B Calm) HQR=4.5: no recording tape.

Pilot F (data runs 209.13-.18 - Config. B Calm) HQR=4.5: And probably the most critical subphase of the task was the -- during the -- during the descent in trying to maintain one position over the ground, due to the fact that you are having to look out, concentrate on the cues out in front, so that you didn't, you know, descend too far down. And then plus the fact you have compounded the position along the ground. Both fore and aft. And I would say that you could almost make that two critical subphases, both up and down. Just the descent and ascent maneuver. End of comments.

Pilot G (data runs 205.9-.13 - Config. B Calm) HQR=3: (No tape for this flight. See No. 14 above for HQR)

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Calm ******************

Pilot B (data runs 186.25-.29 - Config. D Calm) HQR=3: For cases with external load, the load had no impact. No swinging. However, the load may be a factor in terms of the direction of drift during the vertical ascent and descent, but more data will tell. That completes my comments.

Pilot D (data runs 195.18-.20 - Config. D Calm) HQR=5: And external load, yes, significant impact. Not so much that it oscillates or anything like that, but just the fact that it's a heavy gross weight so doing this maneuver with a sling load or doing it with just a heavy gross weight you may not see a lot of difference for this maneuver. And that is all.

**************** Configuration D - Light Winds *************

Pilot C (data runs 188.39-.41 - Config. D Lt Winds) HQR=2: External load, did the load have a significant impact on the assigned HQR? And I think I got the same HQR I had before, but there is an influence and that's the aircraft is very heavy but it's very responsive in vertical. It stops on a dime. Oh, yeah, the excursions on the target were pretty small, also.

DEPART/ABORT MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio. [From the ground-station engineers' notes, three practice runs were performed prior to the three data runs; the pilot was able to achieve desired performance on all of the data runs. The times to complete the maneuver were 22, 23, and 22 seconds.]

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: We were able to meet desired performance standards for this maneuver for all except the first run, but that was really a screening event. Got a little bit high on the speed and then shot through the end point. But all, the last following three maneuvers we were able to meet desired tolerances.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: We met desired in almost, in every category, I believe, every time, so it's relatively easy to meet desired with this aircraft.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: This maneuver is not too bad. The worst work is at the far end where you have to pull the nose up real steep and then field of view becomes a real big issue. If you have got center line okay as you come in and be careful with the lateral stick, you will have a chance of staying on center line and then pick up the horizontal cues, I mean the longitudinal cuing and then settle right in between the cones. A little tendency to be off to the left, I'm not sure if that's just cuing, because trying to keep the center line in front of the pilot's eyes is probably part of it. But anyhow, it tends to be a little bit on the left side, but within desired.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Describe ability to meet desired/adequate. I thought I was in desired pretty easily.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: We met desired, I think, in every category and just about every time. So the ability of the aircraft to meet desired is definitely there. It's not a real factor, I think. It does have some funny things toward the end there when you do the acceleration as you get pretty aggressive you get a tremendous amount of oscillations going on in the roll axis. Even though the aircraft doesn't go anywhere, it just oscillates back and forth in roll. It feels like a lot of stress on the airframe itself. It's slightly disconcerting. But the ability to meet desired performance is definitely there.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: This is for the normal departure/abort with an external slung load. We were able to meet desired standards throughout the three tests conducted.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: Overall, pretty pleased how that worked compared to unloaded. And I think the thing is, when you push the nose down and you have to pull the collective, you can really feel the aircraft take off. And what happens is you get to the air speed sooner and you have a little bit more of a relaxed ride time. And I noticed that the nose up attitude to decelerate was only about 20 degrees where I was using about 30, 35, before. So I had to pretty well stay on centerline and kind of slip right on in to the far end parameters and you feel like you could be pretty aggressive with it. Unlike the lateral, this one doesn't have the load swinging around, I don't feel the load swing. So the longitudinal worked pretty easy. I don't remember doing anything in the pedals, but I probably pulled some right pedal in as I accelerated. Altitude, good visual cues there and I depended on that mostly, with a couple glances at rad out.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Task performance … the ability to meet desired/adequate performance standards? And I felt like I met desired on all of them.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: (No audio for this question, the tape picks up after a TM lockout problem.) [From the ground-station engineers' notes, four data runs were performed and the pilot was able to achieve desired performance on all of these. The times to complete the maneuver were 20.5, 20.5, 21 and 22.5 seconds.]

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.) [From the ground-station engineers' notes, three data runs were performed; the pilot was able to achieve desired performance on all of the data runs, except the heading went close to the adequate range on the first two. The times to complete the maneuver were 22, 21, and 20.5 seconds.]

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: It felt like with proper technique you could meet the desired performance. The only critical area that I could see as far as cues go are the forward cues, longitudinal cues for heading and the termination of a maneuver. Once you picked the nose up you start to lose sight of what's out there in front of you as far as heading. You have to go feel by what the helicopter is doing and what its nose is doing. So it could be -- sort of a guessing about what's happening to it.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.) [From the ground-station engineers' notes, four data runs were performed and the pilot was able to achieve desired performance on all of these data runs. The times to complete the maneuver were 23, 23, 22, and 21.5 seconds.]

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: The maneuver is fairly aggressive, I don't think -- the airplane could take a little more aggressiveness and still do the task, but not within the distance. The precision, I think we were able to hit that end point fairly precisely provided we got a good call on when we reached the target air speed.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: I thought we were pretty aggressive. We were hitting 15 or actually 20 degrees hover attitude down nose low and on the take off pretty good power increases, we were getting well over 20 degrees nose up on the deceleration. So I think that was a reasonable level of aggression, we were hitting about 40 knots. And it felt like it was -- I was being aggressive and we were stopping pretty much midpoint towards the end there. Precision I thought was pretty good. We were maintaining, I was able to maintain center line most of the way and at the end when I decel and I pretty much lose all of my lateral and center line cues, as you would come out of it, the aircraft was still pretty much lined up there. So during that decel even though there is funny things going on longitudinally, there is nothing funny going on laterally or in yaw. The aircraft is holding well there.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: (See answer #1)

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: The speed within the tolerances is somewhat aggressive as far as hitting the numbers 20 degrees down and that's realistic but I think it was -- it was an aggressive task.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: I felt we were able to be pretty aggressive in the sense that we were getting just about the same everything that we did without the sling load in terms of nose down attitude and nose up attitude, ground speed and even stopped twice were relatively predictable. So aggressiveness, I was still able to be quite aggressive or reasonably aggressive with the sling load attached.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: The aggressiveness of precision, it seems to be a very aggressive maneuver with the sling load but at the same time it -- I'm able to get to the point, again within the zone with fewer movements, it seems to be a little bit more stable and not a lot of load dynamics entering into the play.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: (See answer #1)

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Aggressiveness/precision. I felt I achieved the aggressiveness for the required for the desired tolerances.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: The first two were performed at a much higher level of aggressiveness than the latter two. Both beyond the 35 knots desired for the peak speeds as we were transitioning down the course. The first two got to 50 knots and managed -- pitch attitudes ranged up around 20, 22 degrees nose up, with a very aggressive deceleration. Where the latter two, once we achieved peak speed we were less than halfway down the course, required a minimal collective reduction to maintain altitude and very gradual deceleration in to the zone. So the maneuver could be performed within desired precision at a much higher level of aggression than is currently specified.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Aggressiveness. In order to do the maneuver it's not necessary to be super aggressive. I noticed that it just requires about a 20-degree nose pitch down with a slight increase in collective to start your forward acceleration. Just about the time you think you have your -- the -- well, about the time you achieve the 20 degrees nose down and holding it for a couple of seconds, you start to achieve the longitudinal rate. So you can start pitching back up to hold that and the trick is to reduce collective to get it to maintain that speed without climbing.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: There were no unacceptable oscillations in the aircraft.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: And question 3 doesn't apply, I didn't have to reduce the parameters at all to adequate.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: (See answer #1)

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: I never had to shoot for less than desired to make adequate because of oscillations. So #3 doesn't really apply.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Question 3 doesn't apply because we didn't reduce the standards.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: There were no unacceptable oscillations.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: (See answer #1)

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: And I was pretty well pushing it, I don't think I would have tried for any more aggressive on this, so question No. 3 doesn't really apply.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: If trying for desired performance ruled in unacceptable oscillations, I didn't feel as though there were any.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: I wouldn't say that desired performance resulted in unacceptable oscillations.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: I didn't see that there were any objectionable controller force characteristics.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Question 4, any objectionable controller force characteristics. I would say no.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: No. 4, the controller force characteristics, there is really no (objectionable) force there.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Objectionable controller force characteristics. Nothing noticeable there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Question 4, there were no objectionable controller force characteristics throughout the maneuver.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: For item 4, objectionable controller force characteristics, there were none.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: Again, objectionable controller force characteristics, I don't see any there.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Aircraft characteristics. Describe any objectionable controller force characteristics. None noted there.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: No objectionable controller force characteristics. All the maneuvers were done with the trim release. For the aggressive maneuvers there is a tendency in the large pitch attitude change from about 15 to 20 nose down to 20 nose-up. There is a large cyclic application and there is an apparent time delay in the response of the aircraft that has been noted previously. It's just the aircraft appears initially to respond very slowly to that large change. But then the rate increases steadily until it is taken back out by the pilot.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Objectionable controller force characteristics. None. My feet were on the pedals the whole time trying to correct. I noticed that when you initially dip over there was a slight yaw to the right and at the end it looked like it pitched up slightly to the left.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: In the pitch axis, there was good predictability on being able to, a reasonable predictability on being able to get the initial pitch attitude. I could usually get the 20 degrees nose down plus or minus 2 degrees, but I had to focus on it to make sure that I pulled out in time. But it seemed to be predictable with the control response. There is a little time lag from when you go to nose down back to nose up, you make that big control input, there appears to be just a subtle lag but it didn't seem to be objectionable to the aircraft as you come up, as you are traversing such a large pitch attitude change. When the aircraft is up in the air, predicting the point at which the 20 degrees nose up attitude was more difficult because you are focusing outside for the maneuver, so predictability suffered a little bit in the end portion of the maneuver.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Question 5, predictability of initial aircraft response was good. Towards the end during the decel as you decelerate it requires a large amplitude forward cyclic input in order to bring the nose back down. It's a little bit larger than I would expect to see. And then it requires a turning rapid aft input in order to level the aircraft. But the aircraft levels right away. The aft input is quite predictable. I think it's all (inaudible) predictable is the fact if you decel and you want to lower the nose, you start reducing or you start pushing the stick forward and you don't really get that much response right away. So you end up making a pretty large input.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: Predictability, after you have done it a couple of times you know that you have to be aggressive with the controls and just stand the thing up on the nose. The beginning was really nice, push the nose down 20 degrees quickly so I can get the collective in there, because the collective is what is making the thing accelerate. And then at the far end, as soon as I hear the cuing ground speed 30, 35, somewhere in there, I start the recovery at the other end. And then adjust longitudinally as necessary. To keep the thing from overshooting, knowing that overshoots are not allowed, and then accept whatever the nose up (attitude) is.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Predictability, actually fairly predictable through the whole maneuver as far as my flare and coordination between the flare and collective application.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Question #5, describe the predictability of initial aircraft response. It was interesting, if you lower the nose the aircraft begins to accelerate at a very predictable rate. And then it begins to accelerate at a greater rate than normal. I'm sure it's sling dynamics going there. But it is -- it is slightly less than predictable, because as you make this lowered input you get the normal response and then the sling dynamics add to your acceleration somehow and you increase your speed without having planned to, I guess you would say. So it's less than predictable in the longitudinal axis. And then at the end when you pull in a lot of power at the very end of the decel, you have to pull in quite a bit of torque and then lower the nose. And as you do that you get a tremendous amount of roll oscillating going on there. And like I said, it doesn't tend to translate anywhere, the whole airframe just seems to be shaking pretty good in roll.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: Predictability of initial aircraft response. I could put the nose down to the aircraft at 15 degrees without much problem at all and that was the strategy, put 15 to 18 degrees nose down and then I could set an attitude for the final decelerative attitude, pretty precisely each time to get me without having to do a lot of milking at the end to get in the zone.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: Predictability, push the nose down. I'm not really paying too much attention to the attitude indicator. Just pushing it over where it looks like the right and I can really feel the collective results. And then the -- on the far end, the math now I think is really helping slow down.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Predictability. None noted. Clear prediction, not really causing any PIO or oscillations.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: The predictability is good initially to get the initial pitch down attitude, but to get the right decelerative attitude is fairly unpredictable. It depends on the peak speed and the level of aggressiveness at which the pilot applies. But there is really, unless the speed gets up beyond 35 knots into the 50-knot range, there is really no need for a rapid collective reduction. And if there is a rapid collective reduction, the pilot will not get to the zone. You will have to actually fly to the zone after the initial deceleration.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Predictability of initial aircraft response. It was very predictable and I think that's one of the things that saved it at the end from being too much out of tolerance was the fact that when you pitched the nose up the aircraft did not do anything unusual and you could sort of -- in the amount of time that you were pitched up, you could hold, attempt to hold the headings you had.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: Mid and long-term response problems, I don't think there are any here. I didn't see any that were objectionable.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: No mid or long term response problems that I see at all.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: (See answer #5)

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Mid to long term response problems. Nothing really noticeable there as well.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: No. 6, no mid- to long-term response problems. I didn't see any evidence of any kind of long term response being excited or getting in the way.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: Mid and long-term response problems, I didn't see any. The load dynamics were not dramatic as we settled down with less than two to three degrees of load swing during the maneuver.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: No long term (problems).

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Describe any mid to long term response. And no real problems there. If anything, the aircraft is kind of nice. When I put the initial decel in, once I get the acceleration off (inaudible) kicks in, makes a nicer roll or attitude for the acceleration.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Mid to long-term response problems, there are no real -- none of those.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: (No comments)

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: I actually think there is a tendency to undershoot in this one. Because you put a big pitch attitude change in and on the last maneuver that I did here the speed wasn't as high, I put the same pitch attitude in and it was much more effective, so I had to do a two-step decel to get into the zone. The time was actually shorter but it's because I took some out at the end it didn't have to settle down as much to get stable.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: No objectionable oscillations. No real tendency to overshoot. I felt pretty good about my ability to predict the point that we were going to stop at, even within a few feet I was actually shooting pretty much to the center and it seemed like we were getting pretty near the center most of the time. So I was happy with that. No tendency to overshoot.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: I don't see any objectionable oscillations. You can tell the aircraft has got a lot of momentum and it's hard to stop at the far end.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Objectionable oscillations or tendency to overshoot. Again, I didn't really see anything as far as that goes.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Yeah, I'd say the roll oscillations at the very end, when you have a lot of power, up to -- you are making a pretty large power change from about mid power up to about 100 percent or high 90s, maybe, and you get this tremendous roll oscillation that goes on there. So they are kind of objectionable. It kind of makes you wonder if you are beating the aircraft up or anything. So -- but tendency to overshoot was not there. I was able to make it within the near 20, plus 0 minus 20, I'm usually shooting for about 10 and I think we were getting pretty close to 10, so there is no tendency to overshoot.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: I didn't see any objectionable oscillations and there was a tendency to undershoot more than overshoot by adding a little too much pitch attitude resulted in a little bit, coming up short and then having to ease out the pitch attitude to settle into the zone.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: No objectionable oscillations or tendency to overshoot. Coming out of the -- back into the hover at the far end there is a tendency to be a little low and I think that you have got to make that collective adjustment to stay at altitude, so there is a little tendency to sink at the other end. You get down to about 22 feet.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Objectionable oscillations or tendency to overshoot. The only real oscillations are, like I said, just when I'm trying to stabilize in the hover. And anyway are not as great as in roll. I think the aircraft damps those out, seems to absorb those a little better.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: No objectionable oscillations or tendency to overshoot. But I thought there was a tendency to undershoot with too dramatic of a flare or too large of collective reduction.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Any objectionable oscillations or tendency to overshoot. No. It seemed to accelerate and decelerate fairly promptly and it also seemed to stay along the yellow line along the taxiway well.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

8. Describe any non-linearity of response.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: No nonlinearity of response that I could see.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Any nonlinearity of response? That's a tough one. I don't think that forward cyclic required was a nonlinear thing, I'm not sure what it was, but I wouldn't describe it as nonlinear, I would just describe it as less than predictable. Initially.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: No. 8, it's a pretty linear response.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: No nonlinearity either.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: No. 8, describe any nonlinearity of response. Probably the only nonlinearity is the acceleration, as you first begin to accelerate the aircraft. Like I said, it starts off accelerating at one rate and then it kind of accelerates at a different rate without having put any additional input. It seems to be something from the sling that's causing that. Interestingly you don't see (it) at the end, at the end the deceleration is quite predictable throughout. So the sling doesn't seem to have any effect on the deceleration.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: There was no nonlinearity of response.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: I don't see any nonlinearities, if there is cross control in the cockpit, I really don't notice that, either.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: The nonlinearity of response, no problems there.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Again, between the large pitch attitude change and the aggressiveness increase, there appears to be a relatively non -- somewhat of a nonlinearity in the response of the increasing rate.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: (No comments)

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: The harmony of pitch and roll, there really wasn't a harmony issue with this aircraft. Although I would say that the cuing, the cuing environment for pitch cues versus lateral drift are gone -- don't have any harmony because at the end you have got no left and right drift cues because the nose is so high in the air the field of view is so poor. So there is some lateral drift, primarily for me to the left, which occurs in the tail end of this maneuver.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Any problems with harmony of pitch and roll? There is so few roll inputs here required that you really wouldn't see any harmony problems there. The speed control was good, we were getting speeds that I wanted to. Altitude control is relatively easy. And heading hold, I was using the heading hold function and it seemed to work pretty well there. So, no problems with that.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: I don't see any problems with the harmony. As I did accelerate I noticed that I had to kind of feed it light pedal almost up to 40 knots. The question was should I have done it feet off the pedal. I thought it was aggressive enough of a maneuver that I probably would keep my feet on the pedals.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Question No. 9, problems with harmony of pitch, roll, speed control, height control, I thought it was all pretty well in the window. No significant problems.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: I didn't see any problems with harmony of pitch and roll or anything else, really. The heading hold seems to work pretty well. I flew the maneuver mostly feet off the pedals, so heading hold, is holding it, I'm pretty sure, within 10 degrees.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: The harmony of pitch and roll and speed control and heading and turn coordination, again with this feeling the nose is so high that the left and right drift is, lateral drift is difficult to perceive at all with the pilot. And because of the torque becomes a factor in this particular one, the attention to that is even more distracting. There didn't appear to be a problem, the aircraft seemed to stay on a pretty good track without a lot of lateral drift. So it didn't end up being a factor with the sling load as it was without a load.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: So harmony is looking pretty good on No. 9.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Describe any problems with harmony of pitch and roll, speed control, height control, and with heading turn control. Just a little bit of a problem with speed control. No problems there. I would say height control, there was a tendency to balloon in the flare, so my consideration was to control the flare with not jumping the collective too much, rapidly decelerate enough, and initiating my flare in such a manner that I don't balloon it. Which I was able to stay within about a 20-foot band, but it's definitely a consideration.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Describe any problems in pitch, roll, speed control, height control. With the pitch up of the aircraft there is a tendency for me to drift to the left and so compensation is required, both in terms of workload and pilot compensation to monitor the cones and as the task was learned, sight picture out the chin bubble, the right side picture was discernible. In a less visual cue environment with grass and no cones or runway, that drift would be undiscernible for the pilot.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Problems with pitch and roll and speed control and height control. Nothing once I got the power application input and figured out where I could take it out, the height control became easy to do. Heading control, turn coordination, of course we weren't turning, so it really didn't have an effect. Heading control, with the yellow line down there it was fairly -- it was easy to keep it within the 10 degrees of heading just by tracking the line down. The only part where heading control became difficult was at the end during the pitch up.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: My control strategy was to start the maneuver, go right to 20 knots, add collective to maintain my position and when I got air speed on the airplane I tried to hold it down until we were close to condition. Make a smooth increase to about 20, 25 (degrees) nose up pitch attitude and hold it until I could see how effective the deceleration was going to be and then milk the pitch axis until I got to the end point. It wasn't a lot of activity, but there was -- most of the longitudinal pitch activity occurred in the settle down coming from the high nose up pitch attitude to coming back down to the hover point, there is some multi-axis coupling that goes on that (inaudible) was easily damped and easily taken out within a couple of seconds.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Basically using the center line for the main cue and the end of cones down there and the stop points used and control strategy was mostly in the longitudinal axis, however it did require collective input and initial collective increase to get going and a collective decrease, once you do get going. And it required about a half an inch or so of lateral, left lateral cyclic, every time, to maintain center line which then had to be taken out there towards the end or during the deceleration to prevent a left roll from going on. So there is a little bit of compensation in the lateral axis there.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: Overall strategy, I think I described that. Get the nose down, get the thrust (inaudible) increase to accelerate and kind of cue into the ground speed build and around 35 (knots) start going for the other side.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Demands on the pilot. Describe overall control strategy in performing the task. I had to compensate for my -- the field of view over the dash, glare shield. I tended to lose my four cues for longitude or for lateral displacement, therefore I went through, I changed my cues straight off the nose, maintaining center line, cues just off to the right side, looking at the right side of the taxiway and offsetting for that where I thought I should be. But I changed my task a little bit for that as well. And also just to compensate in the end, I think on my first two maneuvers, I tried to flare early, so I had my nose down and then kind of center almost to a little more forward motion once I got the nose back down. Whereas on the last maneuver I think I saved the flare till the end where I expected to, once I rocked the nose forward I was over my spot. A little different control strategy between the maneuvers, between stopping with a little forward motion, rocking the nose down and then coming to a stop versus stopping at the peak of my flare and then rocking the nose over to a steady still. I didn't notice anything (inaudible) I think the tolerances are wide enough for this, but it's not difficult to fly either way.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Overall control strategy is basically -- requires in addition to the normal inputs, the normal torque inputs that are going to be required when you increase torque, there is also a left lateral cyclic increase or a left lateral cyclic input as you translate forward. Just like there is without the load, there is really no difference there. And then control strategy I think as far as the roll oscillation at the end, they are so rapid that the only control strategy for those is just to hold the roll axis fixed and not try to counter that in any way. You know it's going to dampen out as soon as the power reaches normal hover power.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: The overall control strategy to perform the task, make initial input to get me to 15 to 18 degrees nose down, let the aircraft accelerate and stay in that attitude until we were on condition and then one continuous pull up to decelerative attitude and hold it until we saw what that was going to give us to get in the zone. And then, a gradual decrease in the pitch attitude to ease down the load and ease into the zone. I found that as opposed to without a load case, settling down the nose seemed to be a very slow, methodical decrease in the pitch attitude as opposed to an abrupt nose down once the rate had stopped. And that helped with the load dynamics, because it was a very slow, progressive reduction in pitch attitude.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: No. 10, demands on the pilot. Describe the strategy. I think I did that a little bit. Nose down, use the collective, accelerate, listen to co-pilot, he is calling about 30 when I'm starting to recover the other direction and the ground between us going about 40, I think (inaudible) doppler to follow-up. So the visual cues are fine, I just keep the center line in front of me, I tend to be a little bit to the left side of desired and I think that's because I like to have the line right in front to improve the visual cuing.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Demands on the pilot. Describe overall control strategy in performing the task, cues, scan, et cetera. As we have been talking about, I lose the lateral position once I go into the flare, it just goes below the glare shield. My technique again is to, as without a load, come down to my right chin bubble, I see the right side of the runway, I'll set myself on the side of the runway to maintain my position.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: The overall control strategy was to push the nose down 20 degrees with collective application to get initial acceleration. And to initiate the deceleration upon a call from the co-pilot, achieving the 35 knots, there is a little bit of a lead in to that, actually we were calling about 35 to 40K on the doppler and then the deceleration would begin from there. And then it would be a constant adjustment in deceleration to get the zone. The control strategy also was to monitor, pick up what the correct lines were on the runway and using the cones to make sure that you could monitor lateral drift. That was the only real way to discern lateral drift with the high pitch attitudes.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Overall control strategy in performing the task, cues, we sort of talked about those. It was dipping the nose forward, keeping it straight along the -- the helicopter straight along the axis, pulling in a little bit of collective to start the acceleration and then taking it out and sort of accelerating out to the speed and then at the end of taking a lot of collective out, decreasing the collective, and starting the initial pitch for the decel. The more aggressive you are, of course, the more you are going to have to lower that collective and pitch the nose up to maintain your height.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: Control compensation you had to make to account for deficiencies in the aircraft. I think the control compensation is there is such a poor field of view in the longitudinal axis that you have to really kind of milk the pitch axis to get in the zone and then settle the airplane down on condition because your left with whatever you have laterally to correct for the tail end and that little coupling that comes in at the tail end of the aircraft, so you have to put more control activity in the tail end of this maneuver than in the initial portion of it during the translation.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Any control compensation, I just said. That would be a little bit of lateral compensation going on in the roll axis there as you translate forward to maintain center line.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: Control compensation, just large inputs on the longitudinal. I don't think it's really that bad, because, to account for deficiencies, the deficiency might be field of view and then it's just kind of hold on until you come through, but it's not really a control thing.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: (See answer #10)

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: About the only compensation is the left lateral cyclic required. As far as the longitudinal axis, I suppose there is a little bit of compensation going on during the acceleration because I found myself not putting quite as much forward stick, knowing that the sling dynamics were going to cause it to accelerate more than I planned to. So there is a little bit of compensation in the forward axis in that respect and a little bit in the lateral axis.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: Any control compensation you had to account for deficiencies in the aircraft. The only one is that the decelerative attitude, if there was any lack of predictability it was in the end point in how much deceleration you would get. But getting to your attitude was predictable, but judging how much acceleration or deceleration that gave you was the lack of predictability. So there was gradual easing out of the pitch attitude as you entered the zone.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: Control compensation is not too bad, it's just pushing those over, accelerate, take a little bit of that out, wait till the end, a nice, smooth maneuver aft. A couple of longitudinal changes, probably the most drastic and on a recovery, I don't notice any lateral or close, but overall not too bad.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: As far as control compensation to account for deficiencies of the aircraft. I think that field of view is a problem. My compensation is to use different cues for the flare than I did during the initiation.

**************** Configuration B - Calm *****************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Describe any control compensation you had to make to account for deficiencies in the aircraft. Again, this lateral drift during the deceleration, had to change my visual cues and also feed in right stick to make sure that I could stay on the centerline.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: (No comments)

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm ******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: Normal control technique in order to -- the aircraft behave the way you want it. You really have to focus on the side to get all your cuing if you have any hope of maintaining lateral position and use the chin bubble while the nose is up in the air.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: And 12, any modifications, the same thing. I think that the roll input is about the only modification above what I would expect to have to make (for) that maneuver.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: Modifications. The only modifications that would work would be don't make it so aggressive. But other than that, if that's a mission task, so be it.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Modifications how I would normally fly this aircraft. Either way I think it's applicable technique. It depends on the situation. If I had a tree in front of me, I would want to come to a full stop. Otherwise with almost any emergency, whether it's controls or loss of power or anything like that, I think there was a tendency to track land with a little forward motion. So it's rock the nose over with a little forward motion and settle down to land to abort the take off. I think either way is applicable.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: No. 12, no real modifications, maybe you might consider the two things I just talked about modifications between say no external load and an external load. And not both of those things, but the lateral one was present both times, but the reduction in forward cycling might be a different, a change from normal.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: (No comments)

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: (No comments)

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: And modifications from what I would consider normal ops for flying the aircraft. I know there is a heading tolerance here, so I try to maintain my heading and use offset cues and I really find a tendency, if there was a real aircraft landing, I would probably pop the nose out a little more, sacrifice my heading to be able to maintain of view of where I'm landing and possibly that's because I have the taxiway cues. If I didn't have a taxiway cue and I wanted to just look out in front of me, I'd probably pop the nose out a little bit to the left.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Describe any modifications from what you would consider normal control technique. No real changes to normal control technique, but there is a fairly significant cyclic application that is not normal.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Modifications you had to make to normal. None.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: (No comments)

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Question 13, no comment.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: Comment on things that might have influenced you. I think I mentioned the center line, my task I think was to keep it in front of me instead of in front of the aircraft, so therefore I displaced to the left slightly.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: As far as commenting on anything else that may have influenced me, I think I have added everything there for that.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Nothing additional to add.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: There wasn't anything else that influenced me, again load dynamics did not play a role unless it's 2 to 3 degrees of pitch attitude change or load oscillation.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: And I don't know what else would be influencing is, because the wind is right on nose.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Miscellaneous, nothing really else to add on this one.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Nothing else influenced me.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.)

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: (No comments)

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio. [From the ground-station engineers' notes, the pilot was able to achieve desired performance on all of the data runs. The times to complete the maneuver were 22, 23, and 22 seconds. The pilot commented that: the aircraft tends to drift toward the left on the acceleration and drift toward the right on the deceleration (albeit within desired performance); no sense of lateral drift (mildly unpleasant); and the critical sub phase is final deceleration and loss of visual cues. HQR=3]

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: Cooper-Harper rating scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would say yes. Is it satisfactory without improvement? I would say no. The annoying deficiency in this aircraft is that the visual cues are so poor in the aggressiveness of the deceleration that I have no idea that I'm traversing left or right and I can't account for that drift very well, even in the this good visual environment. So I would give it an HQR 4. Desired performance requires moderate pilot compensation … because you have to work so hard to account for the cuing to maintain it and in the settle down of the aircraft at the end. Those are annoying deficiencies that cause it to be HQR 4.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: No. 14, is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I'm going to say yes. And I'm going to say that it has some mildly unpleasant deficiencies and minimal pilot compensation required for desired performance. It's HQR 3. I would say the mildly unpleasant deficiencies are two things, one the left lateral cyclic required if you (inaudible) speed and 2, the amplitude of the forward cyclic input required to lower the nose. So those were both probably in the category of minimal pilot compensation in order to maintain desired performance. So, HQR 3.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: I met desired on everything, but is it controllable? Yes. Is adequate performance attainable with a tolerable workload? Yes. Is it satisfactory without improvement? Let's talk about the whole thing, centerline maintenance, capturing fore and aft. Okay. Let me think about that. I'd say satisfactory without improvement, it's probably on the negative side. It's between a combination of lack of visual because the horizon disappears in front and then pretty large longitudinal inputs, both to arrest the rate of deceleration and large pitch at the end to get the nose back down. But still that's minor but annoying, and moderate compensation. HQR 4.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Going into the Cooper-Harper. Is it controllable? Yes. Is it adequate performance with a tolerable pilot workload? That's also yes. Is it satisfactory without improvement? I would say yes as far as flying the aircraft. But I will also come back with mildly unpleasant deficiencies. I would have to gripe that the field of view for my lateral position, I had to use the taxi line on the right side to be able to stop. I couldn't use any forward views. So if I had a tree out to the front or something, I've lost it, you know, if I don't have a line to the side of me, I don't have any way to maintain my lateral position. So without those cues, without that taxiway, I may not have been within lateral tolerances. So just the fact that I have to change my scan strategy from forward looking to looking out the right chin bubble to the right side of the windshield, that's somewhat of a compensation, I call that. So I would still call it minimal pilot compensation for desired performance. HQR 3.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: Cooper-Harper scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload ? Yes. Is it satisfactory without improvement? I'm going to say no. And I will say that it has minor but annoying deficiencies. And I don't really -- I'd say HQR 4. But the deficiencies are the oscillations in the roll axis at the very end and you don't really compensate for those. The concept of moderate pilot compensation doesn't apply nearly as much here as the minor but annoying deficiencies. The roll oscillations are pretty annoying at the end with the sudden increases in power down there. And so that's the basis for the HQR 4.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: Cooper-Harper rating scale. I thought it was controllable. I thought adequate performance was attainable with a tolerable pilot workload. Is it satisfactory without improvement? I'd have to say yes. And I would give this an HQR 3. The only thing that I still don't like with this maneuver in this axis is the fact I have no idea of lateral cuing because of the poor field of view so I have a very difficult time judging any lateral drift, although this is less than a clean case.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: Is it controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? We are in the yes category here. So pilot compensation not a factor, or minimum compensation required for desired performance is what we are talking about. I think there is still some work in there and I wouldn't call it negligible. What it is, is probably a combination of visual and longitudinal. There is some work there, I don't know how big they are. So we are going to go with HQR 3, minimum compensation.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: Cooper-Harper scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I'd have to kind of say no. I'd say two workload tasks I was in my desired, but two workload tasks are longitudinal channel, I tried to damp out the oscillations with the load, once it gets that heavy, that(s) too much aggressiveness, it becomes difficult, but moderate compensation and the effect of fore and aft maybe you are looking at two to three overshoots in pitch, maybe three to four, and small longitudinal cyclic inputs to follow those and try to get them damped out. I guess the biggest thing, though, is I feel like the field of view is a problem. Not necessarily the handling qualities, just the fact that I have to switch my field of view and look for different cues because I lose what's out in front of me. So overall, HQR of 4.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: Cooper-Harper rating. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I would say no. Minor but annoying deficiencies, primarily due to the lack of -- inability to observe the lateral drift because of the poor field of view and the visual cue environment. And so I will give it an HQR 4. Desired performance requires moderate pilot compensation. And that's primarily in that the altitude settled down and also countering the lateral drift. So HQR 4.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3: (No audio for this maneuver.) [From the ground-station engineers' notes, the pilot commented that: heading was the loosest part of the maneuver; it looks like an aggressive task, but with continued practice, it can be a smooth maneuver; no particular compensation is required; HQR=3.]

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: Cooper-Harper. Controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? No. Minor but annoying deficiencies. Desired performance requires moderate pilot compensation. HQR 4. That's primarily due to the end result of the pitch at the end that you lose track of your heading. Had we had a yellow line-up in the sky or pole or something like that to pitch on, it would have been a, you know, you would have been much more sure of how you were tracking down there at the end.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.) [From the ground-station engineers' notes, the pilot commented that: he used varying levels of aggressiveness; the maneuver is more a precision maneuver; very predictable; feet on the pedals the whole time; some lateral compensation, although compensation not a factor; deceleration is the critical sub phase - but it's not that difficult. HQR=2]

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm *******************

Pilot B (data runs 194.1-6 - Config. A calm) HQR=3: No audio.

Pilot B (data runs 196.1-5 - Config. A calm) HQR=4: And what is the critical sub phase of the task? I'd say the critical sub phase is with the nose attitude up at the extreme angle and settling down from that nose attitude to level and milking the -- (inaudible) milking the tail end point in the pitch axis while you are trying to use side cues.

**************** Configuration A - Light Winds *************

Pilot A (data runs 187.11-15 - Config. A Lt winds) HQR=3: Probably -- I'm not sure if it was -- I guess it was the decel and the leveling off -- both. It's one continuous maneuver pretty much, and it's the one point where you are looking for the most predictability, I think, trying to stop on a given point within plus or minus ten feet, of course, but still stopping in that area. So it required a pretty large amplitude control input in both collective and cyclic, but that's probably the critical phase. And that's all I have.

Pilot C (data runs 190.9-11 - Config. A Lt winds) HQR=4: No comments.

Pilot D (data runs 192.15-17 - Config. A Lt winds) HQR=3: Critical sub phase of the task, again that's in particular the flare where I lose my forward field of view is the most critical stage. I've got to find some other reference, whether it's in the chin bubble or off to the right side somewhere where I can see that. I'd ask the question, this may go to control strategy, you know, how would a pilot compensate for that? And I want to say that there is probably enough pilots out there that kick the nose out a little bit, compensate heading as they come into the landing zone so that they can see forward and see where they are landing at. I think that would be done on a pilot basis, but to keep the heading in, I would then try and do that. It would just be another form of compensation. And that pretty much does all the questions.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: The critical sub phase is probably the power application at the very end and the roll oscillations, the worry (is) if you are going to pull too much power and if the roll oscillations are ever going to dampen out. So those are probably, the critical sub phase would be the very, very end of the maneuver as you apply forward stick to level the aircraft and have lots of power to bring it to a hover.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: I think the critical sub phase for this task is once the nose gets up in the air and you lose all your visual cues you have a real problem determining drift.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: (No comment)

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: The critical sub phase of the task, handling quality wise it's definitely in the area of putting the nose down out of my flare to stabilize, looking at two to three longitudinal oscillations in load. And going back to that comment on the field of view, it's got to be the phase where I'm initiating the flare, because as soon as I bring the nose up, I'm losing my forward reference and that's where I'm compensating by finding a secondary reference point.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.7-10 - Config. B calm) HQR=4: The critical sub phase of the task to me is the initial deceleration and picking up the appropriate cues to get rid of lateral drift. That concludes my comments on this normal take off departure/abort.

Pilot E (data runs 208.21-23 - Config. B calm) HQR=3:

Pilot F (data runs 209.25-29 - Config. B calm) HQR=4: And that would be the critical subphase, would be that pitch at the end to maintain your heading control. End of comments.

Pilot G (data runs 204.4-7 - Config. B calm) HQR=2: (No tape for this flight.)

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.26-31 - Config. D Lt winds) HQR=4: And question 16, does the load have a significant impact on the assigned HQR? In this case I think it did in the sense that minor oscillations were the main reason for the HQR 4, or the objectionable oscillations, I guess you would say, were the main reason for the HQR 4. If it wasn't for that, it might have been a higher HQR. And that's all I have.

Pilot B (data runs 197.1-3 - Config. D Lt winds) HQR=3: For cases with external load, did the load have a significant impact on the assigned HQR and the answer is no to that question. That concludes my comments.

Pilot C (data runs 190.16-18 - Config. D Lt winds) HRQ=3: And I think the load had a significant impact and the fact that it made it better. The aircraft is more stable, accelerates and decelerates a little quicker. That's it.

Pilot D (data runs 195.27-29 - Config D Lt winds) HQR=4: For cases with external load, did the load have a significant impact on the assigned HQR? There are considerations for pilot demands with a higher gross weight but they are not as much as, not nearly as much as some of the other tasks. And I'm concerned about it, especially as I'm rocking the nose over, capturing a rate of descent after the flare. But at the same time I didn't feel I was (inaudible.) You would get a couple oscillations in load and that feeds back into the aircraft. Again, I feel like the aircraft is damping longitudinally the aircraft absorbs it, those oscillations, a little better. But there is a roll axis where the aircraft tends to swing with the load. And that ends my comments.

LATERAL REPOSITION MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm ******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Question #1, ability to meet desired adequate performance standards. I think the ability is there to meet the desired standards. We met the standard of desired every time except for once on heading. I was flying the maneuver with my feet on the pedals all through the six times. So. I'm going to talk about right and left, is that all right? So I think we were meeting desired, no problem.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194. [From the ground-station engineers' notes, five data runs were performed; the pilot was able to achieve desired performance on the last two data runs. For the first three data runs, adequate performance was obtained longitudinally. For the last three data runs, the times to complete the maneuver were 16, 16, and 16 seconds.]

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: We were able to meet desired performance standards. The first two really was a coordination event. We didn't meet desired performance in the first two iterations, primarily in heading to the right and with aft drift to the left and I think that overall the last two maneuvers I was able to meet desired performance, so I think that it can be attained with the level of aggressiveness that we have prescribed for this maneuver.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194. [From the ground-station engineers' notes, four data runs were performed; the pilot was able to achieve desired performance on the first and third data runs. The desired heading tolerance was not achieved for the second and fourth data runs. The time to complete the maneuver was 17 seconds for all four data runs.]

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: We lumped -- we kind of did both these together and there is a little differences between them but there is a lot of similarities. There is a tendency in the aircraft as you go to the left to drift forward on the stopping and on the right to drift aft. However, it's harder to detect the left, I think mainly because of cuing. It could be a little bit of wind down here that effects one direction over the other. But typically going to the left I can't see the center line, going to the right I can see the center line, so I have to make adjustments fore and aft as I'm going to the right and then shift over to the lateral position cues. Going to the left it's a little bit more of a guess of what's in the center. I've got to kind of look at the width of the runway or the taxiway. (Inaudible) there is wind, 25 knots, requiring about 28 degrees bank angle each time, maybe a little bit more, to get started. And then you have got to learn how close you get before you take it out and be willing to reverse quite a bit of bank angle to stop, that bank angle I'm not sure about. But that's all doable, even though the lateral axis seems to be where all the work is. So the problem is longitudinally staying within tolerance. So I guess that's really where all the work is. [From the ground-station engineers' notes, eight data runs were performed, four to the right and four to the left; the pilot was able to achieve desired performance on all the data runs to the right and only the last data run to the left. The first three data runs to the left were adequate performance in laterally. The times to complete the maneuver were between 14 and 18 seconds.]

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Go to task performance. I'd say heading is the most consistent thing that I hit adequate. And desired on most everything else.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Starting off, task performance. Describe ability to meet desired/adequate. Definitely adequate, primarily in the time to complete. Once in awhile out due to the longitudinal.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: It was quite similar to doing it without the load in the longitudinal axis. It was -- going to the right, fore and aft drift was a lot less predictable and going to the left it was quite predictable so it was kind of surprised that it was so similar. But getting to the questions, describe the ability to meet desired performance. I think we met desired every time except for one time with aft drift and other than that, we had a little bit of getting to the limits and I really felt like it was, the ability to meet desired was there [and] not a problem. The biggest problem, I suppose, was trying to pay attention to fore and aft drift in the rightward translation.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Describe ability to meet desired/adequate performance standards. We could meet desired performance standards, but adequate seemed -- we were always on the borderline of some -- one of the parameters as being adequate. So for this task I'm going to say that we could -- that adequate performance could be attained, but not desired. You are always pushing one, and if you focus in one area, something else goes out the window because of the demands of the task.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: I was talking away and nobody was listening to me. Okay. Yeah, I was saying this is similar to without the load, although maybe the workload is a little higher. And to the left I just can't stop from drifting out of the desired. That time I even went out of adequate, I believe. To the right is not so bad and it's because I can line-up well on the centerline and taxiway. Going to the left it's just put in a lateral stick through 90 degree peripheral vision, kind of guess where the concrete is, I can't afford a glance across the cockpit to see how it's going. The fencing and all that stuff is not very good cues. And then about the time I make the adjustment to capture to the left, we -- then I look forward. So we got maybe adequate to the left and desired to the right; although the workload is up.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio) [From the ground-station engineers' notes, six data runs were performed, three in each directions; the pilot was able to achieve desired performance on all the data runs. The times to complete the maneuver were between 14.5 and 17.5 seconds.]

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio) [From the ground-station engineers' notes, seven data runs were performed, four to the right and three to the left; the pilot was able to achieve desired performance on all the data runs, except for three runs (one right and two left) where the longitudinal drift was into the adequate range. The times to complete the maneuver were between 16 and 18 seconds.]

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Ability to meet desired/adequate performance standards. It seemed fairly easy, not much of a workload to meet desired performance standards. There is a little bit of drift longitudinally as we stabilize at the end of the maneuver and I notice that going to the left it was a little bit more critical on heading control. It seemed like that wanted to drift a little bit. And that could be [because] perhaps we are doing it across cockpit from the right seat out the left window. But overall I would say it's reasonable to reach desired performance standards.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio) [From the ground-station engineers' notes, eight data runs were performed, four in each direction; the pilot was able to achieve desired performance on all of the data runs except for one, in which the flight path stabilization unexpectedly kicked off and the heading went out of tolerance. The times to complete the maneuver were between 15 and 18 seconds.]

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: The aggressiveness, it was a fairly aggressive task, it requires a fairly aggressive lateral type of input. And when you are going to the right it also requires a pretty large amplitude forward cycle that is not there when you are translating to the left. So when you are translating to the right, as you build up your rightward speed, you have to input a constant forward stick and then towards the end take it out during the decel. Whereas translating to the left seems to be relatively (inaudible) I don't feel like I'm making a lot of large inputs there. And longitudinal position is a lot easier to maintain to the left. Aggressiveness, able to be pretty aggressive, able to get well beyond 20 degrees angle of bank, able to hit the airspeed, get pretty high airspeed. So, and still I haven't been overshooting the stop lines or anything like that, so I think the aggressive level was pretty good.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: I think the maneuver is more aggressive than what normal pilots would fly and so the level of aggressiveness, 25 knots, I think I exceeded that. In the precision, I think we were able to get pretty close to the center of the end boxes on each time with -- while still meeting desired standards.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: (See field #1)

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Aggressiveness of the task, I had one or two a little more aggressive than the others, but again I think I was in the minimum for this task of 18 seconds pretty consistently.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Describe aggressiveness/precision with the maneuver. I felt if I tried to push the aggressiveness any more there were torque considerations. And it would have been a different strategy in the maneuver. To try and increase the aggressiveness were mission representative, I would settle for adequate.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: Aggressiveness and precision with which the task is performed, I thought I was being reasonably aggressive, we were getting almost the same bank angles and pretty near the same ground speed without the load. So I think the aggressiveness was okay there. And it did require more torque, of course, and a couple of times we had a lot of torque and the aircraft started to shake a lot and stuff like that but it didn't really cause us to -- we had 113 maximum on the torque, it didn't really cause us to reduce our aggressiveness or anything like that. So not really -- the aircraft didn't slow us down in any way.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Describe aggressiveness of precision. I think the aggressiveness of this task is more than would ever be done with sling load. It's very dynamic and it's, the load, this particular axis, the instability is playing a significant role because of the aggressiveness.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: (See field 1)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Aggressiveness/precision with which the task is performed. You could be fairly aggressive with it. You don't want to go over too much, too big of a bank going left to right. But you can certainly be fairly snappy about it in putting in the bank and getting the acceleration out to the desired lateral rate that you are looking for. It did seem like the maneuver was easier to do if you were more prompt with the -- in achieving your lateral speed. In other words you put in a good bank to get that acceleration going up laterally and then you could sort of take out the bank and sort of cruise with that speed on over to the lateral position.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Question 3 does not apply, I didn't have to reduce the parameters.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: There were no real unacceptable oscillations, but there is some coupling and I will talk about that in a minute.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: (See field 1)

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: As far as sacrificing desired for adequate, (inaudible.) I think (inaudible) my control strategy as far as not using the micro switches and depending on heading hold and if I did that alone, heading was out every time. But if I concentrated too much on the heading, longitudinal fell out. So I let -- longitudinal went out and I let the aircraft try and help me in heading and I'll talk about that in my strategy a little bit more.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: So question 3 is getting into that. Even though I was trying to increase, I pretty much settled that I was going to be in the adequate for time to try and keep from losing either longitudinal or heading or really cause any more problems at the end of the maneuver.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 3 doesn't apply. I didn't decrease the goal.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: There were unacceptable oscillations, due to load dynamics during the return back to level. They don't seem to play a role during the translation except for the initial acceleration. If the load doesn't enter the control inputs very much after the initial acceleration, and after the deceleration is complete and you come back to a hover.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: (See field 1)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Oscillations, the only oscillation that I happened to notice was in the heading at the end of the maneuver. There was a slight tendency going to the left and there was a little bit of oscillation in the heading control. And again I think that was due to the fact that it was being done cross cockpit.

Going to the right it seemed like the heading was very stable at the end. Only going to the left was there any kind of problem. But again we achieved desired going both directions.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Question 4, there was no objectionable controller force characteristics.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Objectionable controller force characteristics. None noted during this.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: Aircraft characteristics, I don't really feel a force problem.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Aircraft characteristics. Objectionable controller force characteristics? No problems there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Aircraft characteristics. Describe any objectionable controller force characteristics. None noted there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 4, no, there were no objectionable controller force characteristics.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Controller force characteristics, not objectionable.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: Objectionable controller, no really controller problems there.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Objectionable controller force characteristics. None.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Question 5, describe predictability of initial aircraft response. The only -- it was all predictable because as I translate to the right, I have to make left pedal, that's pretty predictable. It requires a decrease in collective followed by an increase in collective, that's pretty normal. And the only unpredictable portion was the nose up (inaudible) would be translation to the right. It's pretty easily countered, but still it's -- one doesn't normally expect that.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Predictability of initial aircraft response. I thought that the roll was pretty predictable in getting the 20 degrees angle of bank and setting it there. I didn't have to focus on too much because outside the cuing is pretty good with the dashboard and the disc make it very easy to get those pitch attitude changes because of the external cuing. So the predictability of the response with the control system coupled with the cuing makes this much more predictable to get the appropriate roll attitude.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: No. 5, describe predictability of initial aircraft response. I look at predictability of initial like getting it started is pretty normal, 25, 20, 25 degrees and wait for the copilot to tell me what the speed is, around 15 I think about reversing. Predictability of initial response to stopping, you can learn how to lead that. But you do have to lead it in order to let the aircraft momentum carry it over into the spot. You start to (inaudible) and the time pedal thing.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Predictability of initial aircraft response, again it was very responsive in roll and I could snap to and get my initial roll attitude very comfortably.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Predictability of initial aircraft response. I felt like laterally once in awhile I began the maneuver I was kind of searching to see what it would take to get the initial air speed going. I wouldn't necessarily go right to target bank angle. I was putting in an input, trying to get the lateral motion going. More cross checking than bank angle. So it may be some predictable in getting the longitudinal velocity initiated.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 5, predictability of initial aircraft response, it's quite good. It's quite predictable in terms of -- when I make the lateral input it takes off right away. I know I'm going to need more power initially and it's there. And then during the decel pretty good size lateral inputs and the response is quite -- it's predictable. That's all I can say. The only thing that's not predictable is the amount of fore and aft that's going to occur in the rightward translation.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Predictability of initial aircraft response. The predictability of the initial aircraft response into the initial roll attitude is very good. But as soon as the load swings and the acceleration, you have no idea how far the load is going to -- the aircraft will swing, due to the load dynamics. So predictability is poor at the deceleration end and at the initial end, not in terms of the initial attitude change, but what you are going to get with the load comes after some time delay.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: Predictable? Yes, it's predictable but I don't really like the initial response. When I roll to the right or left you can feel the load get out underneath you and it will take one or two cycles for it to settle down. So with large, aggressive inputs you can tell that the load is not staying perpendicular. And then some lateral changes, an inch or so, in order to compensate for that. Although that's still not -- that seems to be the highest workload. But all that's manageable. What it ends up being is you drift longitudinally again, not so much to the right. And again, from the height, you can't tell that you are off until your error is large.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Predictability of initial aircraft response. It was good. It seemed like it -- with 30 degrees of bank in there, 30 to 45 degrees of bank, it was very snappy and prompt in accelerating out to where you wanted. And controllable out to that desired lateral rate. It didn't seem like it wanted to go too fast across there, but it was a very smooth acceleration out to the desired lateral rate.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: I don't see any mid to long-term response problems going on there.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Mid and long term response problems. I think there is a mid-term response problem here because of coupling. When you settle down at either end, either the right or the left, and I think it's more pronounced when you go to the left than when you go to the right, there is a lot of oscillations in the roll axis that have to be damped out by the pilot and they be partly PIO in the roll axis, but I couldn't really discern that. But there is roll oscillations due to the coupling in the aircraft and it would occur both right and left and more pronounced in the left when you roll from your final deccelerative attitude back to the final hover condition. I didn't notice that same tendency to oscillate on the initial roll in to start the maneuver or the initial roll in to stop the maneuver, but in the settle down to the hover it's much more pronounced. I wouldn't say they were objectionable, but they are noticeable for the pilot.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: No. 6, I don't see a long-term response problem.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Mid to long term response problems. Again, no significant problems there. The aircraft was easy to control in roll to get my sideward velocity going.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Mid to long term response problems, nothing there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 6, no mid to long-term response problems that I see at all.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Any mid or long-term response problems. I think there is a mid-term response problem due to the load dynamics that feeds into the low inertia that's in the roll axis, they feed together and make it very difficult to stabilize during the deceleration.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: (No comments)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Mid to long term response problems. I didn't notice any of those.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: I don't see any objectionable -- question 7, no objectionable oscillations or tendency to overshoot. Actually even at the end when it comes to a rest I don't see any oscillations with the roll. I'm able to bring it to a very steady hover relatively quickly.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: (See field 6)

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: 7, no oscillations. There might be a tendency to overshoot in bank angle, only because of the aggressiveness required, you've got a lot of speed and you've got to stop this aircraft. Once again the big workload, I think, is longitudinal, because you just can't put it together.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Objectionable oscillations or tendency to overshoot. I think again I would say no there. It was very responsive in the roll and the, possibly the -- if I wanted the perfect case when I did my recovery from the lateral movement, I want to do one opposite input and then roll back to wings level. And I think I probably have about two overshoots in there, but small more in the minor, minor category as far as that goes. Overall very predictable in the roll to stop it.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Objectionable oscillations or tendency to overshoot. During the decel the initial decel to determine a point was fine. And I'm getting almost oscillation that if I was dead center when I started my decel, or, you know, targeting a defined, where I'd be oscillating from ten feet right, ten feet left, if I was anywhere in between the oscillations were enough, I think, to drive me outside of my target lateral range for stopping. Definitely some objectionable roll oscillations there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 7, objectionable oscillations? Just the fact that it's just load dynamics, but as we accelerate, the load kind of lags behind then the load kind of overshoots and it causes -- you get two pretty good sized roll oscillations during the course of your translation. So in a sense they are objectionable. I found myself having to compensate for them with roll inputs during the course of the translation, which you don't have to do the roll inputs when you do this thing without the load. So a little bit of compensation going on there. No tendency to overshoot. The stopping points, the end points were pretty predictable. We were able to stop pretty much within the cones every time, so no problems there.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Any objectionable oscillations or tendency to overshoot. Again, the objectionable oscillations are due to load dynamics. Tendency to overshoot, there was never a tendency, I think I overshot one time the zone, but all the rest I could get it stopped in the zone fairly consistently but the load dynamics, settling those down took -- increased the time required to call stable.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: I don't see a tendency to overshoot.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Objectionable oscillations or tendency to overshoot. The only time in fact it probably wasn't a problem of overshoot, I noticed that coming back to the right it seemed like I did overshoot the end target just slightly but once I got leveled out, wings level, we were right on the center line of the end position. So it really wasn't that big of a deal, even though it was a perceived overshoot out to the side, it looked like it was sufficient to get us to stop right in the middle. Going the other direction it seemed like we stopped a little bit short of the road, but ended up pretty much in the middle.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

8. Describe any non-linearity of response.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: No. 8, there is no nonlinearity of response that I see.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Nonlinearity of response, I didn't note any.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: No nonlinearity.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Nonlinearity, no problems there.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Nonlinearity, no tendency there.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: Any nonlinearity of response? Not really. I didn't see any nonlinearity.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Describe any nonlinearity of response. I didn't see any.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: The control appeared linear.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Nonlinearity of response. None.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: No. 9, I don't see any problems with harmony of pitch and roll or speed control. I'm not really using the heading (inaudible) my feet are on the pedals, I'm making pretty consistent pedal inputs. Increasing amplitude with increasing speed and then decreasing it with the opposite pedal.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Problems with harmony of pitch, roll, speed control, height control, I think there is a difference in these two maneuvers in that when I roll to the right I have a big structural bar in my way at 20 degree angle of bank and so I have trouble seeing the line, down the center line of the aircraft without making some head adjustments which causes me to focus to the right, and has made heading control, averted me from heading control on the right. On the left I'm able to see through the co-pilot's chin bubble and see the line very clearly so that additional cuing allows me to take a quick glance over there for fore and aft drift. However, because of that cuing I tended to not focus there and it caused me to drift aft. I noticed the aft drift, there may have been aft drift or forward drift going to the right, but it wasn't as noticeable to me because I didn't have as good a cuing.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: Harmony, at least manipulation of the controls, everything seems to be okay. I didn't mention heading at all. I think as I drift to the left there is like a little bit of right pedal on it to go to the right, a little bit of left, but it's almost intuitive how much to use.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Question 9, problems with harmony of pitch and roll, speed control, hover height and heading turn coordination. The only comment there, I don't think the heading hold is tight enough to hold it through this maneuver. We start weather-vaning into the wind at some point.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Any problems with harmony of pitch, roll, speed, height control, heading hold, I did it by depressing the micro switches so heading hold wasn't a factor. I was in the loop the whole time.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 9, any problems with harmony of pitch and roll, no, no problems there. No problems with speed control or altitude control or heading hold.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Harmony of pitch, roll speed control, height control, the harmony is really in visual cues. There is really not a lot of heading in this task. There is not a lot of heading cues. For you to align up you have a high gain fore and aft, a reasonably good gain fore and aft cue, and you -- but you don't have (inaudible) and you don't have any directional heading cue, so there is a little bit of lag there. So the tolerances, I think, allow for that, but that makes the pilot come in and out of there to find a heading. You have to come into the cockpit to look for those heading changes. Which adds to his workload.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: Harmony is all right. As I go to one direction or another, I have got to feed in a larger pedal than I remember from unloaded, although that's not what really brought me to put in like a one time input. Height control, I got off once, but I attribute that to some pilot error. So the heading is okay.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Problems with pitch and roll, speed control, height control. It looked like the pitch and roll response was good. There was no feed through from roll in making the nose pitch up or down. It stayed exactly where it needed to be. And height control seemed to stay right there. There was no big swoop down, like you would anticipate. That was primarily due to control strategy, which we will talk about in the next one. Heading turn coordination; my feet were on the pedals the whole time and I was finding myself definitely putting in heading corrections to keep the nose perpendicular to the lateral task.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm ******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Demands on the pilot, question 10, overall control strategy, the cues I'm using are the center line is (inaudible) to the right and of course the cone is in front. The control strategy is when I anticipate the need for (inaudible) as we translate to the right, anticipate speed from left pedal input and make those two inputs along with the lateral input. And also I anticipate the need for a reduction and then increase the collective. So the control strategy is relatively complex, it's requiring that I input in both (inaudible) direction and the pedal and the collective in order to maintain desired tolerances.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Describe the overall strategy in performing the task. The strategy both ways was to put in 20 degrees of bank and hold it, trying to hold it until I got on speed and then adjust the decelerative attitude to get to the end point. I didn't have to milk it so much to get to the end point, but there still was some lack of precision, predictability as to where the end point would be based just on applying initial angle of bank at 25 knots.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: Overall strategy is like that, go to the right, get the bank angle going and then glance out, spend a lot of time on the center line, but be ready to switch over to the lateral cue. Going to the left, bank it over, use a little bit bigger or broader dimension like to the left, the taxiway, and in that case I really can't see the drift until we are almost stopped.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Demands on the pilot. Overall control strategy, I think to be able to maintain the heading and look 90 degrees out longitudinally, I felt like I had to sacrifice one. The aircraft doesn't fly straight enough by itself for me not to go out one (inaudible) and I took the heading hold. My strategy was, even though I tried it with heading hold in trying to use the micro switches through the whole turn, I also tried to do it without using the micro switches at all. And I got worse results. So what I went with was my last few runs, I was starting off with my feet off the pedals, about two-thirds, three quarters through the run, once I saw heading start to come off, I come in with the pedals, just a slight motion to light it up, and then do my -- primarily still try to track my longitudinal distance through the recovery. But it was just too difficult to maintain heading, you were in the loop at that point, too difficult to maintain heading within desired. It was more difficult for the cues going left; much more so than the right. But at the same time as I'm moving left, I can kind of keep a central 45 degree point and look out the front, see my heading and look left, see my longitudinal cues. Where going right I have to turn further right to see the longitudinal cues and then turn my head back to the left to see my heading line-up. It was kind of a trade-off. Big head movements either way, I guess. Just a little different strategy for each direction.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Okay. Demands on the pilot: overall control strategy in performing the task. Okay. My feet on the pedals to go ahead and main -- I was using pilot cues to check my longitudinal position. That was probably initially starting off to make sure I was on the right track and then I was concentrating more on some heading cues after that. As far as trying to increase aggressiveness, I really felt that I'm not trying to just do the maneuver, but if I do a lateral reposition, I had to keep the speed under control. I didn't think the aircraft had the excess power to go any further in torque and also just the oscillations, we had about 10 degree oscillations on the load laterally and I just didn't feel I was comfortable pushing it much more than that without possibly breaking the aircraft. And I think that's -- for operationally I wouldn't push it any further than that, and I don't even know if I would push it that far, to tell you the truth.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 10, demands on the pilot. Describe overall control strategy. The overall control strategy is to anticipate the need, just like before without the load, it's just anticipating the need so when I'm going to the right I'm automatically making a forward stick input, probably -- it's a pretty good sized input, it's probably larger than an inch forward for a right lateral translation. And then increasing left pedal increases velocity. A little more input in the way of collective, larger number of inputs. But just because we weigh a lot more.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Describe the overall control strategy to perform the task. Took about a 20 degree angle of bank in, hold it until you are on speed and then -- or (inaudible) till the load swung. That allows you to accelerate as it swung back from your initial acceleration. And then continue on and then make one, smooth pitch attitude change and just try to hold that. But you had to compensate for the load swing under you trying to roll you farther into that turn.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: Demands on the pilot (lost audio).

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Control strategy in performing the task. Cues used, first we used -- for the initial position setup, using the radar altimeter for altitude and using the cut grass swath on the right side and the road on the left side for longitudinal alignment. Lateral alignment was done or -- excuse me. Lateral alignment on those and then the longitudinal was done using the yellow line and the cones down the pathway. The one thing I noticed we had an abundance of cones out there and I'm not sure if they really added to the cue field or not. The yellow line was such a predominant cue out there that that's what I focus on. Until I was getting down to the end and do the quick glances out to the side and then forward to the cut grass swath or the roadway to see how I was doing on that. The helicopter held its position longitudinally along the line fairly well without very many control inputs. The initial response as far as control strategy goes was to put in a lateral movement, put in a little bit of pedal, for example if we are going to the right, put in a little bit of pedal, left pedal, to keep the nose straight to keep it from weather vaning around to the right. And putting in a very tad bit of collective. And the speed picked up and we increased bank, we could put in more collective and more left pedal to keep the nose straight. And then once it was stabilized out, you could almost take out the pedal. But I did find myself keeping in a lot of -- (inaudible) take out some of the pedal. But I did find myself leaving in quite a bit of the pedal as we maneuvered back the other way. On the end maneuver, at the end it was a reversal, roll reversal with decreasing the collective slightly and then pulling it back in to arrest -- to help with the deceleration of the maneuver.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Control compensation, I think the biggest compensation factor is the lower collective that's required, I already discussed it. It's only to the right, it doesn't show up in the left. And it's a pretty large amplitude input.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Control compensation you had to make to account for deficiencies in the aircraft. Again, as you decelerate to the point, there is a milking in the roll axis to get to that final end point. And that compensation is required because of the lack of predictability to get to the end point. There is a lot of longitudinal compensation because of the cuing problems in the fore and aft and the fact that this is a very high workload task, heading and aft drift control requires a significant amount of divided attention for the pilot because of poor cuing in the aircraft, because of field of view consideration in the forward direction, there really is nothing to cue on except for your directional gyro as to your heading position. So there is a lot of adjustments required throughout the maneuver to maintain heading and then roll, fore and longitudinal cyclic to maintain fore and aft position.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: Compensation is longitudinally. Going to the left I know that I have to pull back on the stick and even doing that is most of the time kind of stops itself from going outside of desired.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: And control compensation to account for the deficiencies. I think in heading there is some -- I think the flying motion laterally is just tracking the task. Not a whole lot of compensation there. But for the heading, there is definitely some oscillatory inputs, possibly once every secondary degree, depending on how far the heading gets out.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Describe any control compensation you had to make to account for the deficiencies. And again there I think just backing off on possibly aggressiveness to stay where I felt comfortable torque and load oscillation wise.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: The only control compensation that I would -- the only control input that I would label as compensation would be the forward stick in the right translation. Like I said it was well over an inch and it was required just about every time.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Any compensation I had to make to account for deficiencies in the aircraft. In that second roll correction that you have to make once the load dynamics enter, we were getting about 5 to 10 degree swings consistently, but the movement to the left, the load swings were on the order of 10 degrees, back to the right they were on the order of 5 degrees.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: (no audio)

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Control compensation. Again, the only control compensation was that I was definitely having to use the pedals on the lateral maneuver to keep the nose straight, keeping it from weather vaning.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: No. 12, describe any modifications. I didn't, the only thing I would have to modify, the only thing is -- that I would do differently is increase the collective (inaudible.)

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Any modification you had to make to the normal control technique. The only modifications that I was making to do this maneuver was to set the attitude and then milk it to the end to get the end point. I can't just set it and have good prediction there.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: Modifications, I don't know what to do, any kind of modifications, except maybe decrease the aggressiveness, but you don't want that.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: Modifications from what I consider the normal case. I think in a lot of situations I try to take advantage of heading hold mode, if I was doing kind of lateral translations. So that's applicable to the mission relationship. What may be different is that in a lot of cases I may not be quite so tolerant about 10 degrees of heading through the mid portion of the maneuver, I may want to end up on one spot throughout the maneuver, I may not care if the heading is off a little bit. So if the end point is what I'm concerned about, I may not get in the loop and actually stomp on the pedals. So, you know, I came in the loop to try and meet the desired for the task, but they may not be representative of what I would actually do.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: That answers question 12 as well. (See field 10)

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: And No. 12, modifications, again just the torque stick, no other real modifications to technique.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Describe any modifications you had to make to what you consider normal control technique in order to make the aircraft behave the way you want. Encountering the load dynamics, there was a lot of roll corrections required; almost a pure roll swing.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: To start your deceleration to the spot. That takes two or three iterations or you will probably end up being short each time. But the idea is to start the decel and kind of slide into position with the little lateral correction. But at the same time, correct longitudinally and you are distracted so much grabbing the position that it's difficult to keep a handle on longitudinal and out to the left as you drift forward. So the workload has to be longitudinally.

**************** Configuration B - Calm *****************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Modifications to normal control technique. These would be normal techniques that I would find at this particular aggressiveness level to achieve this lateral rate that I would have to put in the flight controls.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm ******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: No. 13, nothing.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Anything else that influenced you. The field of view laterally made the two right and left very different. The winds are pretty calm today, so I didn't see any significant difference in the two maneuvers, right and left, except for the settling down the final end point.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: The only influence might be that we have got wind on the right. And what do we have, about 10 knots I think it was.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: As far as other comments, I can't talk about anything else there.

**************** Configuration D - Calm *****************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: 13, comment on anything else that influenced you. And no extra (inaudible) talked about it.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: No. 13, nothing else.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: (No comments)

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: We have some wind blowing, but I'm not sure that that's an influence.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: (No comments)

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I'm going to say no. And I will say minor but annoying deficiencies and then desired performance requires moderate pilot compensation. HQR 4. And the reason is, both of those things will fly, I think, the thing is the amount, the amplitude of the forward input requires a (inaudible) there if you counter that nose up pitching as we begin to translate to the right. The left is not really present, so I will go through it one more time. This is for translating to the left. Is it controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? I will say yes this time and I will give it, I will say HQR 3. There are some mildly unpleasant deficiencies that has to do with the fact the heading holds will not hold the heading within 3 degrees, you are required to put your feet on the pedals and make your inputs there. And there is some minimal pilot compensation going on, like I said, increasing pedals and increasing rate, decreasing collective and then increasing again. So there are some factors, input speed required with the controls there.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194. [From the ground-station engineers' notes, the pilot commented that: the maneuver to the left is not as aggressive as to the right - not as much bank angle required; there's pilot compensation required to regulate the coupling; the pilot felt forward of the centerline during the maneuver acceleration and aft upon recovery; and there was a high workload in all axes. HQR=4]

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: Cooper-Harper rating, we will do the right first. Going to right, is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would say yes. Is it satisfactory without improvement? I would say no. Because of that oscillation to roll upright and the significant amount of coupling that goes on there. So I would say HQR 4 because to settle the airplane down to make your desired, I had to settle down, the pilot really needs to stay on, making a smooth decelerative approach and then -- so you can minimize those. Roll compensation. I will say that the smoother you make your roll in and set that attitude and can take some of that roll attitude out as you get to your end point, makes the oscillations significantly less at the tail end. So those are adjustments to pilot workload. So HQR 4 to the right. Going back to the left, I would say that coming to the left, I will give it an HQR 5. Although I did achieve -- actually I'm going to make this a 4.5 rating because I could do desired performance, but there is more workload required to the left to settle the airplane down. There is a lot of aircraft movement, more significant to the left. So I would have to give it a slightly worse rating of 4.5. Because I could meet desired performance but I think there is considerable workload, more workload going to the left than to the right.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194. [From the ground-station engineers' notes, the pilot commented that: the heading is difficult to maintain as there are weak heading cues; there's a roll oscillation that couples with heading during capture at the end of the maneuver; there's a loss of fore/aft cues during the deceleration; poor predictability during deceleration; and the critical sub phase is the deceleration due to the coupling. HQR=5]

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: Let's go to Cooper-Harper. I'm going to give you two ratings, one for the left, one for the right. The left first. Yes, it's controllable. Adequate performance -- yeah, we got adequate performance, the question is: is it tolerable? Let's answer that one yes; let's see where we go. Is it satisfactory without improvement? No. I'm talking about the longitudinal axis. We didn't get desired performance, we got adequate, so we are talking about considerable compensation or extensive compensation. Whether or not it's moderately objectionable or very objectionable but tolerable. Very repeatable. That doesn't describe the longitudinal activity very much, except maybe pull back on the stick and hold it for a while. You have got me between a 5 and 6. So I will call it -- performance requires extensive compensation. I think that's it because I was never able to settle it in. So we will call it a HQR 6. Let's go to the right. On the right we seemed to be able to get into desired all the time. Still some workload longitudinally. So it's satisfactory without improvement. I think the drifting fore and aft is still a lot of the workload. It's probably minor but annoying, we are going to go for moderate on that one. HQR 4. And it's longitudinal positioning toward the end of the maneuver.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: As far as the Cooper-Harper, I'll talk a little bit -- again, going left to right. Let's back up. I should talk about this in my strategy with the cues. Otherwise back to the HQR statement. Is it controllable? Yes. Is adequate performance attainable with tolerable pilot workload? I'd say yes there. Is it satisfactory without improvement? No. Deficiencies warrant improvement. To get the adequate performance -- I'd say there is moderately objectionable deficiencies both directions. The fact of coming up into the loop with the pedals, heading hold isn't good enough, so I think one additional pedal input, possibly followed by smaller inputs for the rest of the maneuver, either one inch input followed by half inch inputs at the rate of one to two every second. So adequate performance requires considerable pilot compensation. HQR 5.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: Cooper-Harper. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would back off and I would say I think the pilot workload is kind of too great to get those adequate tolerances. I think there was major deficiencies and I feel like there was maximum pilot compensation to try and maintain, to try and correct for those oscillations once I was trying to stabilize over the point. Adequate performance is not attainable with maximum tolerable pilot compensation, controllability not in question. HQR 7. Oscillations caused me just about 1 hertz inputs on the roll, wasn't real rapid, maybe a little faster, but significant inputs, half inch to an inch, and it just took a pretty good period for it to settle down. I think in general I called the decel right around, close to 15 seconds or so -- 10, 15 seconds, and it took till the 8 to 9 second range for me to settle down.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: Cooper-Harper scale. Okay. I'll talk about going to the right first. We will say is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload ? I'll say yes. Is it satisfactory without improvement? I will say no. And I will say it's an HQR 4. It has a minor but very annoying deficiency. The tendency to pitch up if you drift right and the requirement for a large amplitude longitudinal cyclic input. And so kind of those statements apply, it's a minor but annoying deficiency and there is some moderate pilot compensation going on there. Primarily in the longitudinal axis. And for sliding to the left, or translating to the left, we will say is it controllable? Yes. Is adequate performance attainable? Yes. Is it satisfactory without improvement? I'd say yes, it is. And I will give it an HQR 3, mildly unpleasant deficiencies, one of those being the tendency for the aircraft to roll, to oscillate in roll axis along the route there and minimal pilot compensation going on, that is just the input that is required to compensate for those rolls, try to keep the aircraft attitude, the roll attitude in the desired setting. So I will give it an HQR 3 for translating to the left.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: Cooper-Harper rating scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I would say no. Moderately objectionable deficiencies in that the roll dynamics don't allow for a real precise corrective maneuvering here for this maneuver because of the introduction of the load swing and the need to dampen out. To get adequate performance doesn't require considerable pilot compensation but it certainly requires, desired requires considerable pilot compensation. Adequate is moderate. So I'm going to give both left and right here a 4.5 rating because of the deficiencies in the airplane. I could get desired occasionally, but only with a real extreme workload. But for adequate performance I didn't have to work that hard to stay in the adequate band. It was probably moderate. Actually, I'm not going to do 4.5, let's just stay with a straight 5 for this one in lateral reposition because of the load swing.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: Let's go to Cooper-Harper to the left. Is it controllable? Yes. Is adequate performance attainable? To the left? This performance I'm talking about is longitudinal maintenance, it's kind of yes/no in there, so the second part of this is with a tolerable workload and it doesn't look like I can tolerate it, because I'm not able to overcome it very easily; if at all. So we will say no in that block, and this is for longitudinal positioning at the end of the lateral translation. But I don't think controllability is in question. So we are looking at HQR 7. And again that's for longitudinal at the end of the maneuver, to the left. Now let's go up to the right. To the right it's controllable. We got adequate performance and I think it made the workload tolerable. Is it satisfactory without improvement? Probably not, there is still workload longitudinally. Although I did get desired and I think the visuals would really help out on this one. So I got desired. I think the workload is worse than moderate, so we are going to go considerable compensation, HQR 5. Moderately objectionable. Even though we got desired, and again that's longitudinal work.

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio) [From the ground-station engineers' notes, the pilot commented that: desired performance achieved on all tries with heading and longitudinal the most difficult axes; aggressiveness is high and precision suffers; during the deceleration, there was fore/aft oscillations and the roll axis is "hunting" - but not objectionable; some mid-term response problems; no objectionable oscillations; no non-linearity; heading hold not usable, heading control was difficult during the deceleration; compensation for fore/aft drift and pedals at the start of the deceleration; needs improvement. HQR=4]

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio) [From the ground-station engineers' notes, the pilot commented that: there was some lateral excursions, two out of three runs [to the right] were desired and one out of three [to the left] were desired; it's an aggressive maneuver; decelerations to the right and left look different; there's a tendency to overdrive the deceleration… might be some lateral oscillations. HQR=3]

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: Using the Cooper-Harper scale. Controllable? Yes. Is adequate performance attainable with tolerable pilot workload? Yes. Is it satisfactory without improvement? Yes. I would give it fair, some mildly unpleasant deficiencies; namely the amount of yaw control that you had to put in there to keep the heading straight. And minimal pilot compensation required for desired performance. HQR 3.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio) [From the ground-station engineers' notes, the pilot commented that: he was able to meet desired heading tolerance with his feet on the pedals, but could not achieve adequate with feet off of the pedals, i.e., heading hold; no oscillations; very predictable roll response; with feet off of the pedals, the heading response is not predictable with some excursions as high as 10-15 degrees; cues not quite as good to the left; quite a bit of control compensation (considerable); and deceleration is the critical sub phase. HQR=5 for both directions.]

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm *******************

Pilot A (data runs 187.1-.10 Left/Right - Config. A calm) HQR=3L, 4R: Question 15 the critical sub phase was probably the deceleration. That's where you found several compensating inputs and you have to take them all out at once, things were happening pretty quick. So in both directions the critical sub phase is the deceleration.

Pilot B (data runs 194.11-15 Left - Config. A calm) HQR=4: No audio Flt #194.

Pilot B (data runs 196.6-11 Left/Right - Config. A calm) HQR=4.5L, 4R: So that concludes my comments for lateral reposition except for the fact the critical sub phase is the settling down from the final decelerative attitude to stabilized hover position. That concludes my comments.

**************** Configuration A - Light Winds *************

Pilot B (data runs 194.7-10 Right - Config. A, Lt winds) HQR=5: No audio Flt #194.

Pilot C (data runs 190.1-8 Left/Right - Config. A - Lt winds) HQR=6L, 4R: The answer is it's mostly a longitudinal problem.

Pilot D (data runs 192.18-23 Left/Right - Config. A - Lt winds) HQR=5L, 5R: The critical sub phase of the task, and I would say it's got to be two-thirds to three quarters through the maneuver where I see my heading going out of tolerances. Once I get enough sideward speed that, and I'd say it's within the 20 to 25 knot range, that my heading starts drifting off. The aircraft starts weather vaning or going off the heading. That's the critical phase where I've got to go with the pedals there and then it continues through the recovery to the hover. And that's about it.

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: And coming back to the critical phase, that hits the nail on the head, it was definitely at the decel portion to stabilize in the hover.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: Question 15, critical sub phase, the whole thing seemed kind of critical with a sling load, but I suppose the power application at the very end of the decel is probably the most critical, it's when I seem to be most aware of what's going on in terms of engine power and heading changes and roll attitude changes, et cetera. So I think that that power change required to bring it to a stable hover, the large power increase is the critical phase of the whole thing.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: The most critical part of the task is again settling down to that stable hover attitude.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: (no comments).

**************** Configuration B - Calm ******************

Pilot B (data runs 206.1-6 Left/Right - Config. B calm) HQR=4L, 4R: (no audio)

Pilot E (data runs 208.14-20 Left/Right - Config. B calm) HQR=3L, 3R: (no audio)

Pilot F (data runs 209.19-24 Left/Right - Config. B calm) HQR=3L, 3R: And the critical sub phase would be the end, termination of the maneuver laterally going to the right. It seemed like it was oscillating around a little bit more and required an increase in attention. End of comments.

Pilot G (data runs 204.8-15 Left/Right - Config. B calm) HQR=5L, 5R: (no audio)

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Calm ******************

Pilot D (data runs 195.21-26 Left/Right - Config. D calm) HQR=7L, 7R: And for cases with external load, yeah, that's it right there. The thing is oscillating. A, increasing towards the power margin of the aircraft (inaudible) higher gross weight, torque considerations for the load, oscillations is the restrictions of this maneuver. That is all.

**************** Configuration D - Light Winds *************

Pilot A (data runs 187.16-25 Left/Right - Config. D Lt winds) HQR=3L, 4R: Question 16, did the external load have a significant impact? No, it didn't. It doesn't seem to have altered the maneuver very much, except for those little roll oscillations in route. I think otherwise the maneuver was very similar to doing it without the external load. So it's, you know, a much increased power setting when you have to pay a little more attention to the power you have a somewhat lower power margin, so it's another factor that you are concerned about, but those are the only differences. And that's all I have.

Pilot B (data runs 197.4-10 Left/Right - Config. D Lt winds) HQR=5L, 5R: And the external load, yes, it did have a significant impact on the ability to get that stable number, which added about three or four seconds to the task to do the final stabilization to where you felt like you had stopped making control inputs and were managing the hover. And that concludes my comments.

Pilot C (data runs 190.12-15 Left/Right - Config. D Lt winds) HQR=7L, 5R: (Left) Does the load have a significant impact on the assigned HQR? I think it might, because you get this little swinging underneath and that is a distraction in the lateral control, I can't devote much time to the longitudinal, so I think there was an influence. (Right) And same comments on the load, I think you can feel the load shifting around and it's a detractor.

SLALOM MTE Pilot Questionnaire

Task Performance

1. Describe ability to meet DESIRED / ADEQUATE performance standards.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Describe ability to meet desired performance standards. They were attainable. Desired performance was attainable.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Describe ability to meet desired performance standards. We were able to meet desired standards throughout the maneuver and the maneuvers were done between 65 and 70 knots throughout the maneuver.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: (No audio on tape for the first two questions.) [From the ground-station engineers' notes, three data runs were performed; the pilot was able to achieve desired performance on the last two data runs. For the first data run, the pilot made it around all the traffic cones, but the speed was below the 60-knot desired airspeed. It should be noted that there was about a 15-knot headwind for this maneuver. The second run was flown with a groundspeed of 50 knots and the third was flown with a groundspeed of 60 knots (75 knots airspeed).]

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: With the exception of -- I guess the runs where I didn't quite meet the course rules, I think I was slow on one of those, based on the last one, I hit desired.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Item 1, we did not meet the desired performance, although we were very close on the last run. I think it's just, that is right at the edge of aggressiveness for this maneuver, carrying a sling load. The aggressiveness becomes extreme after the first two or three turns as you are reaching right to the edge of the bank angle limits of 33. And trying to stay that stabilized with a final gain, results in a load oscillation out to 15 degrees and if we weren't in a 30 degree bank angle restriction the maneuver could be done more aggressively, but given that limit we could only reach performance, adequate performance with this maneuver.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: I think we were in desired mostly all the way through there. All the axes are a bit up on workload. Because of the, I guess the size of everything. If you are not hesitant and you can put all the magnitude inputs in, the thing seems to stay inside of tolerances, even air speed and altitude. You have to be pretty aggressive on it.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: I'll start off with task performance. Ability to meet desired/adequate. Time wise or sorry, speed wise I was falling into the adequate for every time that I was -- three limiting factors are A, trying to maintain the angle of bank, (inaudible.)

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: Desired performance standards could be achieved above 60 knots altitude maintenance and staying outside the cones was, we were right within the tolerance of the cones, it seemed fairly easy to do.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight) [From the ground-station engineers' notes, three data runs were performed on this flight. On data runs 14 and 16, the Flight Path Stabilization (FPS) tripped off. In addition, Pilot G also flew this maneuver in the same aircraft configuration on flight number 204, data runs 16-19; on two of these data runs the aircraft's master caution illuminated. It appeared that the pilot was able to achieve desired performance on all of these data runs.]

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Ability to meet desired/adequate performance standards. It was fairly reasonable to meet desired performance standards.

2. Describe aggressiveness / precision with which task is performed.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: I pushed up the aggressiveness to the 80s and 90 knot point. The 70-knot point was not very aggressive at all with bank angles throughout between 30 and 45 degrees to complete that maneuver.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: We were also -- level of precision, we were able to do it without much -- a high level of aggressiveness could be achieved on this and still meet desired standards, but at the expense of pilot workload.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: (No audio on tape.)

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Aggressiveness/precision, it was an aggressive task but I felt it was very controllable for the aircraft. Stayed within 60 knots and even up to 45 degrees angle of bank if necessary.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: (See field 1)

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: (See field 1)

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Aggressiveness/precision of the task. Again, I felt like I pushed the aggressiveness as much as I could to maintain the 30-degree angle bank. I know we had a few exceedances there, I was, I think I was on the fine edge of that.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: Aggressiveness up to 70, 80 knots seemed to be doable with this task with the same amount of precision as 60, just with a little bit of increase in bank angle.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Aggressiveness/precision. At this air speed you could be fairly aggressive with it without -- with the proper response from the helicopter. And you could be as precise as you could, it's possible with the cues that you had perceived from the ground. It was difficult to perceive cues in turns to the right -- or turns to the left from the right seat. In turns to the right, it was fairly easy to look down and see when you were going around the cone down below. But out the other direction it was a little bit more difficult. But overall at this air speed I'd say you could be fairly aggressive.

3. If trying for DESIRED performance resulted in unacceptable oscillations, did decreasing your goal to ADEQUATE performance alleviate the problem?

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: There were no objectionable oscillations, so 3 doesn't apply.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: There were no unacceptable oscillations.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: There is some oscillations, I don't know if you would call them unacceptable or not. When you reverse the lateral control, the aircraft kind of follows up in maybe a one hertz kind of an oscillation and it may have something to do with the break-out forces that you feel, kind of like a tendency to overcontrol in lateral and the aircraft roll rate, I think is a little slow around trim.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Question No. 3 doesn't really apply because I thought desired was easily attained.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: (See field 1)

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: (See field 1)

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: If trying for adequate performance alleviated the problem. I guess so. In order to maintain my aircraft limits, 30 degrees angle of bank, I ended up going a little less aggressive, a little slower through the course. That wasn't a result of oscillations, it was just due to the aircraft, 30 degrees angle of bank.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: If trying for desired performance -- there were no unacceptable oscillations.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Desired performance did not result in any unacceptable oscillations.

Aircraft Characteristics

4. Describe any objectionable controller force characteristics.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: No objectionable force characteristics.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: The only objectionable controller force characteristic that exists here is that there seems to be again like these large amplitude movements because there is such a lot of amplitude there appears to be a time delay, a small time delay in making the large input between when you get some initial acceleration, but it just seems to be a little lag because of the large amplitude inputs you are putting in the cyclic.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: If there was any forces, it was -- no objectionable forces.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Aircraft characteristics, objectionable controller force characteristics. Maybe it's the air speed, maybe it's the, just the turn coordination of this aircraft, I tried to fly it both with my feet off the pedals, depended on the turn coordination and go with it, with my feet on the pedals and the indicated air speed was well above 60 knots every time so I wasn't in a transition area, it was just 60 knots ground speed. It was kind of sloppy with turn coordination so I came in the loop and used my pedals and I think that felt a lot more comfortable.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Describe objectionable controller force characteristics, there were none. During this one there doesn't appear to be as much cyclic swings, so you don't notice the little, what I noticed during the clean configuration is this somewhat lag or something between your input and your maximum roll rate.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Objectionable controller forces, I don't really feel that. In fact in this one you can feel the opposition on the pedal, I think that's good. The pedal is a little heavier than the cyclic but you need to put a lot of big pedal in there and that keeps you from overdoing it.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: No. 4, describe objectionable controller force characteristics. None noted there at all.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: No objectionable controller force characteristics.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Objectionable controller force characteristics. The only time I felt an objectionable force, controller force characteristic was one time I was usually flying it by putting pressure on the yaw pedals without depressing the switches or attempting not to depress the switches. And one time I must have caught one of the switches because I gave way on heading and we had a tendency to wander through, very abruptly, through one of the terms. So that was perhaps just a little bit disconcerting. Perhaps the maneuver should be done with the pedals depressed all the time, and that way you could control it maybe a little bit more. However, you would be working the pedals all the time. Whereas if you just ride on the dog ears, then you can at least use the force that was -- the forces in the system to bring you back to sort of a straight and level flight. Use a little bit more of the turn coordination involved with it. The only thing you are using the pedals for is just a little bit of fine adjustment in your turns, getting it around the turns.

5. Describe predictability of initial aircraft response.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: The predictability is good after you have done it a while, probably a lot of pilots don't do this maneuver, but once you get a feel for how the airplane rolls, I thought it was predictable to get the cones, that's why I pushed up the level of aggressiveness. Predictability of the initial aircraft response, I think the aircraft is predictable to go right into roll rates with one stick input, not multiple stick inputs.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Predictability of initial aircraft response. It was pretty good because I was able to just put in one input, I didn't have to milk it to get around the cones. There were times where I misjudged getting into -- there was a predictability getting the roll attitude, or putting in too much or too little, it was more a judgment as to getting in the cone and when I need to lead my input with a large amplitude excursion. So I think predictability is pretty good at getting the roll attitude. Once you learn this maneuver, you are able to get there repeatedly.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: You can kind of predict, accept a little wallowing in roll.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Predictability, I thought it was a very responsive aircraft, at the same time very predictable in the movements.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: The predictability of initial aircraft response was good for the initial response but then the load would come in and give you 5 or 10 degrees on a secondary roll that you would have to take out, which increased the pilot workload.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Predictability of initial aircraft response, I guess each reversal is sort of an initial and you know the load is going to swing around. Everything seemed pretty normal. Nose down, aircraft accelerates rapidly.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Predictability of initial aircraft response. Nothing to speak of there as well.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: At this speed there didn't appear to be a roll lag similar to what it did at faster speeds. The roll lag wasn't apparent because of the control changes. The response seemed to be predictable and there seemed to be appropriate acceleration with stick displacement, the appropriate control sensitivity.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Predictability of aircraft response. It was fairly predictable.

6. Describe any mid- to long-term response problems.

**************** Configuration A - Calm ******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Mid to long-term response problems, none.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Mid and long term response, not applicable.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: I guess I'm not really sure what mid and long-term responses are. There is really no follow-up.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Mid to long-term response problems. The only long-term response I see, would be the long-term in the turn coordination, if I took my feet off the pedals, it was just going to keep up the aggressiveness of the maneuver.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Mid and long-term response, I think there is a mid-term response problem in that during the maneuver you don't really have to worry about load dynamics as you enter each turn, but the final turn where you stable out to level, the load dynamics are excited pretty dramatically and even after we passed in the final gate it took two or three load swings with a little collective application and a solid turn we could damp it out fairly easily, but if you were spotting straight and level flight, you had to do something to get rid of that load swing and take a little while for it to dampen out, so I think that's a mid-term response problem.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Mid to long term response problem, there might be a little bit of oscillation going as you make the reversal from one side to the other. You can feel the load swinging underneath and that kind of distracts a little bit from maneuvering the aircraft. There is a little biomechanical feedback. The aircraft gets jostled sideways with the external load and then that feeds back up into the pilot.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Any mid to long-term response problems. Again, nothing objectionable in that category.

**************** Configuration B - Calm *****************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: Mid to long-term response problems, there weren't any.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: No mid to long-term response [problems].

7. Describe any objectionable oscillations or tendency to overshoot.

**************** Configuration A - Calm ******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Objectionable oscillations, none. Tendency to overshoot, none. I would say that coming through one of the cones, the only place that there is a tendency to overshoot is when your initial speed comes on if you bleed too much speed, if you accelerate too much through the first couple of cones, your tendency is to overshoot the next cones because now your predictability of what you need for roll is diminished.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Objectionable oscillations or tendency to overshoot. Not applicable.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: No. 7, objectionable oscillations, I just described that in roll. When you go for a reversal, it's easy to kind of over drive it a little bit and you get one or two overshoots in roll each time.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Objectionable oscillations or tendency to overshoot. No, I wouldn't say -- there was once or twice where I tried to cut the corner a little too short and I tried to take the turn out and I also had to do a quick pilot oscillation to go back outside the cone. But that was more pilot, I don't know, misuse of the task, maybe. But the aircraft overall I think repeatedly was not objectionable in those categories.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Describe any objectionable oscillations or tendency to overshoot. There wasn't really a tendency to overshoot, there is actually a tendency to undershoot. Because you are trying to anticipate the load swing and the roll in and as you would roll, you would think you would have the cone, the load would swing out, you would get a little more bank angle in roll right over the top of the cone.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: (See field 6)

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Objectionable oscillations or tendency to overshoot. I don't really notice many, I know at the top of the load I noticed some tendencies if I wasn't going to (inaudible) roll maneuvers, movements, because I was going to go outside or overshoot the cones, there were some oscillations, but no -- (inaudible.)

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: There is somewhat of a tendency to overshoot during the first or second cone. And if you do that it's tough to make the end point. But I didn't see that as being objectionable or a problem.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: No objectionable oscillations or tendency to overshoot.

8. Describe any non-linearity of response.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Describe any nonlinearity of response, I didn't notice any.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Describe any nonlinearity of response. I didn't feel that there was any nonlinearity.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: Everything seemed pretty linear.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Nonlinearity, I don't see any problems there.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Describe any nonlinearity of response, I didn't think there was any.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: The aircraft is pretty nonlinear. I might back up to No. 7 or No. 6. (See field 6)

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Nonlinearity of response, negative.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: No nonlinearity of response.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: No nonlinearity of response.

9. Describe any problems with harmony of pitch and roll, speed control, with height control, and with heading hold/turn coordination.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Harmony of pitch, roll, speed control. To me in this maneuver the harmony is fine between longitudinal and roll. To me this is almost a purely roll and pedal maneuver.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Describe any problems with harmony of pitch and roll, speed control and height control. I felt as though the speed control could be maintained but pitch attitude, was again weak in terms of cuing. So keeping right on air speed in terms of cuing was more difficult, but the variation was only 5 knots, so I don't say it was objectionable. As far as being able to keep the ball on the center, if you start the maneuver and the ball centered trim flight, I think you are getting excursions of about a half a ball as part of the turns, but I didn't have to snake the aircraft through the turns in order to achieve desired performance.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: And No. 9, everything was harmonious if you were willing to put in some rudder pedal and paying a little bit more attention to it, I think I started leaning with pedal before I get much cyclic in there to kind of get the tail thrown around. One time I felt like I was flying sideways a little bit, but I couldn't confirm that, anyway. But anyhow, the pedal gets the aircraft pointed in the direction you want and the roll really helps out. There is a little bit of pause in wings level before you start your next reversal, so there is a little ride time before you have to reverse. The timing seems pretty good and I just have to lead the turn so I don't overshoot the side of the runway.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Control harmony, speed control, it was fairly predictable and easy to maintain through all those. Altitude control, I know it's not a precise task for altitude, but I was trying to maintain altitude. That may be a question, but I guess it's not part of this concern. And I've already talked about turn coordination, I think.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Harmony of pitch, roll, speed control, height control. Again I did this maneuver without snaking the nose through, trying to maintain close to ball center trim plus or minus a half a ball. I think that's doable up to about the 50, 55 knots, and actually if I tried to snake it around you introduce load dynamics that aren't present when you don't do that.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Back on to 9. I think everything is harmonious. All the controls feel good.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Question 9, describe any problems with harmony of pitch and roll, speed control, height control and heading hold. (Inaudible) category of speed control. I'm going through the bank angles, turning in this thing, pulling into the turn, a little aft cyclic to bring the turn around to get that air speed there, I guess pretty much compensate for that. Get my turn in and then a little forward cyclic and increase collective to get my air speed up.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: I think the harmony between pitch and roll was fine. The thing that you have to monitor is when this bank angles starts getting up beyond 40 degrees, there is a tendency to descend during the turn that the cuing doesn't give you a good perception of.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Harmony of pitch and roll was good. Speed control, it seemed to stay fairly much right on speed. Height control seemed fairly reasonable to do and turn coordination with the exception of a little bit of maneuver, fine corrections that you would have in it, seemed to be good.

Demands on the Pilot

10. Describe overall control strategy in performing the task (cues used, scan, etc.).

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Overall control strategy, it's really the roll in the maneuver and snake with the tail to get through the maneuver if I need the nose pointing through. I didn't feel like I had to snake the nose all that much, I was fairly coordinated, maybe plus or minus a half a ball with the trim roll through the maneuver.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Overall control strategy was to get on speed and stabilize prior to entry, then make a smooth entry in a ball centered trim condition and then just smoothly move through the turns. Fix the pedals and trying to maintain that ball of center condition, but I didn't focus on it, I stayed outside and fixed the pedals. Collective applications weren't significant to maintain altitude, but there were times when the bank angle got increased, I felt I needed to increase collective and when collective was introduced, it seemed to me that's where we got more significant air speed variations.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: So No. 10, I guess I kind of described that a little bit. Knowing how the aircraft is going to respond you start ahead of time when you are a few feet off, maybe 50 feet off of the point and start leaning into to make a nice curve around the marker. Each time I looked down at least turning to the right to make sure the marker was outside of me, so staying outside of the tolerances.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Demands on the pilot. The control strategy I talked about, using the turn coordination or no turn coordination. Altitude, I kind of let -- I tried to hit the (inaudible.) And didn't climb too much, but otherwise I went back and I dropped off. But I was just trying to hit the cones. Trying to make it more of an aggressive maneuver early on so when I got to the cone I was already, already outside before I got there and almost started turning inbounds as I was at the cone. And I think that helped a little bit. Otherwise -- also I was trying to stay about 65 knots because I know the tendency was for some of the turns to slow up and I felt the need as I went around each of the corners to actually pull a little collective, to keep myself, keep my momentum up through the turn as I pulled. Otherwise I would have slowed down, I think.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Describe the overall control strategy in performing the task. Smooth control movements to enter each turn and then as the load came in, to take it out with cyclic as you entered the turn to try to improve the quality of the turn and not roll in early.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Overall control strategy is to get the nose pointed over to the side of the runway and use a lot of pedal. A lot of pedal. It's almost straighten out the leg. I'm a little concerned about the angle off to the center line and the aggressiveness required to reverse the opposite direction, but everything seems to work out. You kind of lead the turn around the cone, and put in a lot of pedal and the aircraft will stay between the side of the runway and the cones pretty nicely, just oscillates back and forth. It's all pretty well timed, it requires a pretty high degree of coordination between all axes. That's probably what makes it tough.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Overall control strategy in performing the task. I started out a little slower, down around the 40 knots target range, flew the course around 50 knots to maintain that. Like I said the 55 knots I was on the edge of 30 degrees, sometimes exceeding the angle of bank of 30 degrees and then definitely I flew it one time through above 60 knots and had excursions on probably two to three of the cones, exceeding 30 degrees angle of bank. So I tried to back off in air speed to be able to maintain the angle of bank, just took it around the cones.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: It's get a good stabilized speed at entry and then make the first good turn, the rest usually settled out from there.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Overall control strategy. It was basically coming in through the first gate straight and level and making the turn off of approximately 30 degrees to the left and then an abrupt, almost 90 degree turn back to the right after passing over the cone, or passing the sides of the cone. And getting the bank angle up there sufficiently and using a little bit of collective to pull yourself around. And completion of the turn, getting the collective out of there, out of -- reduced and then coming back in to the left and again pulling in a little bit of collective to pull you around the turn. So that was basically the control technique throughout. Cues, there was no vertical cue for height control, only the radar altimeter, but at this air speed height control didn't seem to be that big a problem. And the duration of the maneuver was short enough that it didn't seem like altitude varied that much outside of the desired parameters.

11. Describe any control compensation you had to make you to account for deficiencies in the aircraft.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Describe any control compensation you had to make to account for deficiencies in the airplane. Really none. But air speed control and monitoring air speed throughout this maneuver is difficult, especially when you are going, putting sideslip on the airplane.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Control compensation you had to make to account for deficiencies in the aircraft. The only one I would say is that there was kind of focusing on air speed and getting call outs from the co-pilot made a big difference on maintaining real tight altitude and coming inside. But I didn't feel as though I had to spend a lot of time outside, I could see the cone, I could make my input, just monitor and then move on to the next cone. I didn't have to spend a lot of time doing this.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: Control compensation to account for deficiencies. I'm not really compensating for the roll oscillation or I really can't tell what I'm doing, whatever it takes to get the bank angle I want. And then the other compensation is the amount of pedal required to help get the nose to turn. I don't find those too objectionable, but they are control compensations.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Control compensation to account for deficiencies, just I came in with the pedals (inaudible) but it was pretty well predictable in the pedal inputs I made, I wasn't making any oscillatory inputs.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: So that was the control compensation to account for deficiencies in the load dynamics.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: (See field 10)

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Describe any control compensation. Nothing really to account for there. I did probably hold back some on control inputs. A tendency -- I felt like my -- a wall that I was trying to avoid (inaudible) or bank, even though I ended up going over, that was my limiting factor, what was in the back of my mind.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: Describe any control compensation you had to make to account for deficiencies in the aircraft. I didn't have to make a lot, there is no pedal application, I just maintained pedal position. There is no need to snake the aircraft through. There was -- the response tended to be one input to the roll, then one input back to level and then very symmetric kinds of inputs left and right. No real pedal applications, but altitude maintenance required the pilot, because the cuing is poor at that altitude, get back inside and monitor ran out. So there were a little bit of compensation in terms of workload of the pilot due in terms of altitude maintenance.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Control compensation you had to make for any deficiency. None.

12. Describe any modifications you had to make to what you would consider "normal" control technique in order to make the aircraft behave the way you wanted.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Describe any modifications you had to make from the normal control technique. None.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: Describe any modifications you would make from normal control technique. The only control technique I would say is that during the high bank angles, collective was required to stay on speed and keep the altitude within tolerance. But the 100-foot [limit] never came into play.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: Any modification would be to try to tame down the pedal requirement.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Modifications were normal. I think it's -- it was normal, if I was flying for any flight I would be on the pedals if need be to fly aggressive maneuvering versus depending on turn coordination, so I thought that was fairly applicable.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Describe any modifications you had to make to normal control technique in order for the aircraft to behave the way you wanted. Really it's just countering the load oscillations and then after the maneuver was over, making the turn to damp out the load swing.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Modifications I had to make, the modifications that I consider normal are all the pedal activity. Big pedal activity.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Modifications to how I'd normally control this is try not to make such sharp turns if I was doing this for real, because I'm always trying to maintain 30 degrees angle of bank.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: Describe any modifications you had to make to what you would consider normal control technique. I described the altitude. Altitude workload required a monitor ran out for collective application.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Modifications, none.

MISC.

13. Please comment on anything else that may have influenced you.

**************** Configuration A - Calm *******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Nothing else influenced me. Initially there when we started that last maneuver a little bit high, and then we came down to the altitude, I think we finished it a little bit low, right around the 50 foot point.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: The only thing I would say also is that the other cuing, because we are doing this at 70 feet, the other cuing in terms of air speed and precision is not there, but it's not really necessary for this maneuver, either.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: On No. 13, any other influence, it might be what we described the wind makes the ground speed look a little different. But I think we adjusted for that adequately. And I think it was a good eval.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Miscellaneous, not really anything else to describe there.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: There is nothing else that influenced me. I thought the maneuver was adequate and I think all the altitude and -- altitude tolerances and everything were fine. I didn't find a lot of collective application except when the load swinged dramatically, I tended to apply collective to try to damp that load swing suddenly.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: And on No. 13, we may have some influence of the wind. In fact I've got to compensate for the wind velocity to get the ground speed. And something goes on the air speed indicator, I'm showing sometimes 80 knots or so (inaudible.) So I have to pick up mostly a visual cue of the ground speed.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: No other really influences.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: (No comments)

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: (No comments)

Assign HANDLING QUALITIES RATING for overall task.

14. Using the Cooper-Harper rating scale, please highlight your decision-making process and adjectives that are best suited in the context of the task. If assigned HQR is Level 2, briefly summarize any deficiencies that make this configuration unsuitable for normal accomplishment of this task, i.e., justify why the procuring activity should reject this configuration as a means to accomplish this task.

**************** Configuration A - Calm ******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: Using the Cooper-Harper rating scale to give this a rating. It is controllable. It's adequate -- adequate performance was attainable with a tolerable pilot workload. Is it satisfactory without improvement? I would say yes. Minimal pilot compensation? I don't know if you can say minimal pilot compensation for this one because of the aggressiveness of the maneuver, but given this maneuver, I didn't feel like I could just make the pure roll inputs either, I didn't have to be in the loop all that much to get involved. So I'd say minimal pilot compensation was required to meet desired performance.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: In terms of the Cooper-Harper rating scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? I would say yes. Is it satisfactory without improvement? At this air speed I would say yes. And I would say that although the control inputs are large, that there is minimal pilot compensation to make it around the cones. I've got to make the turns, but that's part of the task, but I didn't feel like I had to do a lot of milking in any particular axis that really worked me hard to get in there. And I'd say that pilot compensation, minimal pilot compensation was required to do this. I could roll into the maneuvers and make one input and then get around the turn. Maybe one or two inputs every two to three seconds through the turn between pedals and roll. So I will give it HQR 3 at 60 knots.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: The whole slalom was controllable. And I think we got adequate performance. And the workload was tolerable. Is it satisfactory without improvement? I got desired performance, but I think I'm going to say no. There is a minor but annoying -- and that would be the amount of rudder pedal required or pedal required. Not that it's a little bit -- it's (inaudible) to help get the heading and turning while you are rolling the aircraft. So I think it's better than moderately objectionable. So it's minor but annoying, moderate compensation. So that's HQR 4. And then for pedal activity, to get the aircraft changing heading.

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Handling quality ratings. Go to Cooper-Harper. Controllable? Yes. Is it adequate performance with tolerable pilot workload? Yes. Is it satisfactory without improvement? I would say yes there. And then I would also come back and say some mildly unpleasant deficiencies, the fact that I did have to go on my feet. Very minor but minimal pilot compensation required for desired performance. Turn coordination was an automatic feature, I actually had to do it. I said minor pedal inputs, you know one input to help the aircraft around the turn is all I'm talking about, very minor, but HQR 3 nonetheless.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Cooper-Harper rating. I know it's controllable. Adequate performance was attainable with a tolerable pilot workload. Yes. But I would say that adequate performance requires considerable pilot compensation. I don't know whether it's that, I don't think there is considerable, but it does have moderately objectionable deficiencies in that the load dynamics rolls you into the turn unpredictably, depending on how much load swing you have. Which prevents you from getting to higher speeds. And the 30-degree angle of bank limitation that the sling load imposes, it prohibits the true maneuvering capability of the aircraft to be used throughout the turns. HQR 5.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: Is it controllable? Yes, overall it's controllable. Is adequate performance attainable and is the workload tolerable? I don't think it's satisfactory without improvement because of the workload associated all axes, primarily in pedal and the three to four inches it feels like that's required and the fairly large lateral cyclic changes to get the aircraft moving over to the side. Although it's all desired. So I'm going to probably say moderately objectionable because of magnitude of the input and that's considerable compensation, which is HQR 5.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Going to the Cooper-Harper. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Workload really isn't a question there, controllability. Is it satisfactory without improvement? I'd say no. In order to get the 30 degrees tolerance, you could not complete the maneuver in the desired aggressiveness and not exceed aircraft limitations. I'd have to say it's in the moderately objectionable deficiencies. Adequate performance requires considerable pilot compensation. This is kind of a tough one. I don't feel like you can stay in -- you are going to limit (inaudible) to 30 degrees, if I don't want to exceed that, then I can't get the 60 knots. It's not so much that there is pilot compensation as far as the control handling qualities, it's just very difficult to fly within the parameter without exceeding the one flying quality -- air speed range, that requires in addition to the roll to go through the turns, I'm also requiring a forward longitudinal cyclic along with increased collective to maintain my air speed. Otherwise during the turn tends to bleed off air speed. So myself, I would say that's moderate pilot compensation. And HQR of 4. However, without -- because I don't have desired performance, I'm going to fall back into HQR 5 category. And that's where it stands.

**************** Configuration B - Calm *****************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: Using the Cooper-Harper rating scale. Is it controllable? Yes. Is adequate performance attainable with a tolerable pilot workload? Yes. Is it satisfactory without improvement? I would say yes. The mildly unpleasant deficiency is the poor altitude cuing and I would say even though you have to make gross inputs, I think minimal pilot compensation beyond the direct input is required to do this task. So I give this HQR 3 for this task.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight) [From the ground-station engineers' notes, the pilot was able to achieve desired performance on all of the data runs. HQR=4]

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: Cooper-Harper rating. Controllable? Yes. Adequate performance? Yes. Satisfactory without improvement? Yes. Fair, some mildly unpleasant deficiencies, minimum pilot compensation required for desired performance. An HQR 3. And that's primarily a little bit of yaw control that's required, because the turn coordination doesn't seem to keep up in making the turn tight enough.

15. What was the critical sub-phase of the task (e.g., entry, steady-state, exit) or major determining factor in the overall Handling Quality Rating (HQR).

**************** Configuration A - Calm ******************

Pilot B (data runs 193.31-33 - Config. A calm) HQR=3: The critical sub phase for this task, for me I think is how you maneuver in the first two cones determines whether you get through the rest of the course or not, when you are on speed, because as speed bleeds it plays a role in the course.

Pilot B (data runs 196.12-16 - Config. A calm) HQR=3: And what was the critical sub phase of the task? I think the critical sub phase for the task is rolling out on position for the next turn. If you go wide or you come in, you can actually end up making this task very hard. But I think that the predictability was good enough that you could come in tight to the cones to make it a minimal workload task. That concludes my comments.

**************** Configuration A - Light Winds *************

Pilot C (data runs 188.26-28 - Config. A Lt winds) HQR=4: (No comments)

Pilot D (data runs 192.24-27 - Config. A Lt winds) HQR=3: Critical sub phase of the task had to be the turn reversal, going outside the cone, the whole process of turning to get back inside the other cone was where the highest workload is. But it's in lateral, pulling collective, keep my momentum up and then added a little pedal to kind of lead the turn into that. And that does it.

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: The most critical sub phase of the task, I actually think is the final push of the maneuver to get through that final gate and judging the load dynamics to keep you inside that final gate. Certainly the turns are critical in terms of damping the load but I think the critical one is keeping that load in the envelope 15 degrees.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: (No comments)

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: And critical phase is definitely rounding the cones. Roll reversal to go around each cone is where the problems exist.

**************** Configuration B - Calm ******************

Pilot B (data runs 207.13-15 - Config. B calm) HQR=3: I think the critical sub phase is making the first turn. After that everything seems to hold out.

Pilot G (data runs 205.14-16 - Config. B calm) HQR=4: (No tape for this flight)

**************** Configuration B - Light Winds *************

Pilot F (data runs 209.37-39 - Config. B Lt winds) HQR=3: And the critical sub phase of the task would probably be the third, I think it's the second right-hand turn or the third turn. It seems like there is a gradual build up as you go through the turn, how rapid your control inputs have to be. And by that point it seems like they are all coming together at once. So that makes it a little bit tighter there at the end. Had you continued the course on out, I think you would have seen it progressively built up into another point where it might have, you know, it might get more and more difficult to do. I have seen this in other vehicles like this Cobra where you have a real long path slalom, there is sort of a cumulative effect that the control inputs have. End of comments.

16. For cases with external load, did the load have a significant impact on the assigned HQR?

**************** Configuration D - Light Winds *************

Pilot B (data runs 197.11-14 - Config. D Lt winds) HQR=5: Was the load a factor? Per all my previous comments, I think it was. It played a role in the HQR rating. It is the dominant factor, the load and the load limitation imposed at 30 degree angle of bank makes this maneuver, desired performance unattainable with the aircraft. That concludes my comments.

Pilot C (data runs 190.19-22 - Config. D Lt winds) HQR=5: And the load has a significant impact on the assigned HQR and that's because of the -- you can feel the weight shifting back and forth and you have to compensate for that all the time. That should be it.

Pilot D (data runs 195.30-33 - Config. D Lt winds) HQR=5: Last, for cases with external load, the angle of bank limit with external load, (inaudible) itself was causing the problems. Not exceeding -- highest deviations on the weight is 5 degrees roll relative to the aircraft, so I'm not, you know going to the 30 degrees as far as that goes, but the 30 degrees bank limit is where I'm caught up. That's it.