

**AIR FORCE ACADEMY GLIDER SPIN
RECOVERY VALIDATION AND CROSSWIND
OPERATION INVESTIGATION**

(PROJECT ZEUS)

JACK D. FISCHER
Captain, USAF
Project Manager

KEVIN J. ROETHE
Major, USAF
Project Pilot

CORNELIS G. VISSER
Captain, RNLA
Project Pilot

JOSHUA A. LANE
Captain, USAF
Flight Test Weapon System Officer

CHAD M. MORGAN
Captain, USAF
Flight Test Engineer

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**AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE**

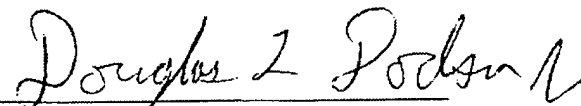
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Prepared by:

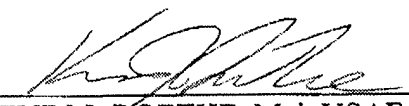
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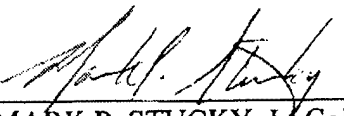
JACK D. FISCHER, Capt, USAF
Project Manager




DOUGLAS L. DODSON JR., Lt Col USAF
USAF Test Pilot School Staff Monitor



KEVIN J. ROETHE, Maj, USAF
Project Pilot




MARK P. STUCKY, Lt Col, USAF
Chief, Test Management Branch



CORNELIS G. VISSER, Capt, RNLA
Project Pilot

This test plan has been approved for publication:

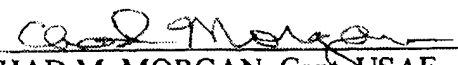


JOSHUA A. LANE, Capt, USAF
Flight Test Weapon System Officer



ERNIE H. HAENDSCHKE, Col, USAF
Commandant, USAF Test Pilot School

Date: 2 SEP 04



CHAD M. MORGAN, Capt, USAF
Flight Test Engineer

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EXECUTIVE SUMMARY

The objectives of this project were to evaluate common Air Force spin recovery techniques for two new U.S. Air Force Academy (USAFA) gliders, as well as investigate their crosswind operating limits. The two gliders, built by Schempp-Hirth Flugzeugbau in Kirchheim, Germany, were purchased for the USAFA National Competition Soaring Team to provide cadets the opportunity to compete in nationally and internationally recognized sports and open class competitions. These gliders were the two-seat TG-15A (Duo Discus), and the single seat TG-15B (Discus 2b). The ZEUS test team from USAF Test Pilot School Class 03B performed the testing at Edwards AFB, supported by TPS staff tow pilots and glider instructor pilots. A total of 95 glider sorties and over 150 test points were flown from 8 April to 27 April, 2004.

Overall, the spin recovery characteristics were considered satisfactory for both gliders. The gliders were tested over a wide range of center of gravity (c.g.) positions using crew pairings and ballast. The TG-15A was extremely resistant to spin and would not sustain a spin with pro-spin controls in mid or forward c.g. band. Although it would occasionally spiral out of the spin in the forward c.g. band, the TG-15B would generally sustain a three turn, developed spin in all c.g. bands. The USAFA spin recovery procedures were technically identical to the manufacturer procedures and stopped spin yaw motion in less than $\frac{1}{2}$ turn for all c.g. positions tested of both gliders.

Both TG-15 gliders demonstrated landing capability in up to 16 knots of crosswind. The TG-15A average lateral aileron deflection exceeded 75 percent of its travel during crosswinds above 16 knots. The TG-15B had more aileron control power than the TG-15A.

Overall, both gliders were extremely resistant to spin with-water-ballast. Two c.g. locations were compared without-water-ballast, and with-water-ballast. There was no increase in residual motion. Both gliders did not spin after three seconds of pro-spin input, and were considered to be extremely spin resistant.

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INTRODUCTION

BACKGROUND

Testing for the USAFA Glider Replacement Program was conducted Jul - Nov 2000 as a Qualification Operational Test and Evaluation (QOT&E) program by the Air Force Operational Test and Evaluation Center (AFOTEC) with a supporting assessment on handling qualities from USAF TPS (References 1 and 2). The program involved multiple gliders intended for fielding to upgrade the USAFA glider fleet. AFOTEC recommended additional testing by AFFTC to evaluate the USAFA spin recovery procedures for aircraft being purchased and evaluate crosswind landing capabilities to help optimize operations at USAFA. Relevant recommendations are excerpted from the QOT&E report as follows:

- (2) The replacement aircraft flight manuals have different spin recovery procedures for each aircraft as listed in Table 1. The USAFA has adopted one single spin **BOLDFACE** recovery procedure for all current glider and motorglider aircraft. Recommend an additional spin investigation by USAF TPS to determine if the existing USAFA **BOLDFACE** procedure can be used in lieu of the commercial flight manual procedures to establish a common recovery procedure.
- (3) Consider a separate test program to determine if all the replacement aircraft can be flown in greater crosswind conditions than currently published (demonstrated capability) in the commercial flight manuals to reduce lost training days and increase throughput.
- (4) Consider requesting USAF TPS evaluate aircraft delivered in final production configuration to confirm no impact to operations.

Recommendation (2) drives the spin investigation. The spin recovery procedures are listed in Table 1. It was apparent that the USAFA and Schempp-Hirth recovery procedures were very similar. After consultation with Schempp-Hirth, no differences were noted in the recovery procedures, and the test team would focus on evaluation of the USAFA common boldface. For Project ZEUS, only erect spins with a clean configuration (no gear or spoilers) were accomplished.

Table 1. Erect Spin Recovery Procedures

Source	Flight Manual Spin Recovery Procedures
USAFA Boldface	1. AILERONS - Neutral
	2. RUDDER - Full opposite direction of spin and hold
	3. STICK - Steadily forward until spinning stops
	4. CONTROLS - Neutral and recover from dive
Schempp-Hirth Procedures	1. Hold ailerons neutral
	2. Apply opposite rudder (i.e. against the direction of rotation of the spin)
	3. Ease control stick forward until rotation ceases and the airflow is restored
	4. Centralize rudder and pull gently out of dive

Recommendation (3) drives the crosswind investigation. The FAA requires sailplane manufacturers to demonstrate crosswind capability at 20 percent of stall speed. The max demonstrated crosswind was 11 knots, with no established crosswind limit. Crosswinds at USAFA typically run as high as 20 knots, which would result in a loss of up to 40 percent of the potential training days. USAFA desired a demonstrated crosswind capability of 20 knots.

Recommendation (11) also necessitates the spin and crosswind testing due to the addition of winglets to the final design of the TG-15B, after completion of the AFOTEC report.

The TG-15A and TG-15B gliders supported the National Competition programs used by a select number of Cadet Instructor Pilots (IPs) that had demonstrated advanced airmanship and flying skills in the USAFA Soaring Program.

PROGRAM CHRONOLOGY

The ZEUS test team received a Program Introduction Document (PID) from the 94th Flight Training Squadron (FTS) in Dec 03. The PID (Reference 3) requested that TPS conduct spin recovery and crosswind testing as described previously in the Background. ZEUS began provisioning and test planning in January 2004. All assets were in place by February. A takeoff and landing triangle marked on the Roger's dry lakebed at Edwards AFB was created by ZOOMIE SPIN two years ago and was still serviceable for flexible crosswind operations.

The gliders were shipped from the Air Force Academy to Edwards AFB. The TG-15A arrived on 2 February 2004 and TG-15B arrived on 6 February. Both gliders were weighed and balanced on 8 April. The TG-15A never received instrumentation and flew all sorties unmodified. The TG-15B instrumentation was completed on 20 April and the final flight release was issued. For testing, the weight and balance changes from instrument installation was determined by analysis. The ZEUS test team accomplished spin recovery and crosswind testing from 8 to 27 April.

TEST ITEM DESCRIPTION

TG-15A (Duo Discus): The glider was designed and manufactured by Schempp-Hirth Flugzeugbau in Kirchheim, Germany for the purpose of advanced training. The dual seat, all fiberglass, Duo Discus featured integral water ballast wing tanks, a water ballast trim fin tank and a T-tail. This 45:1 glide ratio high performance sailplane was purchased for the USAFA National Competition Soaring Team to provide cadets the opportunity to compete in nationally and internationally recognized sports and open class competitions. Able to carry 53 U.S. gallons (440 lbs) of water ballast in the wings, the glider was used to compete and provide training for cross-country events. No instrumentation modifications were made due to delays. The test item (serial number 384) was production representative and was assigned registration number N161AF.

TG-15B (Discus 2b): The glider was designed and manufactured by Schempp-Hirth Flugzeugbau in Kirchheim, Germany for the purpose of national and international competitions. The single seat, all fiberglass glider has been very successful in the Standard Class for ten years (six international championships). With a 45:1 glide ratio, the TG-15B enabled USAFA to compete on an equal level with other soaring clubs and collegiate teams in sports and open class competitions. Easy assembly and disassembly made the TG-15B well suited for USAFA deployments. The TG-15B also had water ballast tanks and a T-tail configuration like the TG-15A. Unlike the TG-15A, the TG-15B (2b) had small winglets to improve performance. The test item (serial number 187) was production representative and carried registration number N165AF.

A Teletronics Technology Corporation MCDAU-2000 digital multi-plexed Data Acquisition System (DAS) was installed just behind the seat of the Discus 2b, TG-15B. Reference 4 describes the operation of the DAS system. The system was powered by a 14 cell Lead-Acid 28 VDC power supply under the seat. The DAS had eight-channel capability with five channels being used for the project. Aileron and rudder control movements were measured and a video feed from a camera looking over the left shoulder was recorded by the DAS on a digital PCMIA format. Microphone recording capability was also used with the DAS to further enhance the cockpit data capture. The DAS could capture one hour of data before card replacement. A cockpit control panel allowed for power application to the system along with record and record pause capability. GPS integration provided altitude information along with a time stamp for accurate data capture. Overall main component weight was 35 lbs. The modification was in place during the weight and balance for the TG-15B. The glider was considered production representative as tested.

See Appendix A for pictures of the test gliders. Further details on the gliders and their operation are available in the commercial flight manuals, listed as References 5 and 6.

TEST OBJECTIVES

The objectives from the ZEUS Test Plan (Reference 7) were as follows:

1. Evaluate USAFA Critical Action Procedures (Boldface) for erect spin recovery, initiated after a three turn spin sequence, for the TG-15A/B gliders.
2. Evaluate the landing characteristics of the TG-15A/B, with up to 20 knots of crosswind component.
3. Determine departure resistance of the TG-15A/B gliders with full, symmetric water ballast loads.

All test objectives were met with both gliders except for evaluating the TG-15B in crosswind landings above 16 knots.

LIMITATIONS

Crosswind testing was limited by the allowable test period and wind conditions. The allowable test period was 8 to 27 April. Winds greater than 11 knots were required to expand the crosswind limits, yet winds greater than 30 knots were cause to terminate testing and recover the gliders to the hangers. Actual testing conditions did not allow the test team to complete crosswind testing above 16 knots in the TG-15B.

TEST AND EVALUATION

General. Before flying the test gliders, a standardized spin entry technique, USAFA spin recovery boldface procedures, and crosswind landings were practiced while flying similar category gliders. A Functional Check Flight (FCF) and crew orientation flights were flown prior to any testing. Spin and crosswind testing consisted of 80 sorties and over 150 data points. The testing was conducted at the Edwards AFB lakebed, from surface to 10,000 ft MSL.

Weight and Balance. Weight and balance was accomplished by qualified personnel in order to verify manufacturer data prior to flying. The flight manuals provided generic weight and balance information, as well as moment arms for the seats and water ballast. The gliders were also weighed with full water ballast to verify manufacturer moments. This data is included in Appendix B. The glider-specific manufacturer moment arms were used to calculate the c.g. data during testing.

Test Aircrew. Glider experience ranged from certified commercial instructor glider pilots to flight test engineers and pilots with limited glider experience. Table 2 provides a summary of the flying and glider experience of the test personnel.

Table 2. Test Personnel Flying and Glider Experience

Name (<i>Weight-lbs</i>)	Rating	Jet/Prop Time	IP/EP Time	Glider Time	CFIG Time	Total Time	Total IP/EP
INSTRUCTORS							
Pilot 1 (145)	IP, CFIG	3600	1250	620	470	4220	1720
STUDENTS							
Crew 1 (175)	FTE, PPL	100	0	3	0	103	0
Crew 2 (169)	B-1 IWSO	1300	475	3	0	1300	475
Pilot 2 (175)	F-15E IP, CPL	1200	50	10	0	1210	50
Pilot 3 (185)	F-16 IP, CFI, CFII, MEI, CG	3100	1050	40	0	3140	1050
Pilot 4 (155)	F-16 IP, CPL	2800	450	3	0	2803	450

SPIN RECOVERY

Methodology. The USAFA spin recovery procedures were technically identical to the manufacturer procedures. These procedures were evaluated throughout the spin testing. Spins were accomplished in each glider at forward, mid, and aft c.g. locations. Forward and aft c.g. conditions were defined by the test team to be locations within 33 percent of the forward and aft c.g. limits, in terms of the distance measured from the leading edge datum.

Spins were accomplished at all altitudes between 10,000 and 5,800 ft MSL. Spins were executed from a wings level, 1g condition with a 1 knot/sec bleed rate. Upon losing elevator authority or reaching the aft stop with the stick, full rudder was applied to enter the spin in the desired direction. The following altitudes were noted during the spin: entry altitude, altitude the recovery controls were applied, lowest altitude during the dive recovery, and final altitude after dive recovery zoom-up. The number of turns from the application of recovery controls until control was regained (yaw motion stopped) was also recorded. Backseat crewmembers in the TG-15A and a hand held voice recorder aided in the collection of data.

Two objective comparison criteria were used to evaluate the spin recovery: (1) Altitude lost (to the nearest 50 ft) from the input of recovery controls to lowest altitude during the recovery, and (2) Number of turns (to the nearest 1/8 turn) from the input of recovery controls to the final heading after control was regained (spinning stopped). A minimum of two pilots flew in each c.g. band for comparative analysis.

Results. Nineteen spin sorties were flown and 93 spins accomplished across a wide range of c.g. locations (using crew pairings and nose ballast) as depicted in Figures 1 and 7 below. Refer to Appendix C for a detailed listing of all spin sorties and crew pairings. Overall, the spin recovery characteristics were considered satisfactory for both gliders. Both gliders were extremely spin resistant and easily recovered once in a spin using the USAFA boldface recovery procedures.

TG-15A (Duo Discus): The TG-15A was extremely resistant to spin and would not sustain a spin with pro-spin controls in the forward and mid c.g. bands. A spin could be sustained in the aft c.g. band which will be explained later. Figure 1 illustrates the defined c.g. and weight limits of the operational flight envelope, as well as the actual TG-15A c.g./weight combinations flown for both the spin and water ballast sorties.

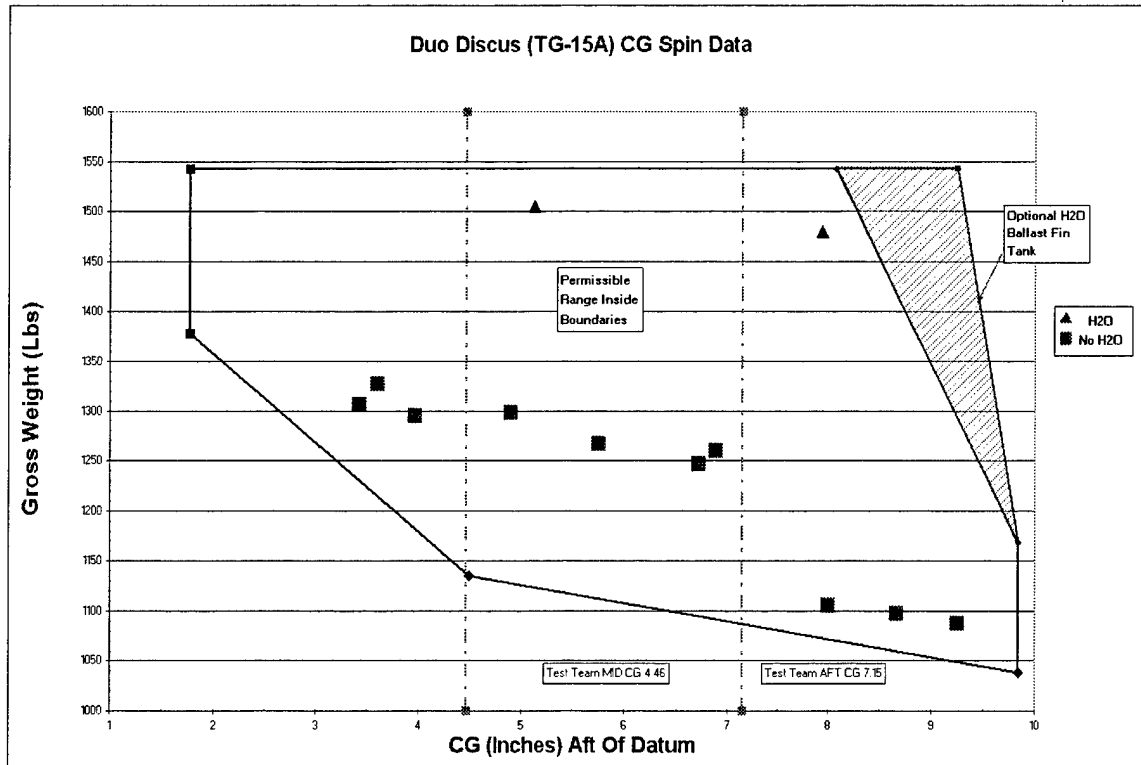


Figure 1. Tested c.g. Locations for TG-15A Spins

In the forward and mid c.g. bands, the aircraft would spiral out of the spin in less than two turns with full pro-spin controls. The resulting spiral caused the aircraft to rapidly gain airspeed during the recovery and quickly exceed the maneuvering speed (V_A) of 97 knots. Once above V_A , the aircraft g limits were reduced from +5.3g to +4.0g, further limiting a pilot's ability to recover from the dive without overstressing the aircraft. This limit in available g and increasing speed exaggerated altitude loss during spiral recoveries.

Figure 2 shows the number of turns required to transition to a spiral self-recovery during the forward and mid c.g. band spin attempts. Turns were measured, to the nearest 1/8 turn, from the input of pro-spin controls to the point where yaw rate stopped. In all cases, the aircraft transitioned from the spin to a spiral prior to reaching the required three turns for application of USAFA boldface recovery inputs. In addition, the two test points flown by the manufacturer (Schempp-Hirth, Reference 8) in the extended forward c.g. region are shown for comparison.

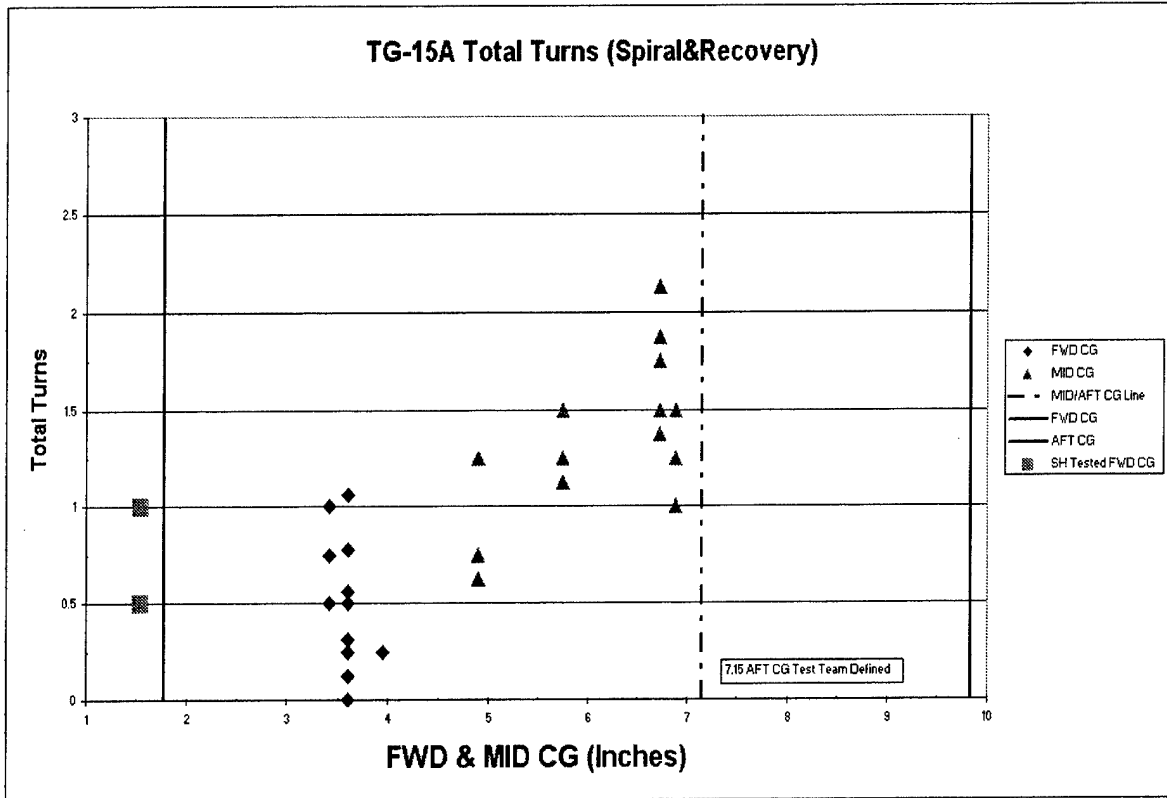


Figure 2. Turns to Recover During TG-15A Spiral Recoveries (MID/FWD c.g.)

Figure 3 shows the altitude lost during spiral self-recovery during the forward and mid c.g. band spin attempts. Altitude loss was measured, to the nearest 50 ft, from the input of pro-spin controls to the lowest altitude during recovery dive (altimeter reversal). Altitude lost during the full spiral including the recovery ranged from 150 ft for the forward c.g. band to 800 ft for the worst case mid c.g. band. Dive recovery speeds averaged 95 KIAS. The worst case was the mid c.g. spiral, which reached 80 degrees nose low and 105 KIAS. An average of 200 ft was regained during the recovery.

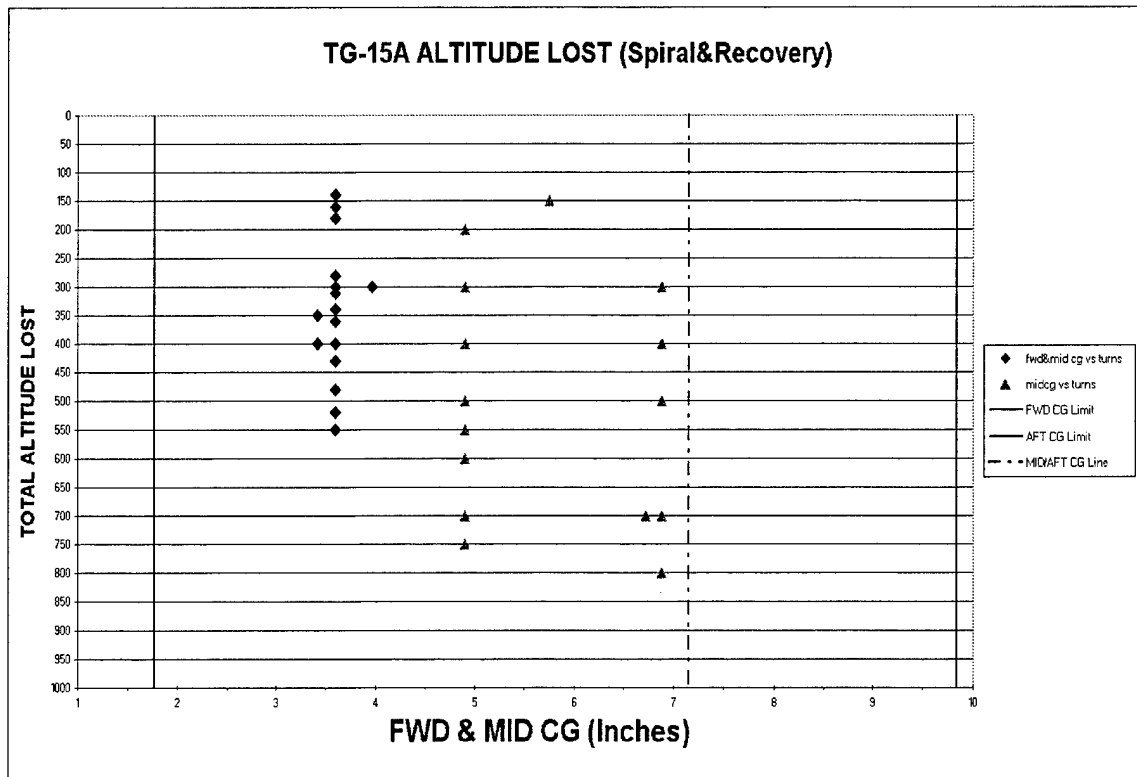


Figure 3. Altitude Lost During TG-15A Spiral Recoveries (MID/FWD c.g.)

The spiral recovery concerned the test team, and an attempt was made to utilize the USAFA boldface as a spin prevent maneuver to improve recovery characteristics. The USAFA boldface was then applied 1/2 turn prior to transition from the incipient spin into the spiral to evaluate effectiveness of the boldface during the initial phases of spin. In all cases, the application of the USAFA boldface rapidly arrested yaw rate and minimized altitude lost by an average of 100 ft. The resulting airspeed decreased by more than 20 knots with an average of 84 KIAS in the mid c.g. band. Additionally, the recovery g was also reduced from 4.0g to 3.5g compared to the self-recover spiral exit of the spin. Figure 4 shows a vertical profile of the spin recovery and how applying the USAFA boldface, even prior to establishing a developed spin, greatly improved recovery characteristics.

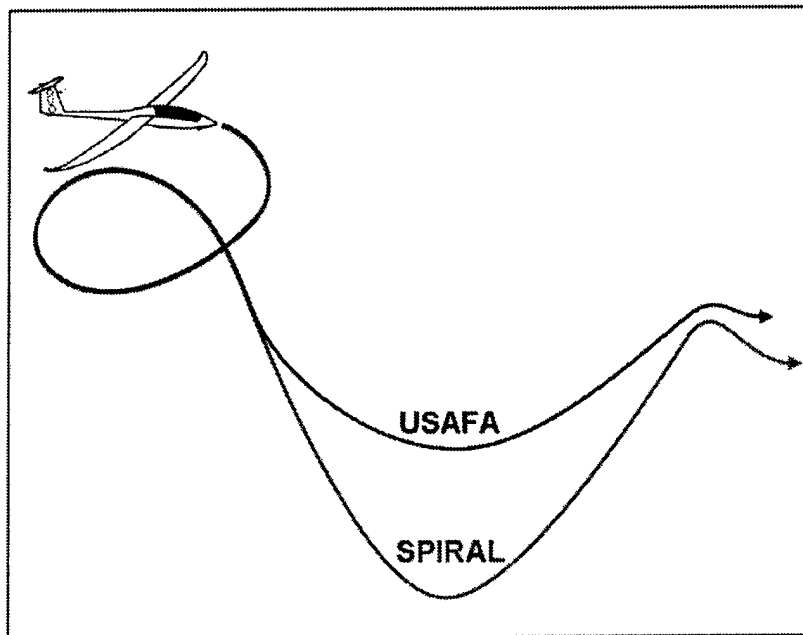


Figure 4. USAFA-Spiral Vertical Profile Comparison

In the aft c.g. band the aircraft would sustain a three turn spin with pro-spin controls, but was still in the incipient phase (inconsistent/decreasing yaw rate and oscillatory nose motion) when recovery controls were applied. Even so, the aircraft recovered rapidly upon application of the USAFA boldface recovery.

Figure 5 shows the number of turns during spin recovery for the USAFA recovery procedures during aft c.g. spin attempts. Turns were measured, to the nearest 1/8 turn, from the input of recovery controls to the point where spinning (yaw motion) stopped. Motion ceased within 3/4 turn for all aft c.g. positions tested. In addition, the two test points flown by the manufacturer (Schempp-Hirth, Reference 8) in the extended aft c.g. region are shown for comparison. The Schempp-Hirth recovery turns average of 1/2 turn was slightly higher than the test team average of 3/8 turn, primarily due to the manufacturer's extended aft c.g. position.

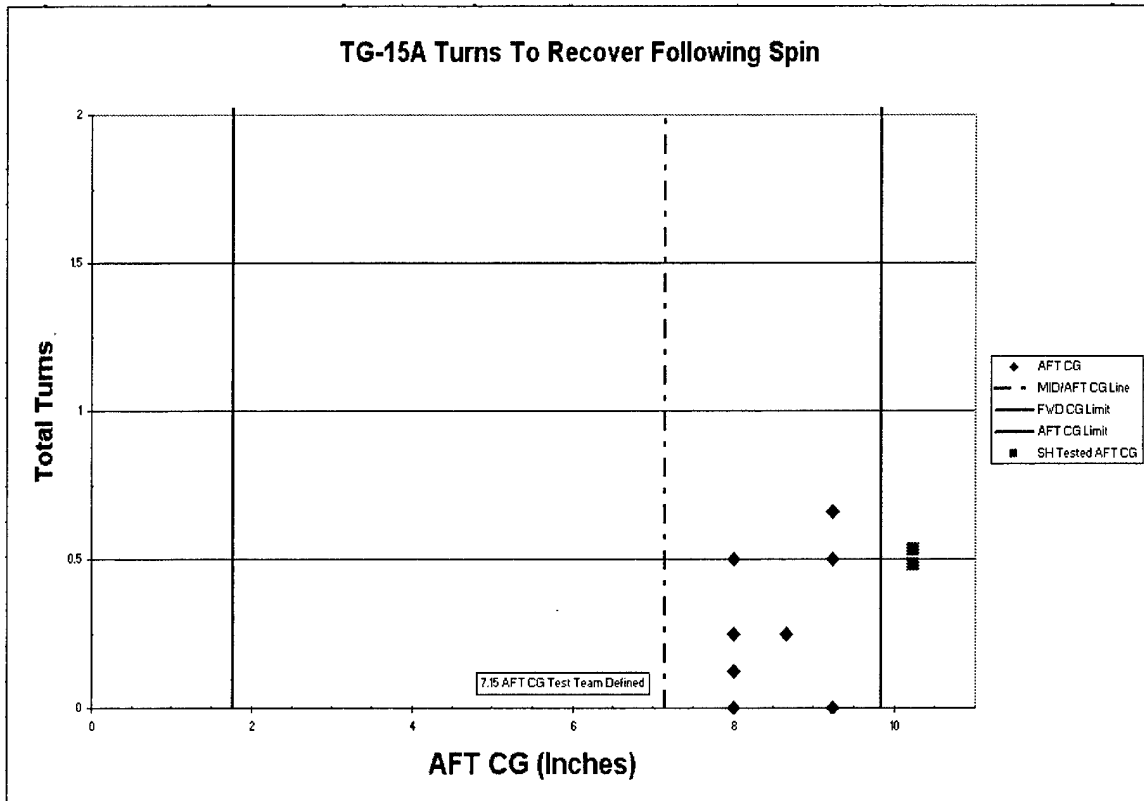


Figure 5. Turns to Recover During TG-15A Spin Recoveries (AFT c.g.)

Figure 6 shows the altitude lost during spin recovery for the USAFA recovery procedures during aft c.g. spin attempts. Altitude loss was measured, to the nearest 50 ft, from the input of recovery controls to the lowest altitude during dive (altimeter reversal). Two test points flown by the manufacturer (Schempp-Hirth, Reference 8) in the extended aft c.g. region are shown for comparison. The Schempp-Hirth recovery altitude average (300 ft) was slightly higher than the test team average of 250 ft, primarily due to the manufacturer's extended aft c.g. position.

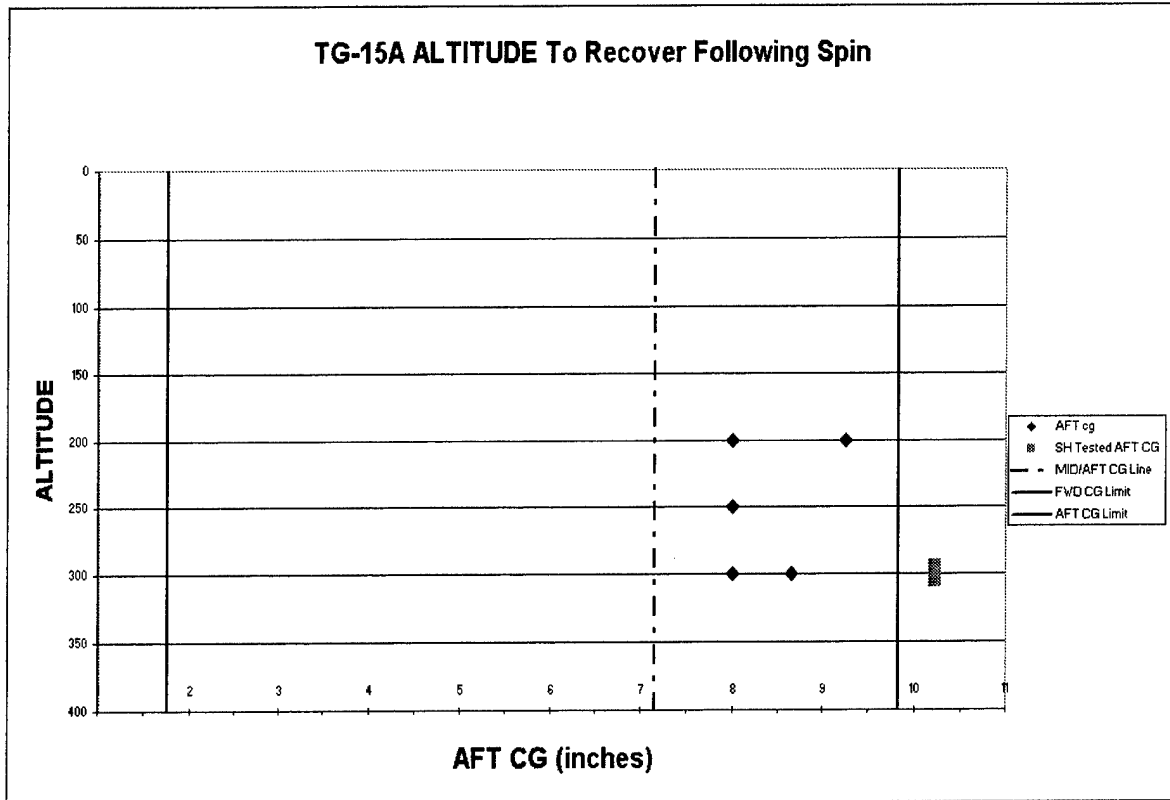


Figure 6. Altitude Lost During TG-15A Spin Recoveries (AFT c.g.)

For all three c.g. bands tested for the TG-15A, the USAFA boldface recovery procedures rapidly arrested yaw motion, minimized altitude lost, reduced recovery speed and g, and recovered the aircraft.

TG-15B (Discus 2b): The TG-15B was also extremely resistant to spin but unlike the TG-15A, could sustain a three turn spin with pro-spin controls in all three c.g. bands. Figure 7 illustrates the defined c.g. and weight limits of the flight envelope, as well as the actual TG-15B c.g./weight combinations flown for both the spin sorties and water ballast sorties.

Although it would spiral out of the spin 23 percent of the time (5 out of 22 spins) in the forward c.g. band, the TG-15B would generally sustain a three turn, developed spin with pro-spin controls in all c.g. bands. The TG-15B sustained an erect, 60-70 degrees nose low, 90-120 degrees /sec spin rate, non-oscillatory spin. The aircraft also displayed repeatable and consistent recovery characteristics during recoveries. All spins from all three c.g. bands were recovered in less than 1/2 turn at speeds ranging from 65 - 90 KIAS, and in no more than 450 ft using the USAFA boldface recovery.

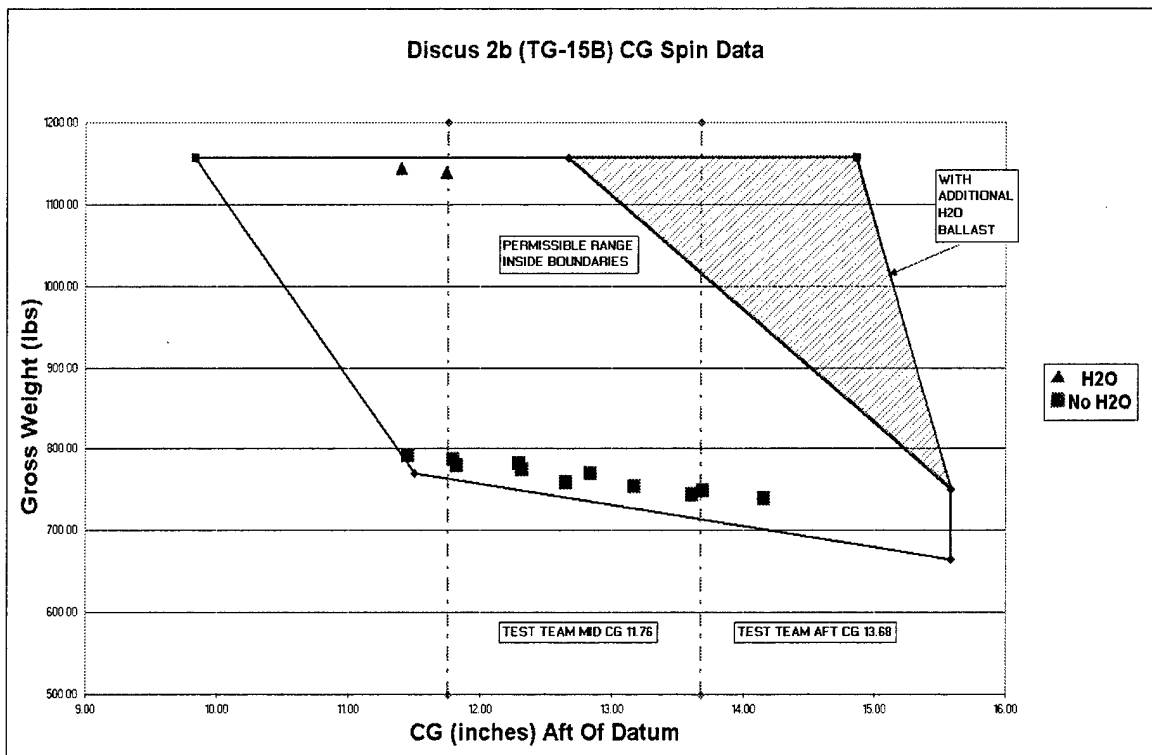


Figure 7. Tested c.g. Locations for TG-15B Spins

The TG-15B spiral dive recovery, similar to the TG-15A, resulted in a significant nose low attitude and increased airspeed. Slow response time to recovery could lead to an overspeed condition, while an aggressive recovery at higher speeds could lead to an over-g situation.

Figure 8 shows the number of turns during spin recovery using the USAFA recovery procedures for all three c.g. bands. Turns were measured, to the nearest 1/8 turn, from the input of recovery controls to the point where yaw motion stopped. Yaw motion ceased within 3/8 turn for all c.g. positions tested. The three test points flown by the manufacturer (Schempp-Hirth, Reference 9) in the extended aft c.g. region are shown for comparison. The Schempp-Hirth recovery turns average (1/2 spin) was slightly higher than the test team average of 1/4 turn, primarily due to the manufacturer's extended aft c.g. position.

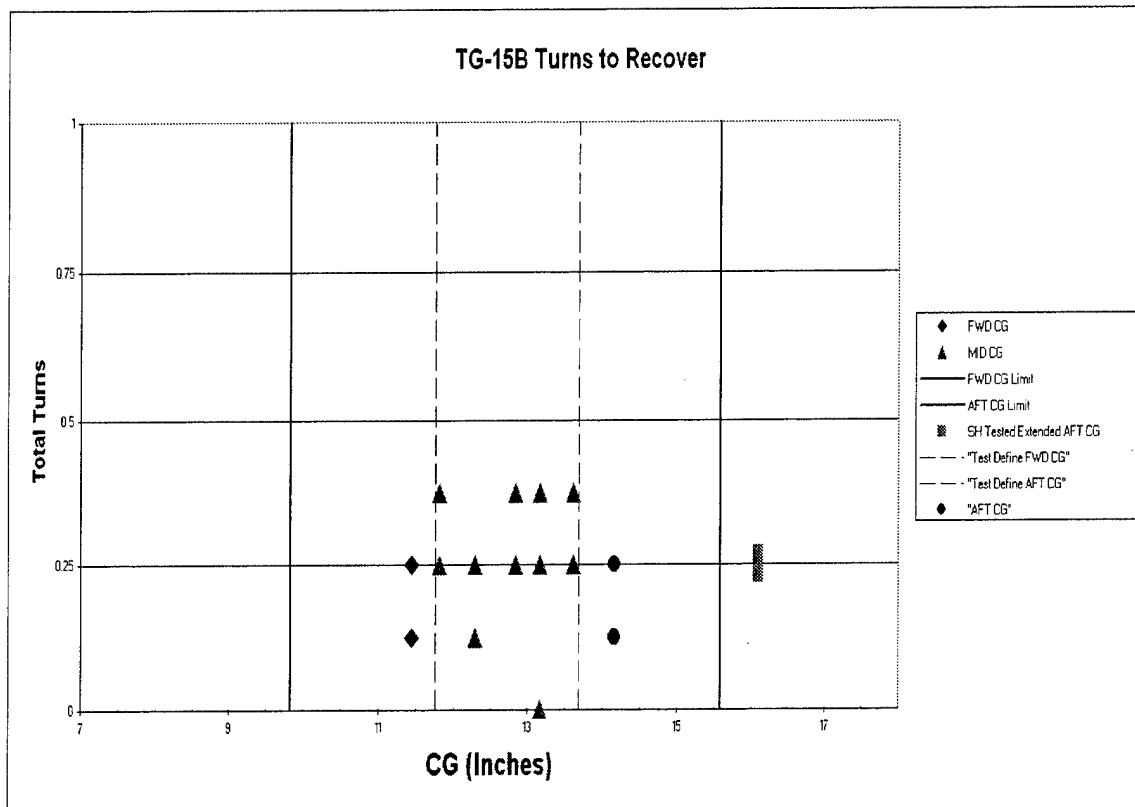


Figure 8. Turns to Recover During TG-15B Spin Recoveries

Figure 9 shows the altitude lost during spin recovery using the USAFA recovery procedures for all three c.g. bands. Altitude loss was measured, to the nearest 50 ft, from the input of recovery controls to the lowest altitude during dive (altimeter reversal). Three test points flown by the manufacturer (Schempp-Hirth, Reference 9) in the extended aft c.g. region are shown for comparison. The Schempp-Hirth recovery altitude average (390 ft) was slightly higher than the test team average of 240 ft, primarily due to the manufacturer's extended aft c.g. position.

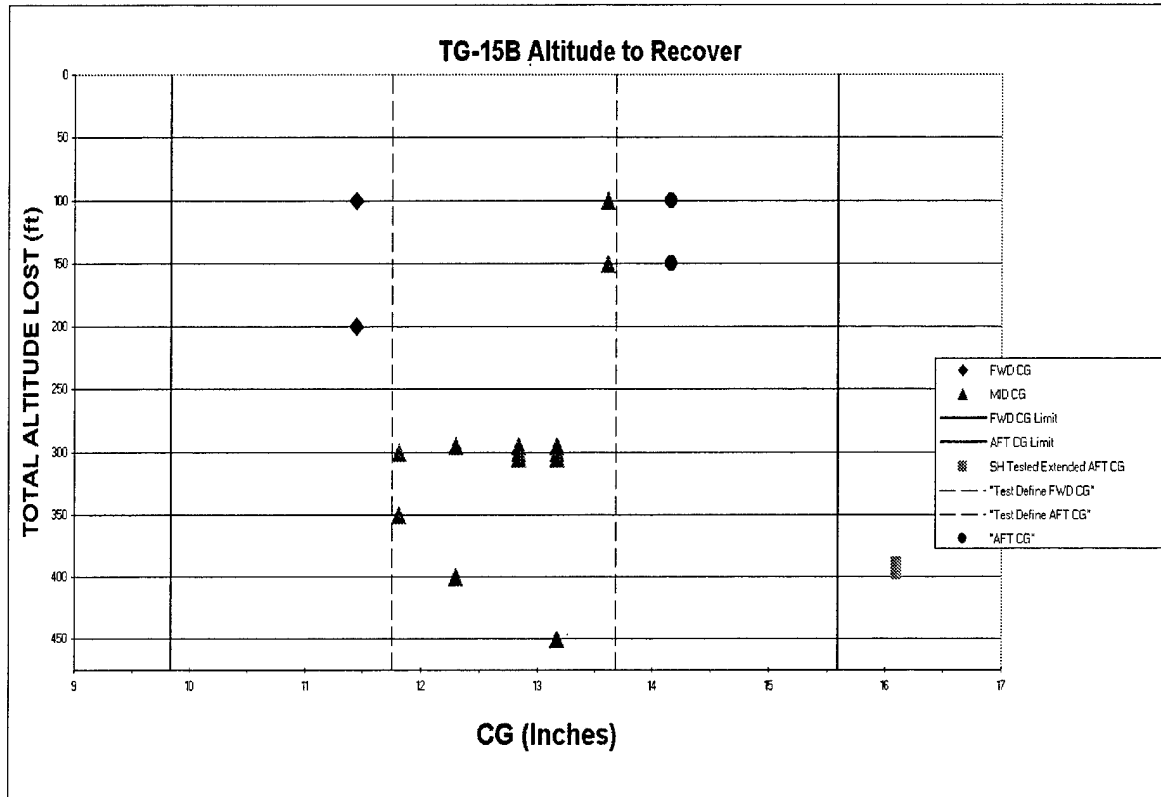


Figure 9. Altitude Lost During TG-15B Spin Recoveries

CROSSWIND LANDINGS

Methodology. Crosswind testing was accomplished on the Edwards dry lakebed surface allowing aircrew to land with the desired crosswind component. The build-up matrix divided crosswind bands into 1-8 knots, 9-12 knots, 13-16 knots and 17-20 knots. Pilots accomplished landings in a lower band with acceptable results prior to attempting a landing in the next higher band. Acceptable results were considered CHR Level 1 or 2 for the defined landing task. The landing task is described in Table 3. The standard wing-low landing method was used with no crab or drift, while a parallel course to the reference line was maintained. The end of the landing task was defined as the point where the glider came to a complete stop. The aircrew's priority was to stop in as short a distance as practical during crosswind landings, rather than keeping the glider rolling to a desired location on the runway. Stick deflections were collected, and a limit of 75 percent average was set to assure sufficient control authority exists. A minimum of two pilots were required to fly in each data band for data comparison. The pilot performing the landing commented real-time on his performance and workload in order to determine a CHR after landing. If the pilot exceeded 75 percent stick deflection, or landed in crab, the CHR was deemed unusable.

Table 3. Cooper-Harper Crosswind Landing Task

Task	Desired performance	Adequate performance
Ground Track	Maintain a straight ground track within +/- one half the glider wingspan from the initial touchdown reference point	Maintain a straight ground track within +/- one glider wingspan from the initial touchdown reference point
Wingtip Clearance	Maintain wingtip clearance from the ground until loss of aileron authority	Maintain wingtip clearance from the ground until loss of aileron authority
Airspeed	Landing speed +/- 5 knots of computed touchdown speed	Landing speed +10/-5 knots of computed touchdown speed
Note: The 75 percent stick deflection restriction was removed once the main gear had touched down.		

Results. A summary of the TG-15A and TG-15B crosswind landing test points is provided in Appendix C. The test environment was different than the typical glider landing surface. Operating on the lakebed provided the pilots an unobstructed approach. The sandy lakebed surface had a lower coefficient of friction than asphalt or concrete had. The sandy surface allowed the glider to slide in response to drift. Based on the design task and environment, directional control was not in question.

Only hand-held data were collected in the TG-15A, since this aircraft was not instrumented. The DAS in the TG-15B was installed and operational after most of the test flights were conducted. A combination of hand-held data and digital DAS data was used for post flight analysis and reporting.

TG-15A (Duo Discus): A total of 30 crosswind landings were performed in the TG-15A. Figure 10 depicts the average lateral stick deflection on touchdown for all the respective data bands. In over 90 percent of the landings with crosswinds up to 16 knots, less than 75 percent average stick deflection was required. Directional control was easily maintained throughout the landing roll and the glider did not deviate from the landing reference line by more than 1/2 wingspan. A total of 9 landings were performed in the 17-20 knots crosswind band. In this band the average stick deflection did exceed the 75 percent average limit in the majority of the cases. The 75 percent average lateral control stick deflection restriction was a MIL-HDBK-1797 (Reference 10) specification and was designed to provide a buffer for crosswind landings in gusty conditions. Since this restriction was exceeded during landings in crosswinds above 16 knots, planned landings above this condition should be avoided. **Do not plan to land the TG-15A in crosswinds exceeding 16 knots (R1)**¹.

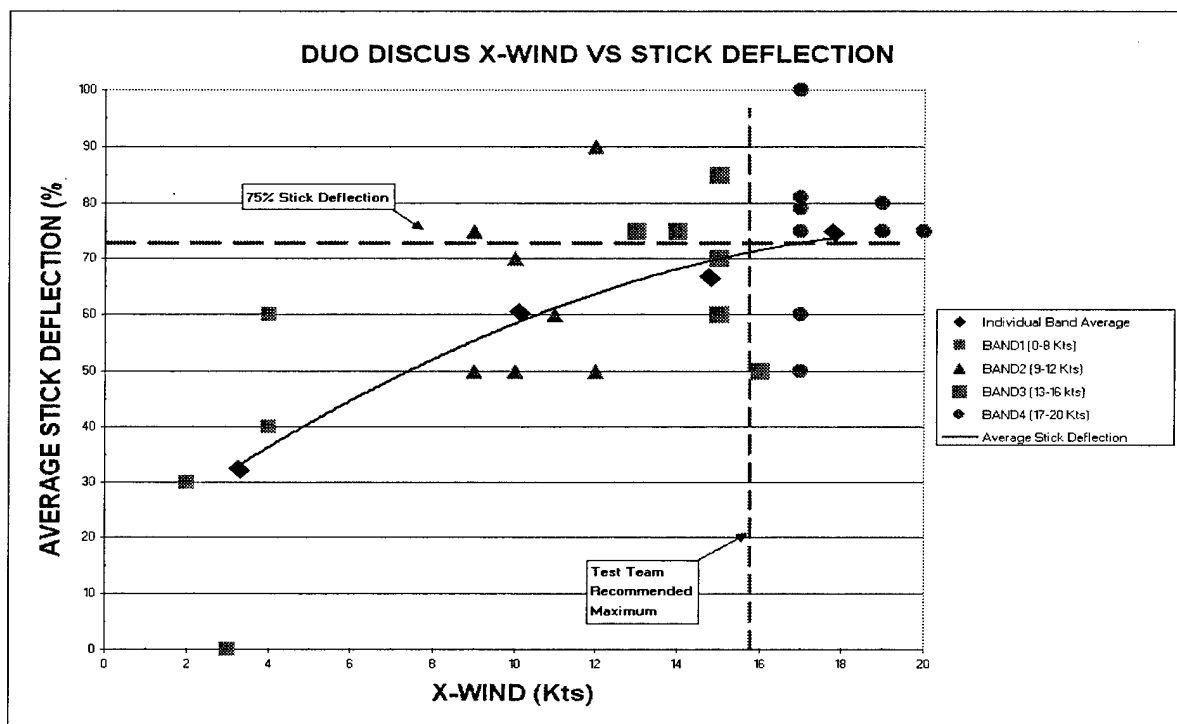


Figure 10. TG-15A Average Stick Deflection During Landing

¹ Numerals preceded by an R within parentheses at the end of a paragraph correspond to the recommendation numbers tabulated in the Conclusions and Recommendations section of this report

The diminishing aileron control power during the landing roll-out caused the wingtip to touch the ground shortly before the glider came to a complete stop in crosswind conditions above 12 knots. This caused the glider to deviate from the landing heading. These occurrences increased wear on the soft wing tip skids, though no wingtip damage occurred during testing. Since the hydraulic wheel brake proved to be very effective, this normally resulted in the glider not deviating more than one-half wing span from the landing reference line, providing desired performance.

A total of 21 landing tasks were assigned a CHR. These results are depicted in Figure 11. Ratings were based on pilot workload and task performance. Even though the 75 percent average stick deflection was exceeded in high crosswinds, the pilot workload was always tolerable. Except for two landings that were assigned a CHR 4 and 5, all landings were rated with a CHR Level 1.

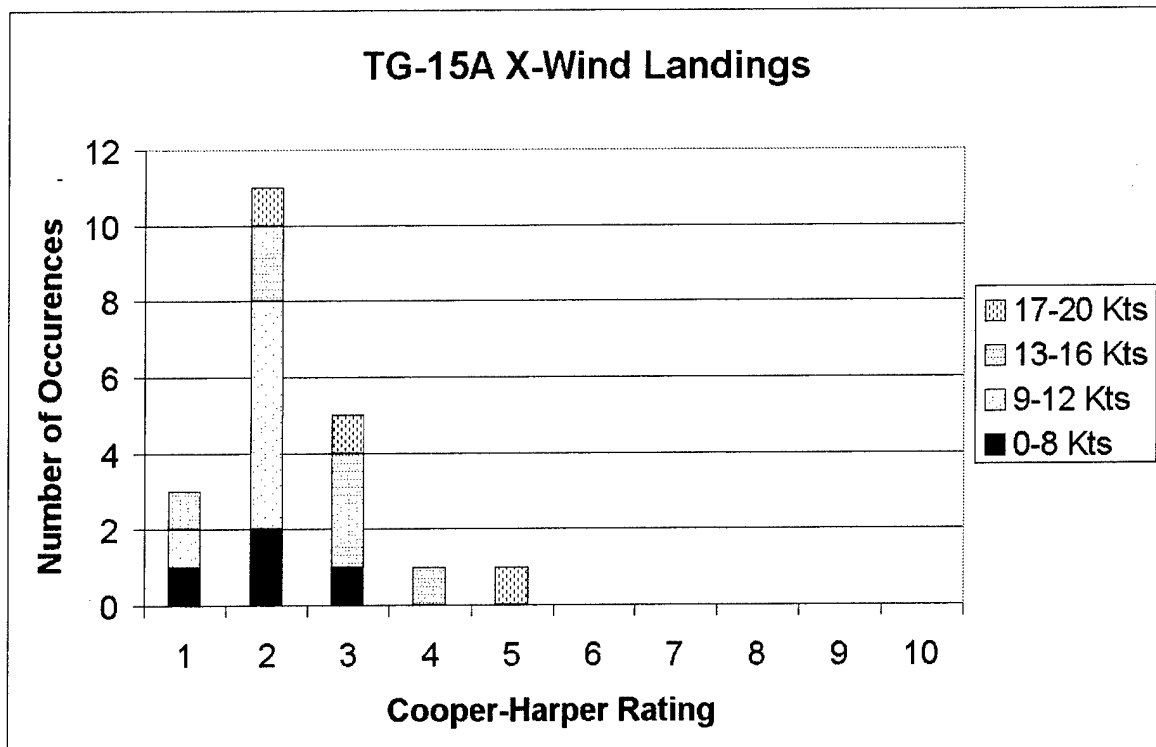


Figure 11. TG-15A Cooper-Harper Crosswind Landing Results

Figure 12 depicts the assigned PIO ratings. The majority of the landings were assigned a PIO rating 1, indicating that no undesirable motion was experienced.

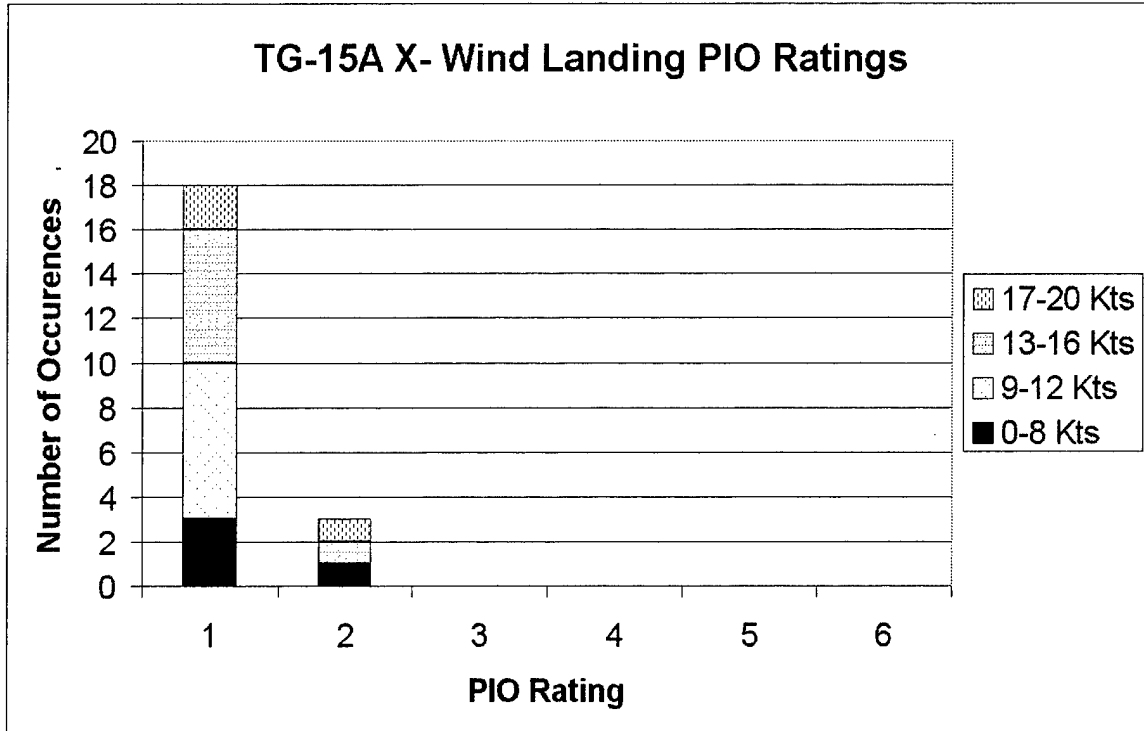


Figure 12. TG-15A PIO Ratings for Crosswinds Landings

TG-15B (Discus-2b): A total of 24 crosswind landings were performed in the TG-15B. The test matrix could not be completed in the 17-20 knots crosswind band. Gusty winds and extreme thermal activity above the lakebed lead to non-ratable landing tasks. These landing tasks were aborted due to thermals or touchdown occurring too far from the landing reference to be used for a rating. Five landings were attempted in this band, four of which could not be rated.

Figure 13 shows the average aileron deflection was less than 75 percent during crosswind landings up to and including 16 knots. Figure 14 depicts that the lateral stick deflection during a 17 knots crosswind landing was a maximum of 74 percent with an average of 35 percent. Landings above 16 knots cross might be possible while still achieving Level 1 or 2 CHR performance and not exceeding 75 percent average lateral stick travel. This however, was not fully tested due to weather issues. **Do not plan to land the TG-15B in crosswinds exceeding 16 knots (R2). Accomplish further testing to explore crosswinds above 16 knots (R3).**

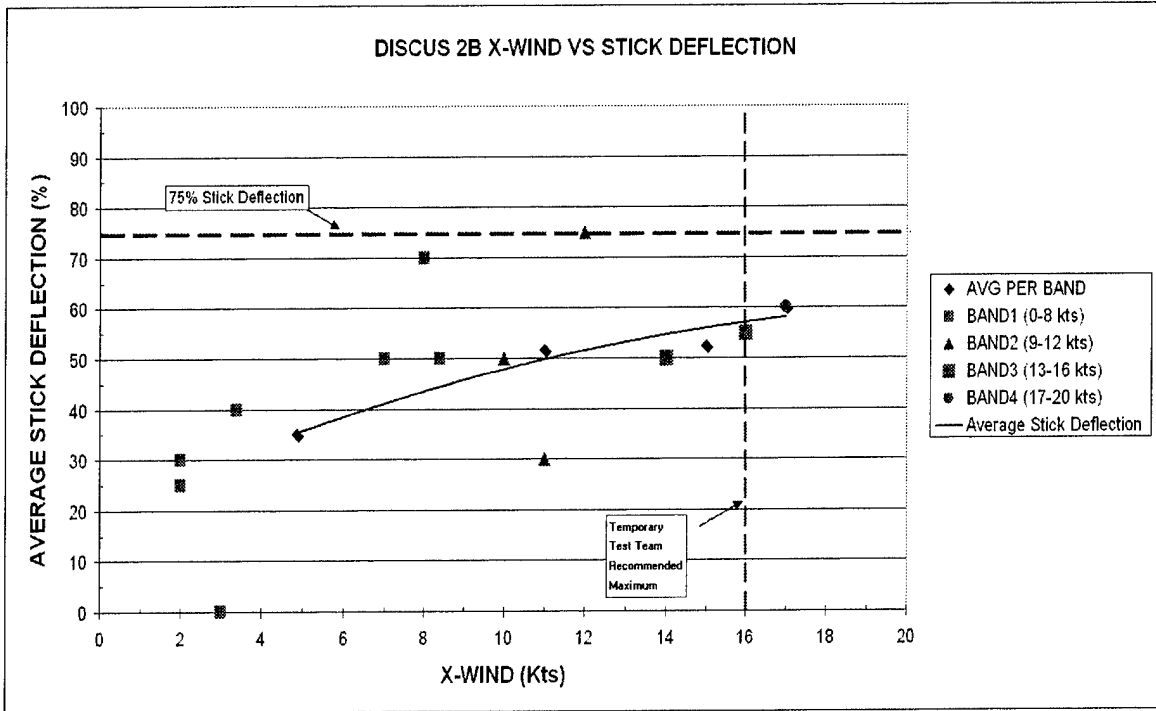


Figure 13. TG-15B Average Stick Deflection During Landing

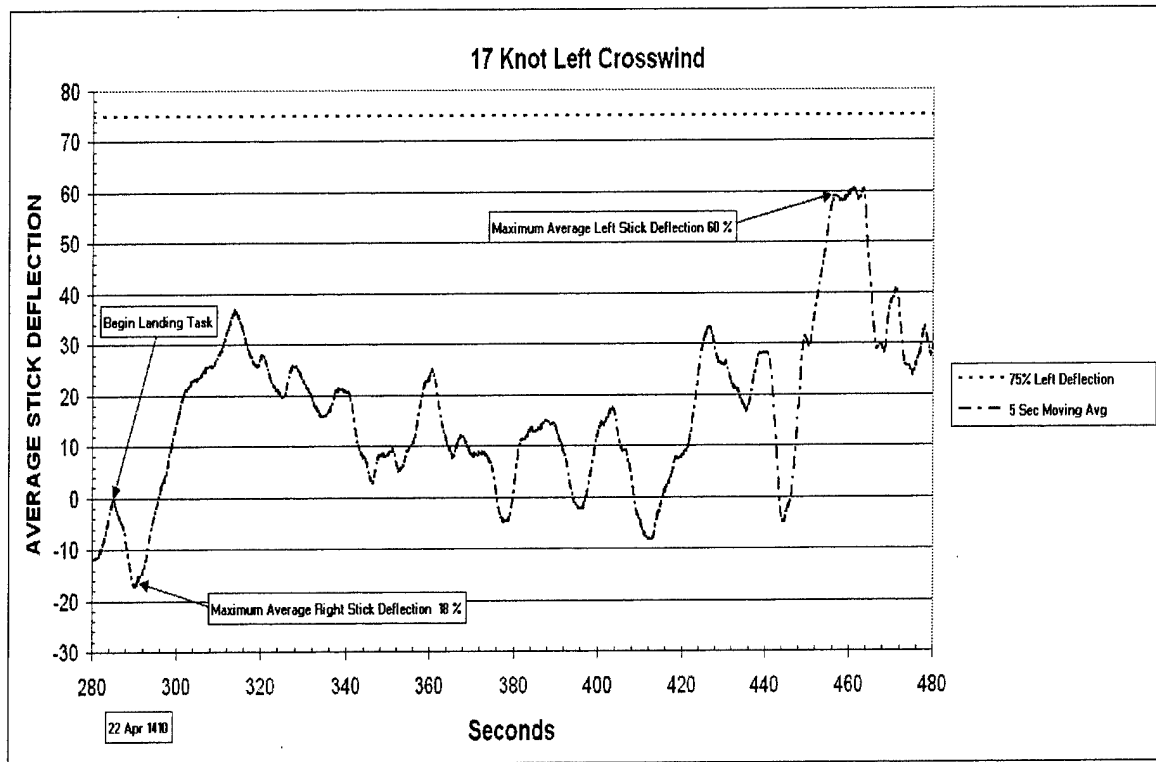


Figure 14. TG-15B Stick Deflection During 17 Knot Crosswind Landing

Figure 15 shows that all landings in a crosswind of up to and including 16 knots resulted in CHR 1, 2 or 3, indicating Level 1 Handling Qualities. The aileron control power was more than in the TG-15A, so the TG-15B could be brought to a complete stop before a wing touched the ground during most of the landings. PIO ratings were 1 for all landings.

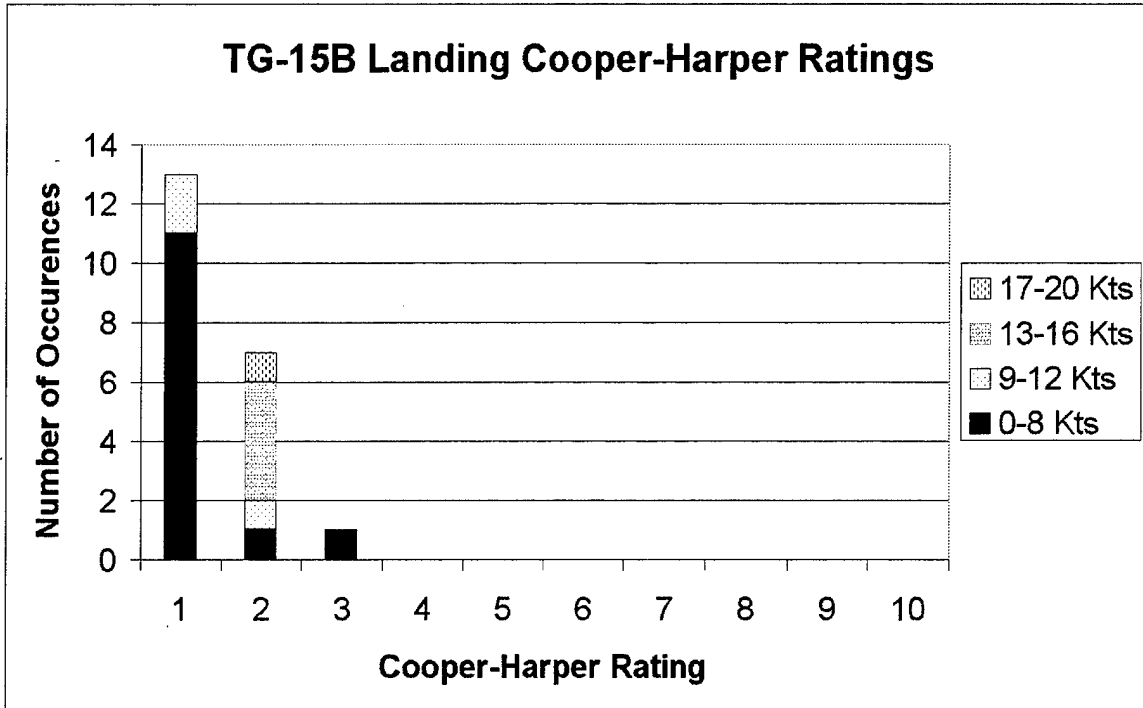


Figure 15. TG-15B Cooper-Harper Crosswind Landing Results

DEPARTURE RESISTANCE WITH-WATER-BALLAST

Methodology. For aircraft like the TG-15's the departure was a spin. Testing was initiated by evaluating the departure resistance of the TG-15A and TG-15B without-water-ballast. Phase A, B, and C (Reference 11) stalls were flown, noting the departure tendency and setting a baseline. The c.g. locations that demonstrated the worst departure characteristics (altitude lost and turns to recover) were evaluated with full, symmetric water ballast. The gliders with-water-ballast were evaluated for departure resistance by again flying Phase A, B and C stalls. The characteristics with-water-ballast were compared to without-water-ballast. Heading change and pitch attitude were recorded to evaluate residual motion. Each glider was only tested at two c.g. locations, and only with full water ballast. The manufacturer also tested departure resistance with less than full water ballast, and found those conditions to be extremely departure resistant.

Departure resistance tests were accomplished at all altitudes between 10,000 and 5,800 ft MSL. Three Phase A stalls were flown: 1g straight ahead stall, and both right and left turning stalls. Two Phase B stalls were flown: 1g straight ahead with both left and right one second inputs (full pro-spin rudder, full aft stick and ailerons neutral). Six Phase C stalls were flown: 1g straight ahead stalls with both left and right three second inputs (full pro-spin rudder, full aft stick and ailerons neutral), left turning stalls with both left and right three second, and right turning stalls with both left and right three second inputs.

Results. The gliders with-water-ballast exhibited the same departure resistance as without-water-ballast. Since neither glider showed any tendency to depart after three seconds of pro-spin inputs, they are considered extremely resistant to departures in accordance with MIL-F-83691 (Reference 11).

TG-15A (Duo Discus): Figure 16 shows how the TG-15A exhibited very similar residual motion with-water-ballast as it had without-water-ballast. With one second of pro-spin input, there was only 60 degrees of residual motion. With three seconds of pro-spin input, 180 degrees of residual motion occurred. The glider did not enter a spin after three seconds of pro-spin input, the TG-15A was considered extremely resistant to departure with-water-ballast.

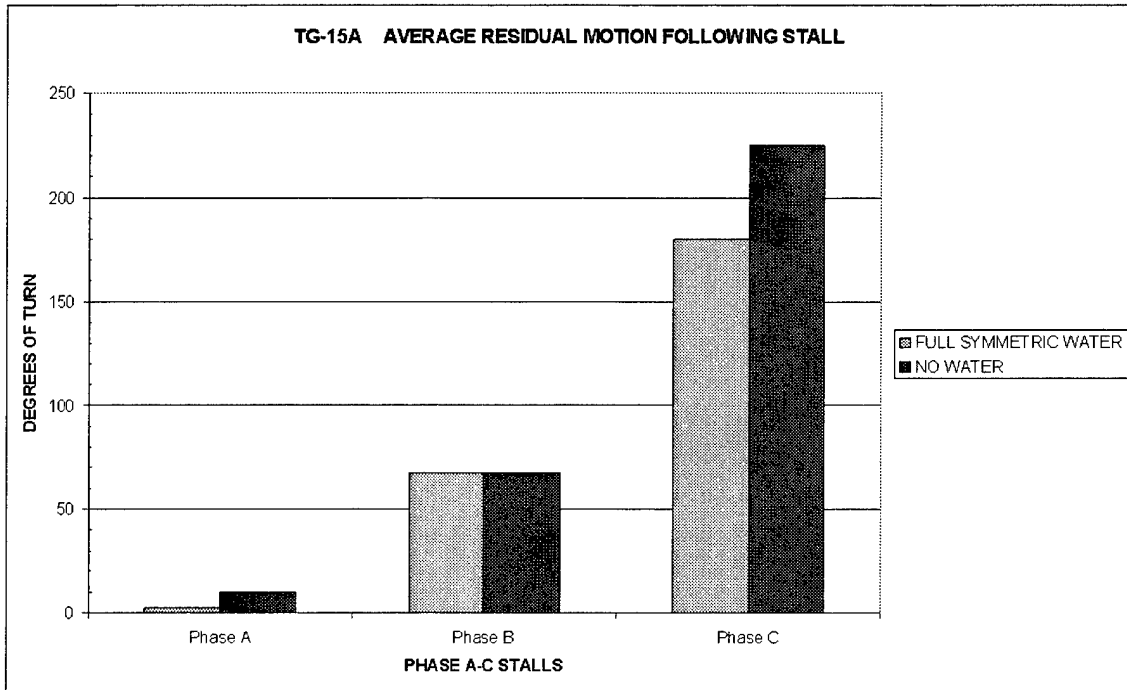


Figure 16. TG-15A Average Residual Motion Following Stall

TG-15B (Discus 2b): Figure 17 shows how the TG-15B had similar residual motion with-water-ballast as it had without-water-ballast. With one second of pro-spin input, there was only 45 degrees of residual motion. With three seconds of pro-spin input, there was 180 degrees of residual motion. The glider did not enter a spin after three seconds of pro-spin input, so the TG-15B was considered extremely resistant to departure with-water-ballast.

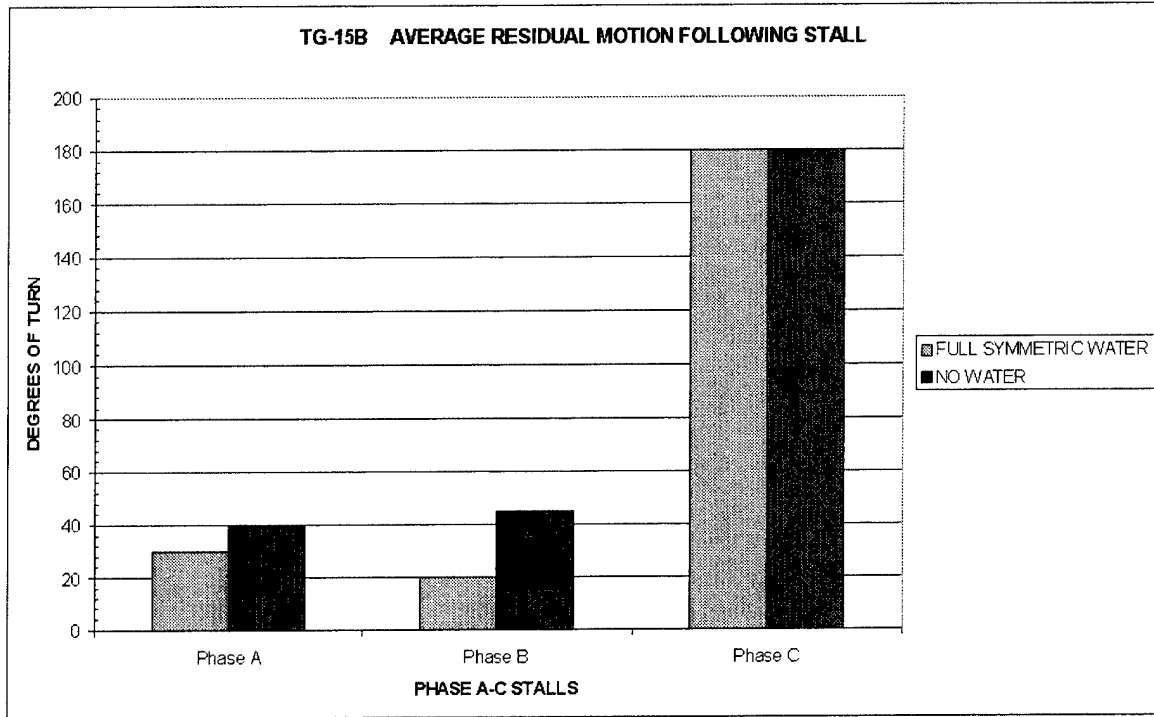


Figure 17. TG-15B Average Residual Motion Following Stall

CONCLUSIONS AND RECOMMENDATIONS

SPIN RECOVERY

Overall, the spin recovery characteristics were satisfactory for both gliders. The USAFA spin recovery proved an effective means of recovering from spins. USAFA spin recovery procedures were technically identical to the manufacturer procedures and stopped spin yaw motion in less than ½ turn for all c.g. positions tested of both gliders. The maximum altitude lost during spin recovery was 450 ft. In all cases, if the controls were neutralized after stall entry, the aircraft would self-recover and fly out of the stall.

The TG-15A and TG-15B spiral dive recovery resulted in a significant nose low attitude and increased airspeed. Large altitude loss should be expected. Slow response time to recovery could lead to an overspeed condition, while an aggressive recovery at higher speeds could lead to an over-g situation.

CROSSWIND LANDINGS

The TG-15A had less aileron control power than the TG-15B. This resulted in a tendency to drop a wing before the glider came to a complete stop during landings above 12 knots crosswind. The average lateral stick deflection exceeded 75 percent when landing above 16 knots crosswind.

(R1) Do not plan to land the TG-15A in crosswinds exceeding 16 knots.

The TG-15B had more aileron authority to keep the wings level throughout the landing roll. Successful landings were demonstrated during crosswinds of up to and including 16 knots.

(R2) Do not plan to land the TG-15B in crosswinds exceeding 16 knots.

The test team was confronted with gusty conditions and undesirable thermals while testing in the 17-20 knots crosswind band. This resulted in insufficient test data in this band.

(R3) Accomplish further testing to explore crosswinds above 16 knots.

DEPARTURE RESISTANCE WITH-WATER-BALLAST

Overall, both gliders were extremely resistant to departure with-water-ballast. Each glider was only tested at two c.g. locations, and only with full symmetric water ballast. The gliders had similar departure resistance with full water ballast compared to without-water-ballast.

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3. Cooper, G.E. and Harper, R.P., Jr., *The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities*, NASA-TN-D-5153, NASA Ames Research Center, Moffet Field, California, 1 April 1969
4. *Air Force Academy Glider Spin Recovery Validation and Crosswind Operation Investigation*, USAF TPS-TP-01B-04 Test Plan, Air Force Flight Test Center, Edwards AFB, California, 3 April 02

APPENDIX A
GLIDER ILLUSTRATIONS

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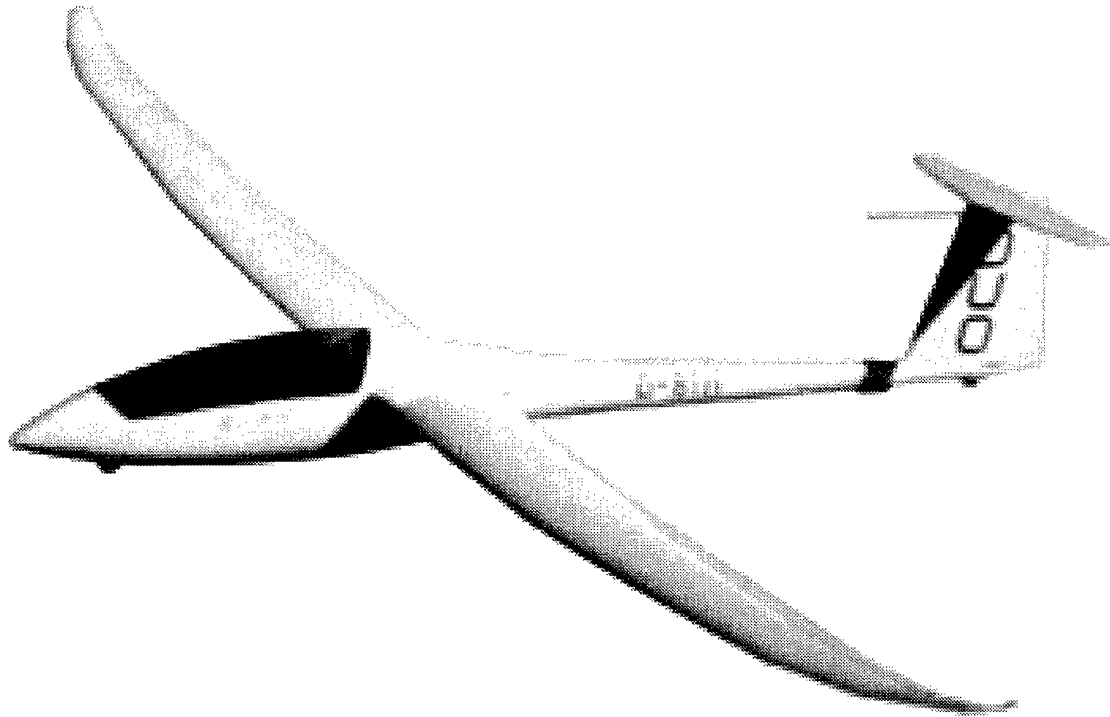


Figure A1. TG-15A (Duo Discus) – Dual Competition Glider

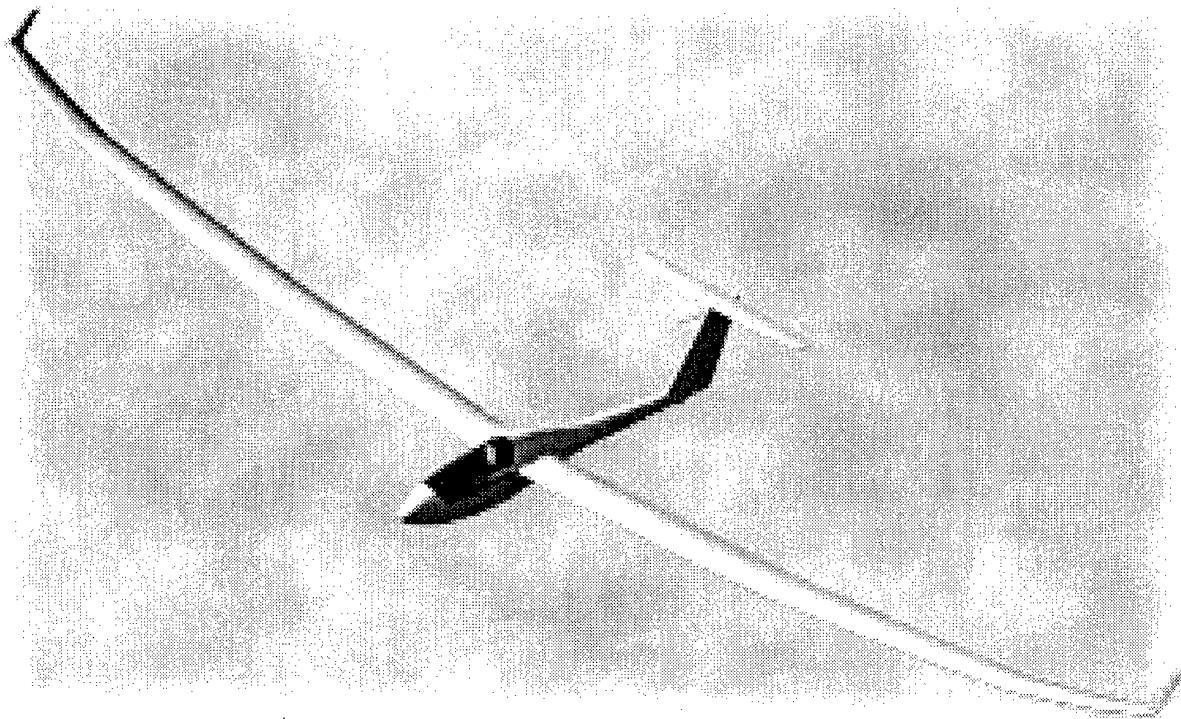


Figure A2. TG-15B (Discus-2b) – Solo Competition Glider

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APPENDIX B
WEIGHT AND BALANCE

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FORM B

Page 1/2

FORM B - AIRCRAFT WEIGHING RECORD				3-POINT							
DATE WEIGHED		2004/06/08		MODEL/DESIGN		TJQ-DISCUS		SERIAL NUMBER		N161AP	
PLACE WEIGHED		EAFF CA TECHNICIAN		FLY/NT		ORIENT		DUTY PHONE		277-3540	
REACTION	SCALE READING	CORRECTIONS	NET WEIGHT	HOR. ARM	HOR. MOM	LAT. ARM	LAT. MOM				
LEFT TAIL											
RIGHT MAIN	840	0	840								
NOSE/TAIL	100	-17	83								
TOTALS			940	-17	923	21.2					
HORIZONTAL MEASUREMENTS											
B = 2.56	Distance from the jig point to the center line of the main reactions										
I = _____	Distance from the reference datum line to the jig point										
E = _____	Distance from the reference datum line to the center line of the main reactions										
D = 207.28	Distance between the main and the nose or tail reactions										
F = _____	Distance from the reference datum line to the center line of the nose or tail reactions										
LATERAL MEASUREMENTS											
L.M. = _____	Distance from the lateral reference datum line to the Left Main reaction										
R.M. = _____	Distance from the lateral reference datum line to the Right Main reaction										
N.T. = _____	Distance from the lateral reference datum line to the Nose or Tail reaction										
ADJUSTMENTS				NET WEIGHT	H. ARM	H. MOMENT	L. ARM	L. MOMENT			
Level Weigh - No Correction											
Total (As Weighed Above)											
Total of Column I (page 2)											
Total of Column II (page 2)											
BASIC AIRCRAFT											
SIMPLIFIED HORIZONTAL MOMENT				SIMPLIFIED LATERAL MOMENT				CONSTANT		1000	
SCALE				CORRECTIONS							
SCALE TYPE: FAIRBANKS-VORSE (FLUSH)				REACTION		CALIB		SCALE		TEMP EQUI/OTHER TOTAL	
SERIAL NUMBER: 8,1				RIGHT MAIN							
CALIBRATION ACCURACY: +/- 0.02%				NOSE/TAIL		0		-4		-15	
CALIBRATION DATE: 2003/05/01											
REACTIONS USED											
MAIN AND TAIL WHEELS											
REMARKS											
W/O H ₂ O											

$$x = \frac{83 \cdot 207.28}{923} + 2.5$$

Figure B1. TG-15A (Duo Discus) Weight and Balance Without-Water-Ballast

FORM B

Page 1/2

FORM B - AIRCRAFT WEIGHING RECORD				3-POINT				
DATE WEIGHED		2004/04/08		MODEL/DESIGN		Duo-Discus		
PLACE WEIGHED		FAFB, CA		TECHNICIAN		FLW7		
				OBSERVER		DUTY PHONE		
						277-3349		
REACTION	SCALE READING	CORRECTIONS	NET WEIGHT	HOR. ARM	HOR. MOM	LAT. ARM	LAT. MOM	
RIGHT MAIN	1240	0	1240					
NOSE/TAIL	100	-17	83					
TOTALS			1340	-17	1323	15.56		
HORIZONTAL MEASUREMENTS								
B = 2.56	Distance from the jig point to the center line of the main reactions							
I =	Distance from the reference datum line to the jig point							
E =	Distance from the reference datum line to the center line of the main reactions			$x = \frac{83 \cdot 207.28}{1323} = 2.5$				
D = 207.28	Distance between the main and the nose or tail reactions							
Z =	Distance from the reference datum line to the center line of the nose or tail reactions							
LATERAL MEASUREMENTS								
LM =	Distance from the lateral reference datum line to the Left Main reaction							
RM =	Distance from the lateral reference datum line to the Right Main reaction							
NT =	Distance from the lateral reference datum line to the Nose or Tail reaction							
ADJUSTMENTS				NET WEIGHT	H. ARM	H. MOMENT	L. ARM	L. MOMENT
Level Weigh - No Correction								
Total (As Weighed Above)								
Total of Column I (page 2)								
Total of Column II (page 2)								
BASIC AIRCRAFT								
SIMPLIFIED HORIZONTAL MOMENT				SIMPLIFIED LATERAL MOMENT		CONSTANT		1000
SCALE				REACTION		CORRECTIONS		
SCALE TYPE: FAIRBANKS-MORSE (FLWSP)				CALIB		SCALE		
SERIAL NUMBER: 3,1				TEMP		EQUIP		
CALIBRATION ACCURACY: +/- 0.05%				OTHER		TOTAL		
CALIBRATION DATE: 25030801				RIGHT MAIN	0			
REACTIONS USED				NOSE/TAIL	-17	-13		
MAIN AND TAIL WHEEL								
REMARKS								
W/ H ₂ O								

Figure B2. TG-15A (Duo Discus) Weight and Balance With-Water-Ballast

FORM B

Page 1/2

FORM B - AIRCRAFT WEIGHING RECORD					3-POINT						
DATE WEIGHED		2004/04/08 MODEL/DESIGN			DISCUS - 2 B						
PLACE WEIGHED		FAFB CA TECHNICIAN			FLYNT O'BRIEN DUTY PHONE						
REACTION		SCALE READING	CORRECTIONS	NET WEIGHT	HOR. ARM	HOR. MOM	LAT. ARM	LAT. MOM			
LEFT MAIN		520	-3	517							
NOSE/TAIL		80	-15	65							
TOTALS		600	18	584	23.24						
HORIZONTAL MEASUREMENTS											
B = 5.04	Distance from the jig point to the center line of the main reactions										
L =	Distance from the reference datum line to the jig point										
E =	Distance from the reference datum line to the center line of the main reactions			$X = \frac{65 \cdot 163.39}{582} + 5.04$							
D = 163.39	Distance between the main and the nose or tail reactions										
F =	Distance from the reference datum line to the center line of the nose or tail reactions										
LATERAL MEASUREMENTS											
LM =	Distance from the lateral reference datum line to the Left Main reaction										
RM =	Distance from the lateral reference datum line to the Right Main reaction										
NT =	Distance from the lateral reference datum line to the Nose or Tail reaction										
ADJUSTMENTS					NET WEIGHT	H. ARM	H. MOMENT	L. ARM	L. MOMENT		
Level Weigh - No Correction											
Total (As Weighed Above)											
Total of Column I (page 2)											
Total of Column II (page 2)											
BASIC AIRCRAFT											
SIMPLIFIED HORIZONTAL MOMENT					SIMPLIFIED LATERAL MOMENT		CONSTANT		1000		
SCALE					CORRECTIONS						
SCALE TYPE: FAIRBANKS-MORSE (FLUSH)					REACTION	CALIB	SCALE	TEMP	EQUIP	OTHER	TOTAL
SERIAL NUMBER: 3,1					DISCUS MAIN		-3				
CALIBRATION ACCURACY: +/- 0.05%					NOSE/TAIL		-3		-12		
CALIBRATION DATE: 2003/08/01											
REACTIONS USED											
MAIN AND TAIL WHEEL											
REMARKS											
W/O H2O											

Figure B3. TG-15B (Discus-2b) Weight and Balance Without-Water-Ballast

FORM B

Page 1/2

FORM B - AIRCRAFT WEIGHING RECORD				3-POINT			
DATE WEIGHED		2004/04/08		MODEL/DESIGN		DISCUS - 2B	
PLACE WEIGHED		EAFB, CA		TECHNICIAN		FLYNT O'BRIEN	
REACTION		SCALE READING		CORRECTIONS		NET WEIGHT	
						HOR. ARM	
						HOR. MOM	
						LAT. ARM	
						LAT. MOM	
FROM MAIN		960		0		960	
NOSE or TAIL		120		-12		82	
TOTALS		1060		-12		1042	
						17.9	
HORIZONTAL MEASUREMENTS							
B =	5.04	Distance from the jig point to the center line of the main reactions					
I =		Distance from the reference datum line to the jig point					
E =		Distance from the reference datum line to the center line of the main reactions					
D =	163.39	Distance between the main and the nose or tail reactions					
F =		Distance from the reference datum line to the center line of the nose or tail reactions					
LATERAL MEASUREMENTS							
LM =		Distance from the lateral reference datum line to the Left Main reaction					
RM =		Distance from the lateral reference datum line to the Right Main reaction					
NT =		Distance from the lateral reference datum line to the Nose or Tail reaction					
ADJUSTMENTS				NET WEIGHT		H. ARM	
Level Weigh - No Correction							
Total (As Weighed Above)							
Total of Column I (page 2)							
Total of Column II (page 2)							
BASIC AIRCRAFT							
SIMPLIFIED HORIZONTAL MOMENT				SIMPLIFIED LATERAL MOMENT		CONSTANT	
						1000	
SCALE				CORRECTIONS			
SCALE TYPE: FAIRBANKS-MORSE (FLUSH)				REACTION			
SERIAL NUMBER: 3,1				CALIB SCALE TEMP EQUIP OTHER TOTAL			
CALIBRATION ACCURACY: +/- 0.05%				FROM MAIN			
CALIBRATION DATE: 2003/08/01				NOSE-TAIL			
REMARKS USED							
MAIN AND TAIL WHEEL							
REMARKS							
w/ H ₂ O							

$$x = \frac{82 \cdot 163.39}{1042} + 5.04$$

Figure B4. TG-15B (Discus-2b) Weight and Balance With-Water-Ballast

APPENDIX C
TEST MATRICES

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Spins Flt #	Crew	CG	GW	Spins Flt #	Crew	CG	GW
33	PILOT3/CREW1	3.6	1328	3	PILOT2/PILOT1	5.75	1267
33	PILOT3/CREW1	3.6	1328	3	PILOT2/PILOT1	5.75	1267
33	PILOT3/CREW1	3.6	1328	3	PILOT2/PILOT1	5.75	1267
33	PILOT3/CREW1	3.6	1328	3	PILOT2/PILOT1	5.75	1267
33	PILOT3/CREW1	3.6	1328	6	PILOT1/CREW2	6.88	1260
33	PILOT3/CREW1	3.6	1328	6	PILOT1/CREW2	6.88	1260
33	PILOT3/CREW1	3.6	1328	6	PILOT1/CREW2	6.88	1260
33	PILOT3/CREW1	3.6	1328	6	PILOT1/CREW2	6.88	1260
33	PILOT3/CREW1	3.6	1328	6	PILOT1/CREW2	6.88	1260
33	PILOT3/CREW1	3.6	1328	6	PILOT1/CREW2	6.88	1260
33	PILOT3/CREW1	3.6	1328	7	PILOT4/PILOT1	6.72	1247
33	PILOT3/CREW1	3.6	1328	7	PILOT4/PILOT1	6.72	1247
33	PILOT3/CREW1	3.6	1328	7	PILOT4/PILOT1	6.72	1247
33	PILOT3/CREW1	3.6	1328	7	PILOT4/PILOT1	6.72	1247
33	PILOT3/CREW1	3.6	1328	7	PILOT4/PILOT1	6.72	1247
33	PILOT3/CREW1	3.6	1328	7	PILOT4/PILOT1	6.72	1247
4	PILOT3/PILOT1	3.42	1307	7	PILOT4/PILOT1	6.72	1247
4	PILOT3/PILOT1	3.42	1307	7	PILOT4/PILOT1	6.72	1247
4	PILOT3/PILOT1	3.42	1307	29	PILOT4	8	1106
4	PILOT3/PILOT1	3.42	1307	29	PILOT4	8	1106
5	CREW1/PILOT1	3.96	1295	29	PILOT4	8	1106
28	PILOT2/CREW2	4.9	1298	29	PILOT4	8	1106
28	PILOT2/CREW2	4.9	1298	29	PILOT4	8	1106
28	PILOT2/CREW2	4.9	1298	10	PILOT4	8.66	1098
28	PILOT2/CREW2	4.9	1298	10	PILOT4	8.66	1098
28	PILOT2/CREW2	4.9	1298	10	PILOT4	8.66	1098
28	PILOT2/CREW2	4.9	1298	10	PILOT4	8.66	1098
28	PILOT2/CREW2	4.9	1298	10	PILOT4	8.66	1098
28	PILOT2/CREW2	4.9	1298	10	PILOT4	8.66	1098
28	PILOT2/CREW2	4.9	1298	8	PILOT1	9.25	1088
28	PILOT2/CREW2	4.9	1298	8	PILOT1	9.25	1088
26	PILOT2/CREW2	4.9	1298	8	PILOT1	9.25	1088
28	PILOT2/CREW2	4.9	1298				

Figure C1. TG-15A Spin Sortie Test Matrix

Spins Flt #	Crew	CG	GW	Spins Flt #	Crew	CG	GW
48	PILOT3	11.45	792	52	PILOT3	12.3	782
48	PILOT3	11.45	792	42	PILOT1	14.16	739
48	PILOT3	11.45	792	42	PILOT1	14.16	739
48	PILOT3	11.45	792	43	PILOT1	13.61	744
48	PILOT3	11.45	792	43	PILOT1	13.61	744
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	45	PILOT4	13.17	754
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
48	PILOT3	11.45	792	50	PILOT2	12.84	769
51	PILOT2	11.82	779	50	PILOT2	12.84	769
51	PILOT2	11.82	779	52	PILOT3	12.3	782
51	PILOT2	11.82	779	52	PILOT3	12.3	782
51	PILOT2	11.82	779	52	PILOT3	12.3	782
51	PILOT2	11.82	779	52	PILOT3	12.3	782
51	PILOT2	11.82	779	52	PILOT3	12.3	782
51	PILOT2	11.82	779	52	PILOT3	12.3	782
51	PILOT2	11.82	779	52	PILOT3	12.3	782
52	PILOT3	12.3	782	52	PILOT3	12.3	782

Figure C2. TG-15B Spin Sortie Test Matrix

X-wind Flt #	DATE	Crew	CG	Weight	Wind dir-mag	RWY	Crosswind Band			
							1-8	9-12	13-16	17-20
8	20-Apr	PILOT2	11.82	779	240/10	28		17		
3	20-Apr	PILOT4	13.17	754	240/10	22				
4	20-Apr	PILOT4	13.17	754	240/10	22				
9	20-Apr	PILOT2	12.84	769	260/10	28		3.4		
7	20-Apr	PILOT3	12.3	782	240/08	22				
10	20-Apr	PILOT2	12.84	769	240/12	28		8.4		
11	20-Apr	PILOT3	12.3	782	250/14	22				
19	22-Apr	PILOT1	14.16	739	010/16	04		8		
20	22-Apr	PILOT2	12.84	769	330/13	34		2		
18	22-Apr	PILOT3	12.22	784	350/08	28				
24	22-Apr	PILOT3	12.22	784	290/15	28				
25	22-Apr	PILOT3	12.22	784	020/13	34				
21	22-Apr	PILOT1	14.16	739	010/20	04			10	
30	22-Apr	PILOT3	11.3	792	250/23	28				
23	22-Apr	PILOT2	12.84	769	010/11	28			11	
22	22-Apr	PILOT1	14.16	739	010/16	28				16
27	22-Apr	PILOT1	14.16	739	010/14	28				14
26	22-Apr	PILOT2	12.84	769	010/13	28				13
31	22-Apr	PILOT3	12.22	784	020/16	10				
28	22-Apr	PILOT1	14.16	739	020/16	10				16
32	22-Apr	PILOT3	12.22	784	020/17	10				17

Figure C3. TG-15A Crosswind Sortie Test Matrix

X-wind Ft #	DATE	Crew	CG	Weight	Wind dir/mag	RWY	Crosswind Band			
							1-8	9-12	13-16	17-20
5	12-Apr	CREW1 PILOT1	3.96	1295	VRB004	28	4			
40	15-Apr	PILOT3 CREW2	4.75	1305	200/14	22	4			
7	12-Apr	PILOT4 PILOT1	6.72	1247	240/04	28	3			
61	22-Apr	PILOT5 CREW2	5.44	1290	300/06	28	2			
22	14-Apr	PILOT3 PILOT1	3.28	1309	240/19	28		12		
39	15-Apr	PILOT3 CREW2	4.75	1305	200/18	28				
41	15-Apr	PILOT3 CREW2	4.75	1305	220/12	28				
25	14-Apr	PILOT3 PILOT1	3.28	1309	260/26	28				
35	15-Apr	PILOT3 CREW1	3.6	1328	210/10	28				
11	19-Apr	PILOT4 PILOT1	6.72	1247	240/16	28				
17	14-Apr	PILOT2 PILOT1	5.75	1267	260/13	22		9		
18	14-Apr	PILOT2 PILOT1	5.75	1267	270/12	28			10	
63	22-Apr	PILOT6 CREW2	6.15	1275	010/18	34		9		
20	14-Apr	PILOT2 PILOT1	5.75	1267	250/15G20	16				15
23	14-Apr	PILOT3 PILOT1	3.28	1309	240/22	28				
13	19-Apr	PILOT4 PILOT1	6.72	1247	240/16	16				15
29	15-Apr	PILOT4	8	1105	210/16	28				15
31	15-Apr	PILOT4 CREW2	5.28	1285	210/17	28				15
19	14-Apr	PILOT2 PILOT1	5.75	1267	290/14	28				13
28	15-Apr	PILOT2 CREW2	4.9	1298	210/16	28				15
59	22-Apr	PILOT7 CREW2	4.75	1305	280/18	22				16
24	14-Apr	PILOT3 PILOT1	3.28	1309	260/24	22				17
7	12-Apr	PILOT4 PILOT1	6.72	1247	270/20	16				19
34	15-Apr	PILOT3 CREW1	3.6	1328	210/18	28				
36	15-Apr	PILOT3 CREW1	3.6	1328	210/18	28				
33	15-Apr	PILOT3 CREW1	3.6	1328	210/18	28				
16	19-Apr	PILOT4 PILOT1	6.72	1247	240/20	16				19
37	15-Apr	PILOT4 CREW1	6.3	1277	210/18	28				17
38	15-Apr	PILOT4 CREW1	6.3	1277	200/20	28				20
21	14-Apr	PILOT2 PILOT1	5.75	1267	250/17G20	16				17

Figure C4. TG-15B Crosswind Sortie Test Matrix

APPENDIX D
COOPER-HARPER AND PIO RATING SCALES

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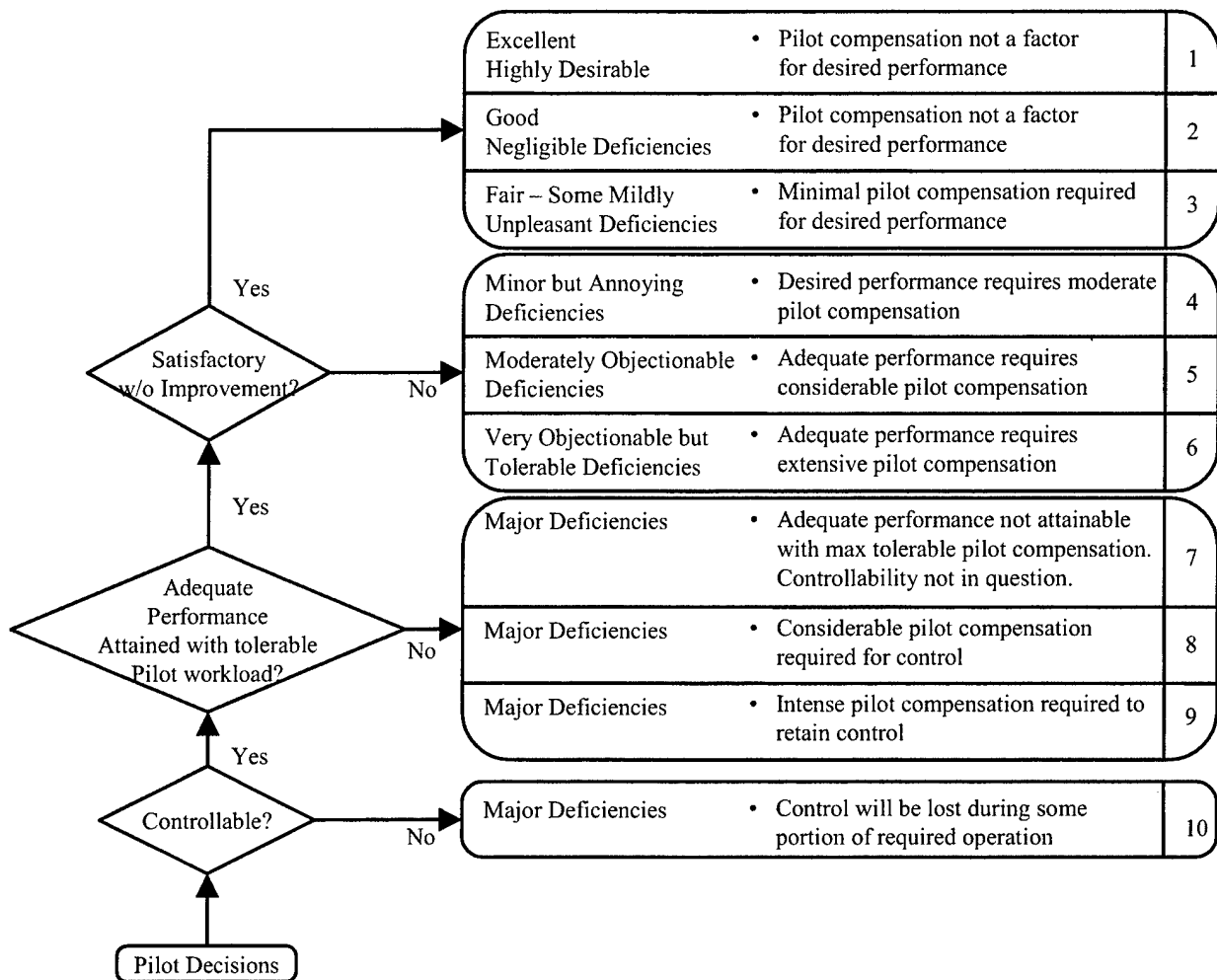


Figure D1. Cooper-Harper Rating Scale

PIO RATING SCALE	
Did I experience a PIO?	
NO	
Did I experience undesirable motion?	
NO.....	1
YES	
Did undesirable motion <i>tend</i> to occur?.....	2
Was undesirable motion <i>easily induced</i> ?...	3
<hr/>	
YES	
While attempting abrupt maneuvers or tight control	
Was the PIO bounded?.....	4
Was the PIO divergent?.....	5
While exercising normal control.....	6

Figure D2. PIO Rating Scale

APPENDIX E
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