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HIGH ACCELERATION COCKPIT CONTROLLER LOCATIONS

Volume III - Onsite Pilot Evaluations

McDonnell Aircraft Company
St. Louis, Missouri 63166

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AIR FORCE FLIGHT DYNAMICS LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

NOTICE

This final report was submitted by McDonnell Aircraft Company, St. Louis, Missouri, a division of McDonnell Douglas Corporation, under Contract F33615-74-C-3093, job order 61900326, with the Air Force Flight Dynamics Laboratory. Mr. James A. Uphaus, Jr. was the Laboratory's Technical Monitor.

This report has been reviewed by the Information Office (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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A High Acceleration Cockpit evaluation program was conducted for an advanced fighter concept. Program effort included evaluations within the context of a mission scenario by a total of 40 operational pilots in a static design aid (20 pilots each at Nellis AFB and Edwards AFB). Various specific areas of the concept were evaluated as well as the overall need/utility of the crew station. Resulting measures allowed identification of those areas where future R&D effort should be focused.

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FOREWORD

This technical report summarizes research performed at McDonnell Aircraft Company (MCAIR), P. O. Box 516, St. Louis, Missouri, 63166, a division of McDonnell Douglas Corporation, under Air Force Contract F33615-74-C-3093 (P00002), Project 6190, from 1 June 1974 to December 1974. This report consists of three volumes:

Volume I	Program Summary
Volume II	Test Plan
Volume III	Onsite Pilot Evaluations

The contract was initiated under AF Project 6190, "Control-Display for Air Force Aircraft and Aerospace Vehicles," which is managed by Mr. J. H. Kearns, III, as project engineer and principal scientist for the Flight Deck Development Branch, (AFFDL/FGR), Flight Control Division, Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. The work was performed as a part of Task Number 6190 0326 under the guidance of Mr. J. A. Uphaus, Jr. (AFFDL/FGR) as task engineer.

High Acceleration Cockpit Program activities are conducted within the McDonnell Aircraft Company (MCAIR) Advanced Aircraft Systems Project, under the cognizance of Mr. H. H. Ostroff, Director - Advanced USAF Fighter/Attack Systems. This project is an element of MCAIR Advanced Engineering, directed by Mr. H. D. Altis, Director - Advanced Engineering Division. The High Acceleration Cockpit Project is managed by Mr. J. M. Sinnett, Project Advanced Design Engineer.

The principal contributors to this volume and for the program elements reported here, in addition to the authors, are: D. C. Gendreau, Senior Design Engineer; S. L. Loy, Senior Engineer Psychologist; L. L. Pingel, Senior Design Engineer; and J. W. Roberts, Technical Specialist, Avionics.

Successful accomplishment of the cockpit remote evaluation tasks were made possible through the patient cooperation and helpful suggestions of the Air Force Pilot Teams at Edwards Air Force Base and Nellis Air Force Base.

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LIST OF ABBREVIATIONS AND SYMBOLS

A/A, A-A	Air-to-Air
AAI	Air-to-Air IFF
A/C	Aircraft
ACF	Air Combat Fighter
ACM	Air Combat Maneuvering
AFCS	Automatic Flight Control System
A/G	Air-to-Ground
CAP	Carrier Air Patrol
Chan	Channel
CRT	Cathode Ray Tube
Comm	Communications
DFC	Direct Force Control
Depr	Depress
DLF	Direct Lift
DSF	Direct Side Force
ECM	Electronic Countermeasures
ECS	Environmental Control System
Eng	Engine
EO	Electro Optical
FBW	Fly-By-Wire
Fus	Fuselage
G	Load Factor
Gen	Generator
HAC	High Acceleration Cockpit
HUD	Head-Up Display

LIST OF ABBREVIATIONS AND SYMBOLS (Cont'd)

Hyd	Hydraulic
IFF	Identification Friend or Foe
INS	Inertial Navigation System
LGB	Laser Guidance
LWF	Lightweight Fighter
MCAIR	McDonnell Aircraft Company
MDC	McDonnell Douglas Corporation
MSD	Multi-Sensor Display
MVR	Maneuvering
NAV	Navigation
O_2, Oxy	Oxygen
R and D	Research and Development
RDR	Radar
SAM	Surface-to-Air Missile
SEA	South East Asia
SEL	Select
SRM	Short Range Missile
TACAN	Tactical Air Navigation
TEWS	Tactical Electrical Warfare System
UHF	Ultra High Frequency
USAF	United States Air Force
VEC	Vector
VEL	Velocity
WPN	Weapon

SECTION I

INTRODUCTION AND SUMMARY

This report describes the High Acceleration Cockpit design aid, test procedures, and evaluation results obtained from a large group of operational fighter pilots at Nellis AFB and Edwards AFB.

The overall objectives were to determine pilot acceptance of the concept, validate the design approach, and identify those potential areas where the crew station design may be improved to increase pilot combat effectiveness.

The High Acceleration Cockpit Controller Location Program is the latest in a series of exploratory development programs performed by McDonnell Aircraft Company (MCAIR) under sponsorship of the Air Force Flight Dynamics Laboratory, Flight Deck Development Branch (AFFDL/FGR), under USAF Contract F33615-74-C-3093, Project 6190. During this program and the previous effort, Reference (1), major elements of a High Acceleration Cockpit (HAC) have been evaluated by operational Air Force pilots. Refinements were suggested and implemented as appropriate. The primary design and operational areas which have been investigated are:

- Articulating seat design and mechanization
- Flight and Throttle Controller location and mechanization
- Secondary control/display layout
- Crew station integration
- Fixed base simulation to illustrate ACM advantage for the HAC approach.

Throughout these studies the participating pilots have universally encouraged continued development of the High Acceleration Cockpit concepts. Both fixed base simulation and centrifuge data have illustrated the potential performance benefits which can be derived.

The data base for these early experiments was limited to a rather small pilot sample. To expand the data base, evaluations were conducted at Nellis AFB, Nevada and Edwards AFB, California using the full scale minimum size cockpit mockup shown in Figure 1. The evaluation was performed by a group of 20 pilots at each base ranging in rank from Captain to Brigadier General with total flight experience exceeding 97,000 hours. This evaluation in conjunction with a series of pilot questionnaires was used to determine pilot acceptance of the overall concept and some of its specific design features. Acceptance of the HAC approach was very high with only three pilots expressing direct doubts (mainly centered on safe escape) as to the practicability of the concept.

The pilots, without exception, felt that G tolerance improvement was necessary for future fighter aircraft. Many pilots also considered G tolerance improvement beneficial for current aircraft in both the air-to-air and ground attack roles.

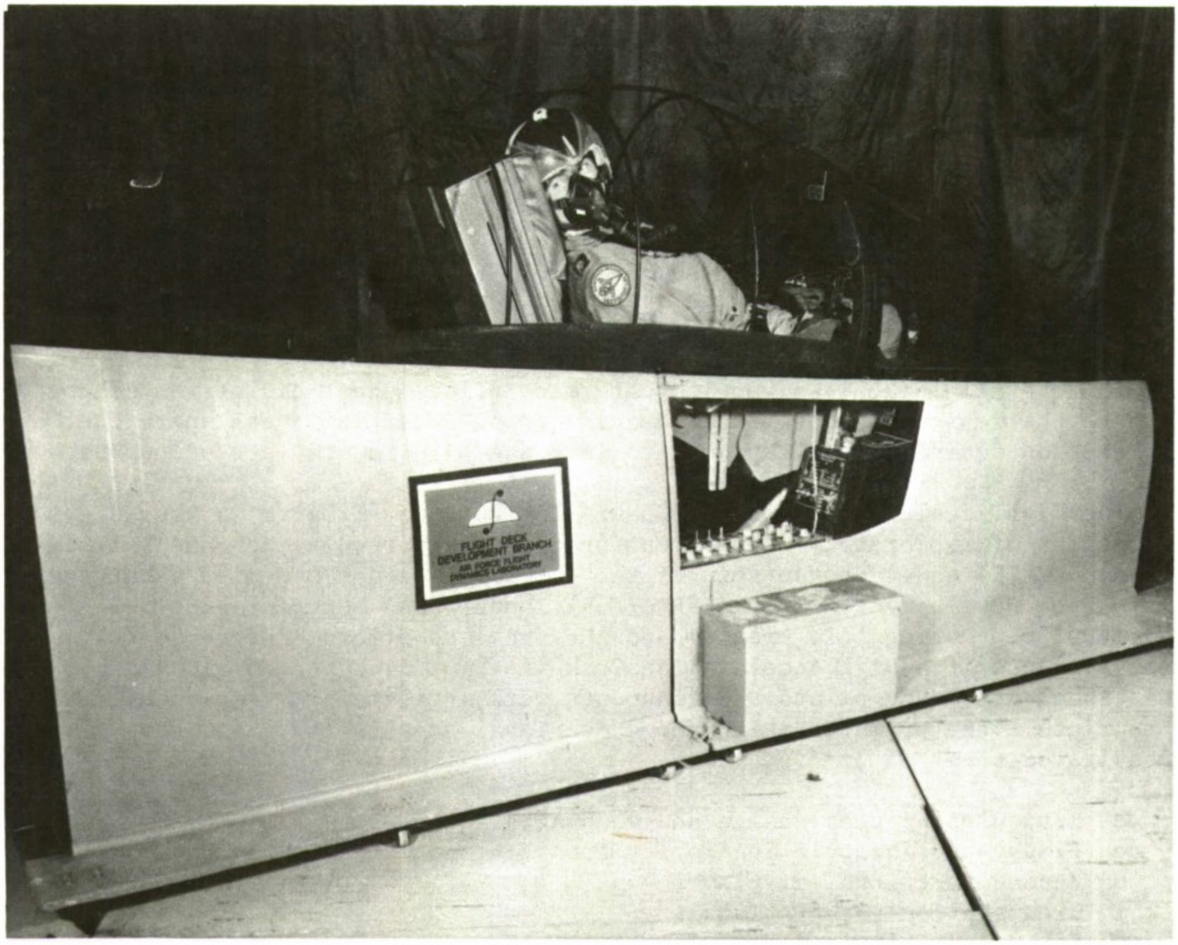

FIGURE 1
HIGH ACCELERATION COCKPIT DESIGN AID

A summary of the major comments obtained at both bases during the testing and debriefing follows:

o Head Rest - Too large, restricts rear vision, cannot roll head when reclined. Possible modifications mentioned were shorter head rests and rollers to reduce helmet friction for improvement in head mobility and aft vision.

o Rudder Pedals - The need to readjust the pedals forward during articulation was experienced by nearly all pilots. The pilots would adjust the pedals in the upright position for maximum pedal throw which resulted in the need for readjustment when reclined. Use of limited displacement pedals with isometric overtravel should improve this. Incorporation of an electric adjust feature and/or automatic readjustment during articulation may be required. Some pilots also expressed the need for heel cups under high G loading. Due to the forward slant of the pedals many pilots found it difficult to apply the brakes.

o Throttles - The shape of the grips (contour and slope) was liked by almost all pilots however switch placement was less than ideal. Clearance between the throttles and sill was considered unacceptable by many pilots. More clearance is required (current clearance is 1/4 inch).

o Flight Controller - The shape of the grip received wide acceptance with very few complaints. Most pilots would have preferred that the seat recline switch operate in the reverse direction (forward for upright). A dedicated trim control is required as opposed to the integrated/mode select approach used in the design aid. A displacement stick was preferred over an isometric.

o Arm Rests - Arm rests are required in both the upright and reclined seat positions.

o Seat - Most pilots considered the seat very comfortable. In the reclined position some of the shorter pilots experienced interference between their shoulders and the lower portion of the head rest.

The above are the major comments from the evaluation. Numerous other comments, pertaining to the above items and particular controls and displays, are included in the following sections.

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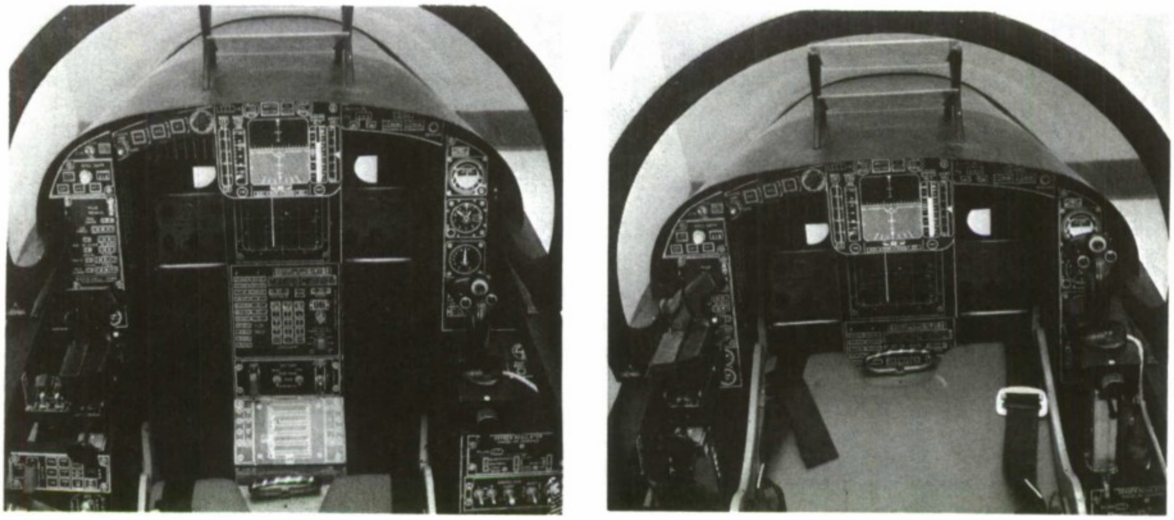
SECTION II

COCKPIT DESCRIPTION

The High Acceleration Cockpit is shown in Figure 2. Primary features of this cockpit are:

- An articulating seat which orients the pilot with respect to the load vector
- Compatible control/display layouts in both upright and reclined seat positions
- Mechanized side arm controllers which maintain effective pilot/controller orientation.



Upright **Reclined**

FIGURE 2
HIGH ACCELERATION COCKPIT

The reclining ejection seat, shown in Figure 3, articulates from an upright position (20° back angle) to a reclined position (65° back angle) while maintaining a constant external visual capability and primary flight and engine control access. The combination of the reclined seat and G suit will provide the pilot with adequate protection for sustained maneuvering at reduced fatigue and work levels to load factors approaching 7G, with excursions as high as 10G.

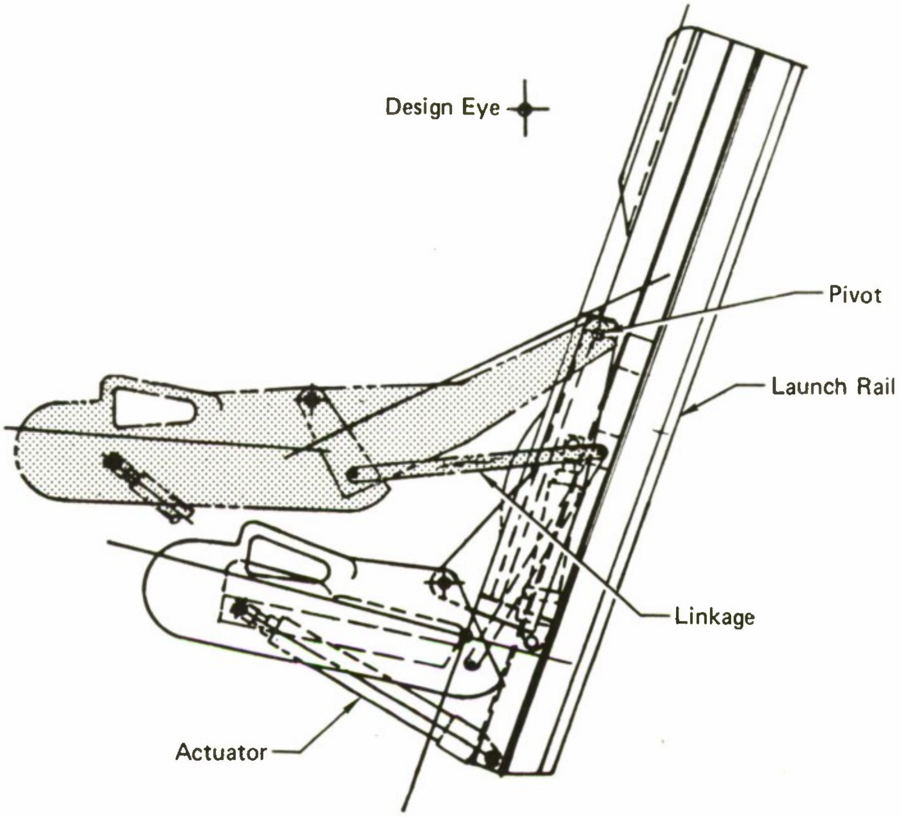


FIGURE 3
ARTICULATING EJECTION SEAT

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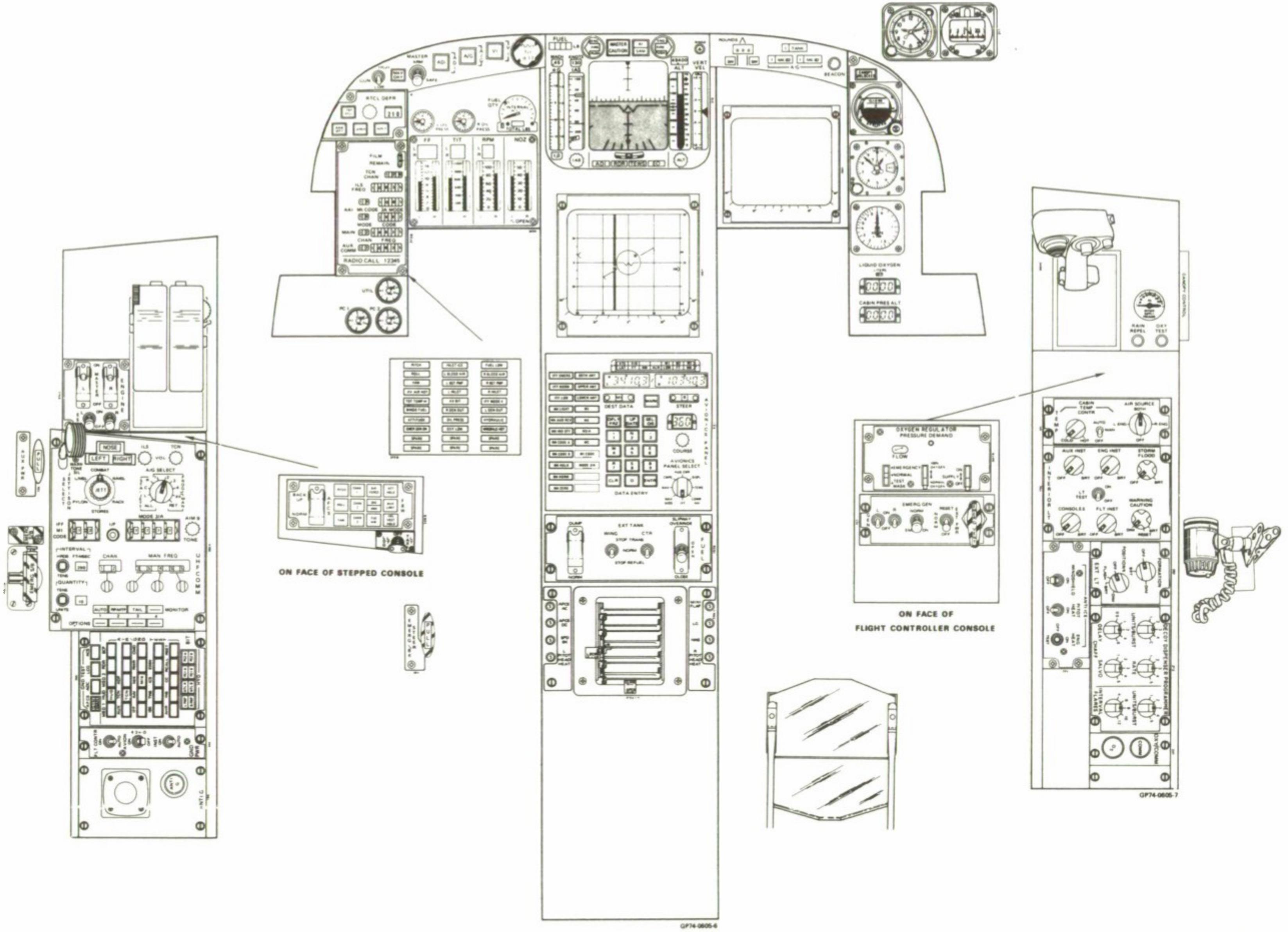
The control display layout developed for this seat concept, with side arm controllers is shown in Figure 4. Primary weapons delivery displays and flight displays are on the HUD. Multi-sensor CRT's, master caution and avionics controls are located forward on the centerline. Secondary displays (engine and caution warning) are recessed above the knees. Rapid access panels, incorporating master arm, jettison, gun rate, and CRT mode switches are designed at the top of the main instrument panel, immediately under the glare shield. A side arm hand controller is integrated into the right side of the cockpit. Remaining panel/console space on the right side is devoted to either display or noncritical controls. Armament, AFCS, landing gear, propulsion controls, and emergency handles are located on the left side.



ON FACE OF STEPPED CONSOLE

ON FACE OF FLIGHT CONTROLLER CONSOLE

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FIGURE 4
CONTROL/DISPLAY LAYOUT

The controller location used in the evaluations is illustrated in Figure 2 with the seat in a reclined position. Mechanization of this concept provides near constant pilot/controller orientation for both the upright and reclined seat positions. The grips are adjustable, both fore and aft and vertically, with an additional six inches of vertical travel during articulation.

The flight controller shown in Figure 5 incorporates provisions for the basic flight control functions (pitch and roll) through force applied to the grip or small angular displacements. Additionally, the following functions are incorporated to provide accessibility and to reduce workload during critical mission phases. A multi-function thumb-operated control in conjunction with a mode select provides in-flight trim, manual fuselage aiming, and direct lift/side force capabilities. A visual cue on the HUD indicates the current operating mode. Weapons release and the gun trigger are positioned in the normal locations. A nose gear steering/automatic radar acquisition mode dual function bush button is located on the lower portion of the grip and is activated by the little finger. When weight is on the wheels, this button provides a nose gear steering mode. After gear retraction this push button operates as an automatic radar acquisition selector. A two-position switch is provided on the right side for seat control. This control is located on the grip to allow pilot access synchronous with G command and also to provide immediate access while the seat is reclined in the event of an emergency situation.

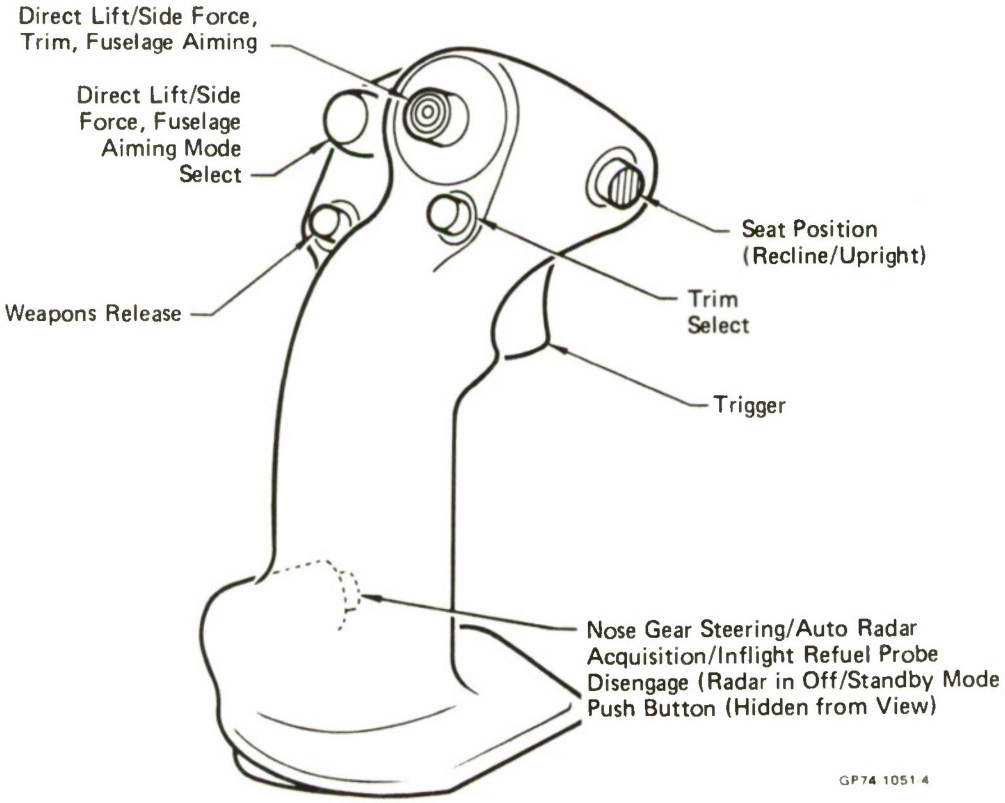

FIGURE 5
FLIGHT CONTROLLER FUNCTIONS

The throttles are canted at a 35° angle to reduce grip width as shown in Figure 6. A radar designator control is mounted on the front of the throttle. A three-position weapon/mode select switch and missile/weapon uncage push button are mounted on the side surface of the right throttle. The weapon mode select switch is used to select gun, AIM-9L missiles, or missile reject. When the missile mode is selected and master arm activated, the uncage push button uncages either missiles or bombs depending on programmed flight phase (air-to-air and air-to-ground). For other weapon mode selections, this button provides rudder trim. Finger lift controls are provided for engine cutoff. Five additional controls are located on the throttle to perform the following functions: (1) speed brake/modulated drag, (2) communications - transmit/receive, (3) IFF interrogate, (4) ECM - chaff/off/special ECM Dispenser or Flares, and (5) radar antenna elevation.

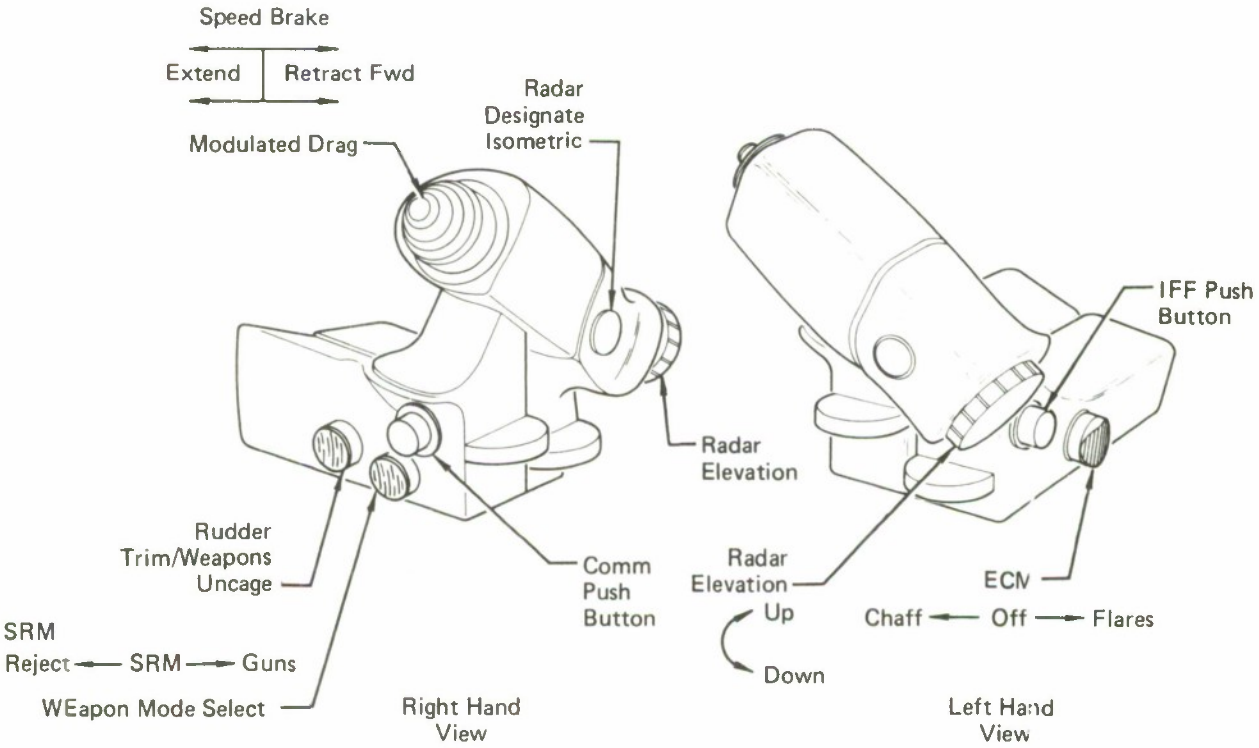

FIGURE 6
THROTTLE CONTROL FUNCTIONS

SECTION III

EVALUATION PROCEDURE AND TEST RESULTS

The evaluation was conducted with each pilot sitting in the design aid, wearing his flight suit, flight helmet, oxygen mask, anti-G suit and gloves, and restrained by the shoulder harness and lap belt. A total of forty pilots from Edwards Air Force Base, California, and Nellis Air Force Base, Nevada, participated in this evaluation. The test sessions and test results are described below in the order in which this evaluation was performed.

PREBRIEFING

A briefing on the background of the HAC design approach was presented to the participating pilots prior to the start of the evaluation. The purpose of this session was to provide the test subjects with sufficient prior knowledge of the system in order to make valid evaluative responses during the structured evaluations. The following elements were covered in the orientation: High Acceleration Cockpit approach, background, utility and payoff characteristics, potential tactics pertinent to direct lift and direct side force features, organization of mission segments, structure of test plan and schedule, basis for combat tracking using manned simulation, and cockpit design.

BACKGROUND QUESTIONNAIRE AND REPLIES

A pilot background questionnaire was used to determine pilot experience in aircraft, combat and exposure to high load factor maneuvers. The range of test subject experience is illustrated in Table 1. These data lend credence for generalizing the test data to the pilot population. The thirty-eight pilots who completed the questionnaire all met the requested requirements of:

- o Jet pilots, current flight status in fighter type aircraft
- o Air combat experience and/or air-to-ground weapons delivery experience
- o High load factor experience.

The pilots had flight experience covering over fifty-four different aircraft types. F-4 flight experience accounted for approximately 27,000 of the 92,070 total flight hours. Assuming comparable experience for the remaining two pilots, the total flight hours would exceed 97,000 hours.

The background questionnaire also included a question to determine if the pilots felt that G tolerance improvement is necessary. The replies presented below represent a cross section of pilot responses.

"For high speed maneuvering, yes - as might be expected in F-15 and ACF type aircraft. Much maneuvering done with current (Summer '74) operational aircraft probably done under 5-6G."

TABLE 1
PILOT BACKGROUND

QUESTION	PILOT RESPONSE
Aircraft Current in 27,000 to 1,330 Flight Hours (Listed in Descending Order)	F-4, T-38, A-7, T-33, F-111, KC-135
Other Aircraft Experience 6,520 to 100 Flight Hours (Listed in Descending Order)	F-100, T-37, F-105, F-86, F-106, F-101, A-4, OV-10, C-141, O-2, A-37, F-104, F-102, F-80, T-28, T-39, F-8, F-9 (An additional 30 A/C types were noted with less than 100 flight hours each)
Total Flight Hours	1000-6000 +Hours (Average 2430)
Air-To-Air Combat Experience	1 Pilot - Korea 8 Pilots - Southeast Asia (SEA) 24 Pilots - Air Combat Maneuver (ACM) Practice 5 Pilots - No Experience
Air-To-Ground Weapons Delivery Experience	34 Pilots - SEA 1 Pilot - Training 3 Pilots - No Experience
Load Factor (G) Experience	10 Pilots - Less than 7G 28 Pilots - 7G or Greater
Rank	1 Brigadier General 3 Lieutenant Colonels 2 Lieutenant Commanders 7 Majors 25 Captains

Note: This data pertains only to the 38 pilots who completed and returned the pilot background questionnaire.

"Yes. Vision, judgement and mobility are all restricted with present day seat design. The pilot must be able to perform at maximum capability when the aircraft is performing at its maximum."

"Yes, but not just to allow me to subject the aircraft to more G, but rather so I can use available G if necessary. By itself, G does not win fights - correct employment of G wins."

"Yes. There is no doubt that performance in flight is reduced as G builds. Increased tolerance will allow improved performance (such as target acquisition and tracking - both air and ground)."

"Yes. It is important to match the pilot's physiological capability with the increased G capability of future aircraft. The pilot of the future must feel "natural" in long duration high G maneuvers."

"Yes, aircraft limits dictated available G until clean F-4. Then Mach 1.0 plus maneuvering was commonplace with 8.0G sustained for short duration ....but for hit and run tactics new aircraft have greater G available - pilots haven't changed and will be incapable of keeping up with technology unless seat positions are changed. Combat and safety both in training and combat dictates more tolerance, otherwise advances in aircraft maneuvering are wasted."

"Definitely. If we can build aircraft to pull and sustain up to 10G we will have a great advantage over any type of enemy. But we have to be able to physically cope with such high load factors, especially when sustained."

"Yes. Even the limited air-to-air capability of the A-7D would be improved by increasing G tolerance."

"Yes, definitely. In the T-38 at around 5-1/2 G I have a definite loss of visual acuity. It probably starts lower than that, but this is about the regime in which it becomes noticeable. At higher G loads visual search is difficult if not impossible. For example, in a hard turning engagement if visual contact with the bogie were lost and he didn't reappear where expected, it would be necessary to relax to attempt to reacquire him. Additionally, it is almost impossible under such conditions to see another bogie or a wing-man. Secondly, increased G tolerance on the part of the pilot will allow the pilot to maximum perform modern fighter aircraft which are structurally capable of higher G forces."

"Yes, under high G loads, (6G to 7G), moving, breathing and talking are very difficult which make it hard to maneuver the aircraft. Greyouts and blackouts occur under different G loads on various days. Although greyouts and blackouts are not physically uncomfortable, they are annoying and cause a temporary loss of sight of the target or cause one to relax G at a time when he may not wish to do so. To me it would be most desirable to fly an aircraft to its G limits for sustained periods without worrying about breathing, talking or blackouts."

"Yes. Not necessary for air-to-ground - definitely needed for air-to-air to allow the pilot to function properly keeping aware of the total situation and allowing him to maneuver vs his adversary."

"It is vital since loss of vision is the first symptom of high G flight and retention of vision (maintaining sight of opponent) is vital in an engagement. It obviously also allows the pilot to perform tighter turns at higher Gs, so he can out-maneuver the opponent."

ANTHROPOMETRIC MEASURES

Anthropometric measurements were taken for the pilots. These measurements were made in order to learn relative pilot size for such dimensions as sitting eye height and reach distance. By knowing each pilot's relative size, his responses and capabilities in succeeding test sessions became even more meaningful to the evaluators. Measurements were made with the pilot either standing or sitting in an erect manner. Corresponding percentiles of these measures are shown in Table 2 (percentiles are based on 1967 Survey of USAF Flying Personnel).

TABLE 2
PILOT ANTHROPOMETRIC PERCENTILE

MEASURE	MINIMUM(1)	MAXIMUM(1)	MEAN(1)	MEAN(2)	STANDARD(2) DEVIATION
Weight	4	98	65	170.4	20.0
Stature	32	100	83	71.4	2.5
Eye Height	22	100	82	66.9	2.6
Sitting Height	1	100	56	36.2	1.5
Eye Height (Setting)	1	100	50	31.5	1.5
Knee Height	12	100	80	22.5	0.9
Arm Reach From Wall	3	99	52	34.7	1.7

Notes: 1) Units are in percentile.
2) Units are pounds for weight and inches for other measures.

In general, the pilots comprised an excellent sample with which to evaluate a crew station designed to accommodate the 5th through 95th percentile pilot population. This sample contained small, large, light, and heavy pilots. The critical measures came very close to providing the desired 5th through 95th percentile measurements.

The distributions by pilot size for arm reach from wall and sitting eye height are presented in Figures 7 and 8. These two factors have the primary influence on internal cockpit design. The arm reach from wall determines what the pilot can reach without leaning forward. Reach is also influenced by sitting eye height in that low percentile pilots must adjust the seat towards the upper adjust limit which places them further away from the controls.

The plots are shown for equal percentile increments. For a perfect pilot sample each increment would contain the same percentage of pilots. This ideal case is nearly met for the arm reach from wall as shown in Figure 7. The distribution for sitting eye height is weighted towards the extremes as shown in Figure 8. However, since all percentile ranges were adequately covered, the results presented in subsequent sections are considered representative of the general pilot population.

VISION ENVELOPES

The pilot's internal cockpit visual envelope was determined in both the upright and reclined seat positions. The pilots were seated in the design aid and adjusted vertically to provide 15° over-the-nose vision. He was restrained by the seat belt and wore his flight helmet, O_2 mask, and G suit. Pilots were asked to avoid head movement and to use only eye motion for internal cockpit scan.

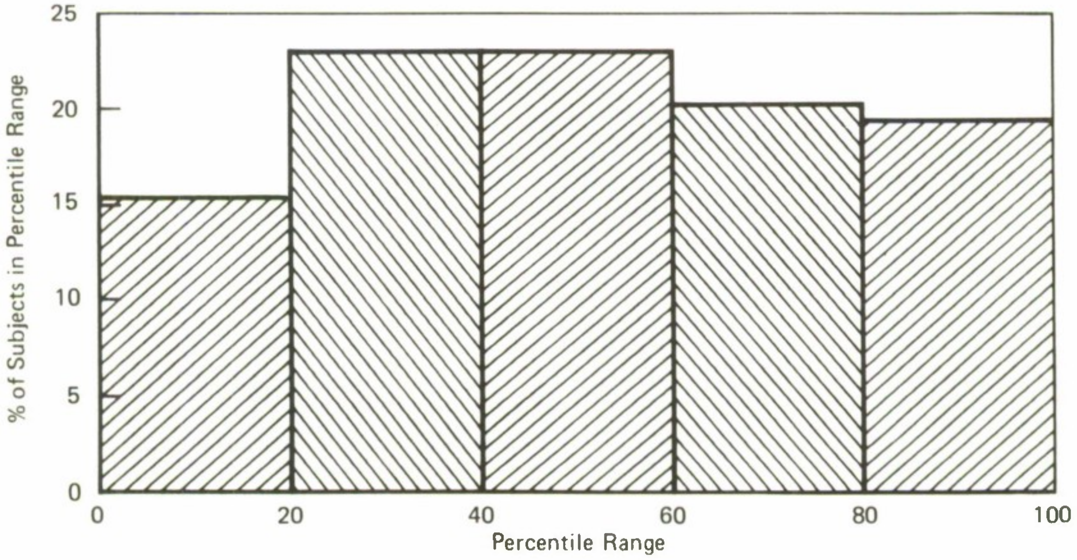

FIGURE 7
ARM REACH FROM WALL
Percent Distribution

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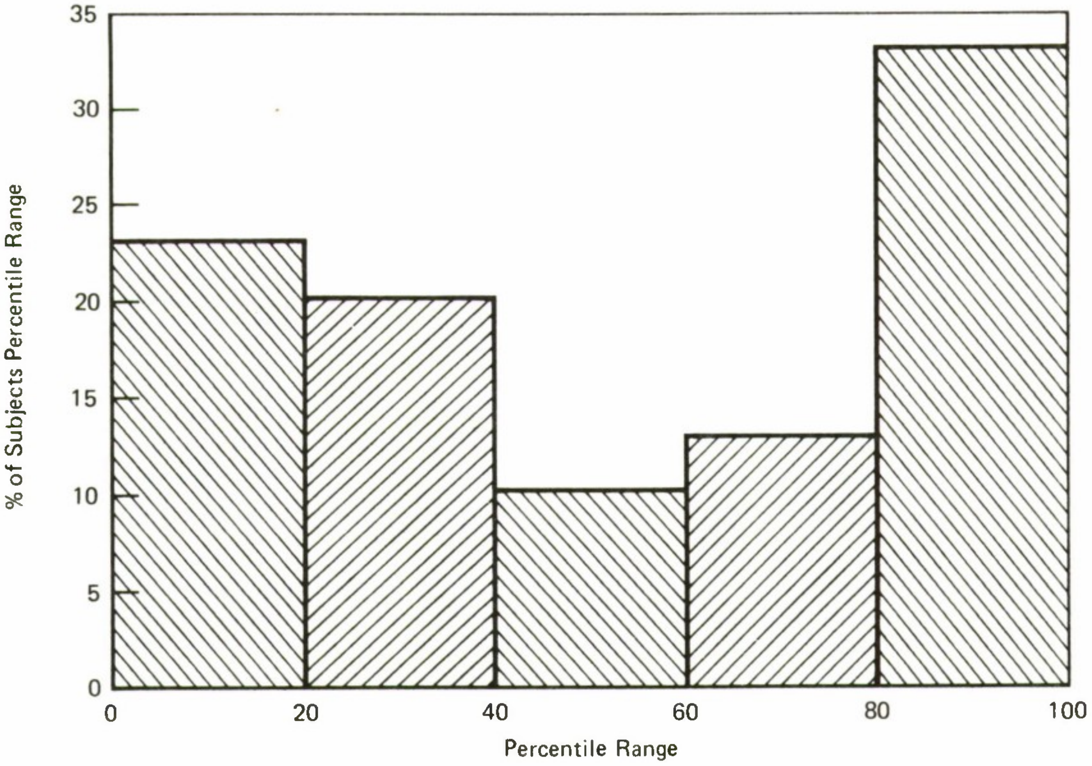

FIGURE 8
SITTING EYE HEIGHT
Percentile Distribution

The data obtained is presented in Figure 9 for the upright position and Figure 10 for the reclined position. If head motion were allowed, 100% of the cockpit would be viewable except for that area blocked by the articulating seat at the 65° back angle. The visual masking is presented for the best case (minimum masking) and the worst case (maximum masking). In general, visual masking increases with increasing weight and decreasing height.

Additionally an additive area of masking on the center console is noted for two USN pilots who wore the standard 13A Navy O_2 mask. The size of the mask is considerably larger than the AF mask due to the valve design.

The primary area of concern in visual masking is determining what functions are viewable in the reclined position. The maximum masking, neglecting the USN O_2 mask, still permits uninhibited viewing of the top center MSD and the rapid access panels which is considered the primary display area, in addition to the HUD, in the reclined position.

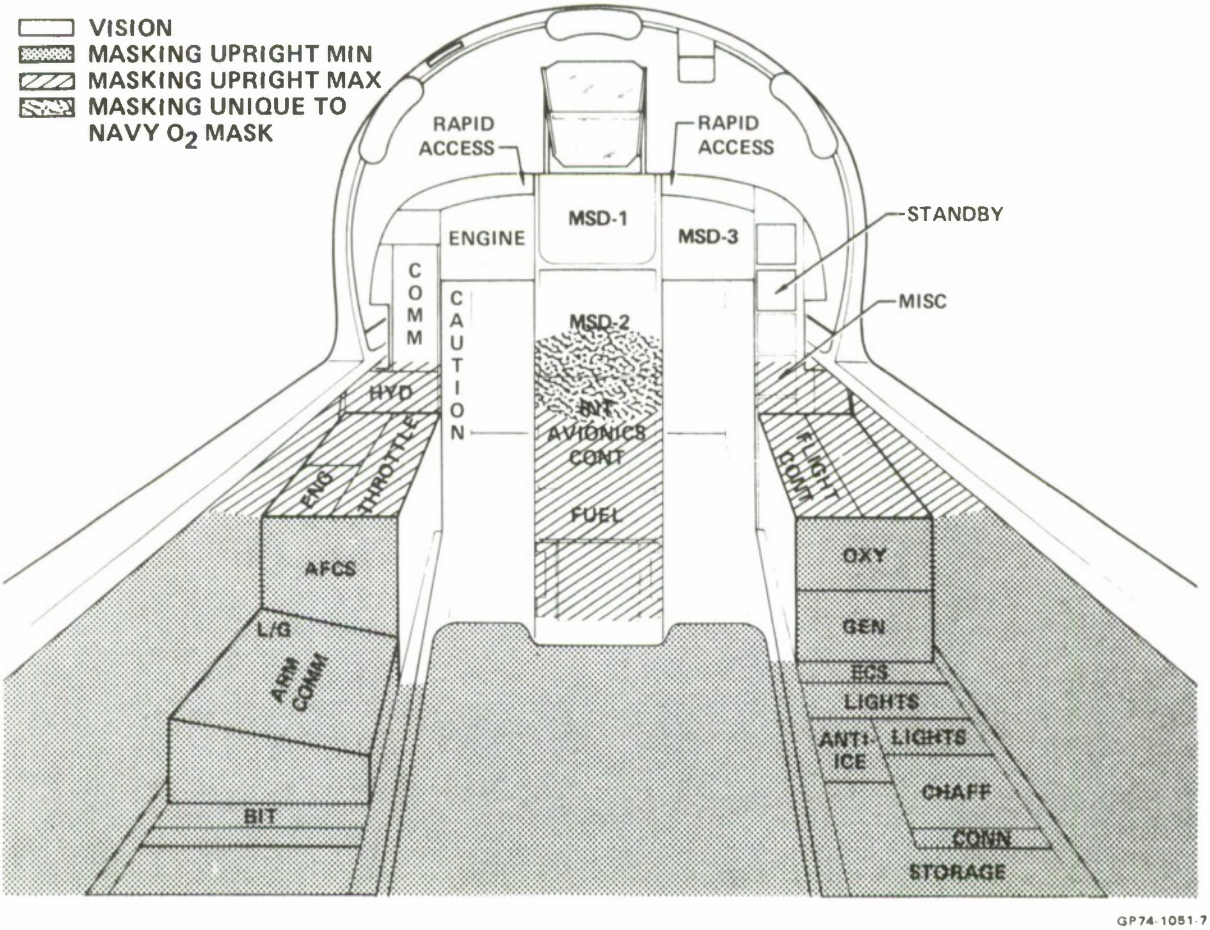

FIGURE 9
VISION ENVELOPE
Seat Upright   Fixed Head/Eye Position

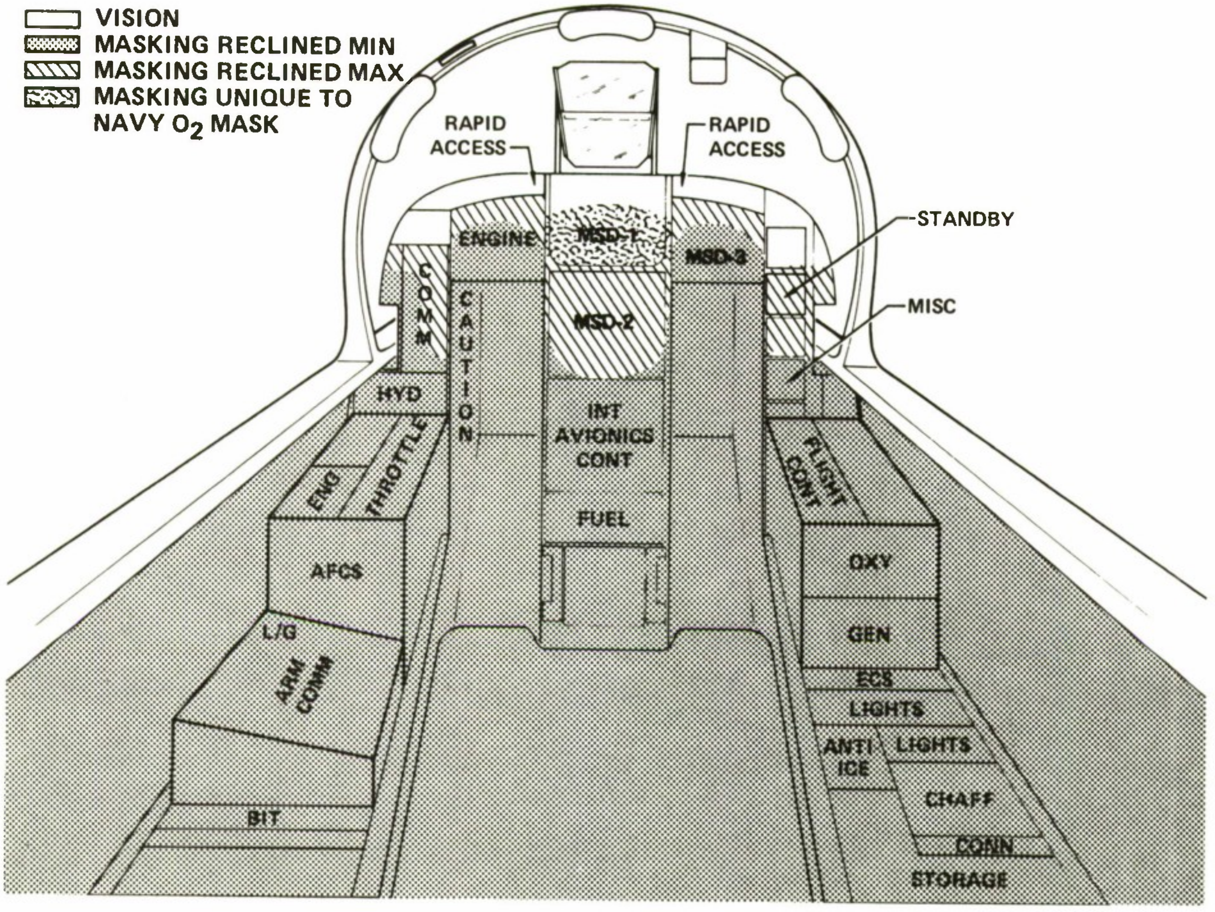

FIGURE 10
VISION ENVELOPE
Seat Reclined Fixed Head/Eye Position

REACH ENVELOPES

Reach envelopes were established in both the upright and reclined position with the pilot restrained in the seat. He was asked to reach certain areas of the cockpit without leaning forward. When a pilot was unable to reach specific areas the reach discrepancy was noted. Test results are shown in Figures 11 and 12. The areas are categorized into three classes:

1) Panel area within reach of all pilot subjects
2) Panel area which some pilots were unable to reach
3) Panel area beyond the reach of all subjects.

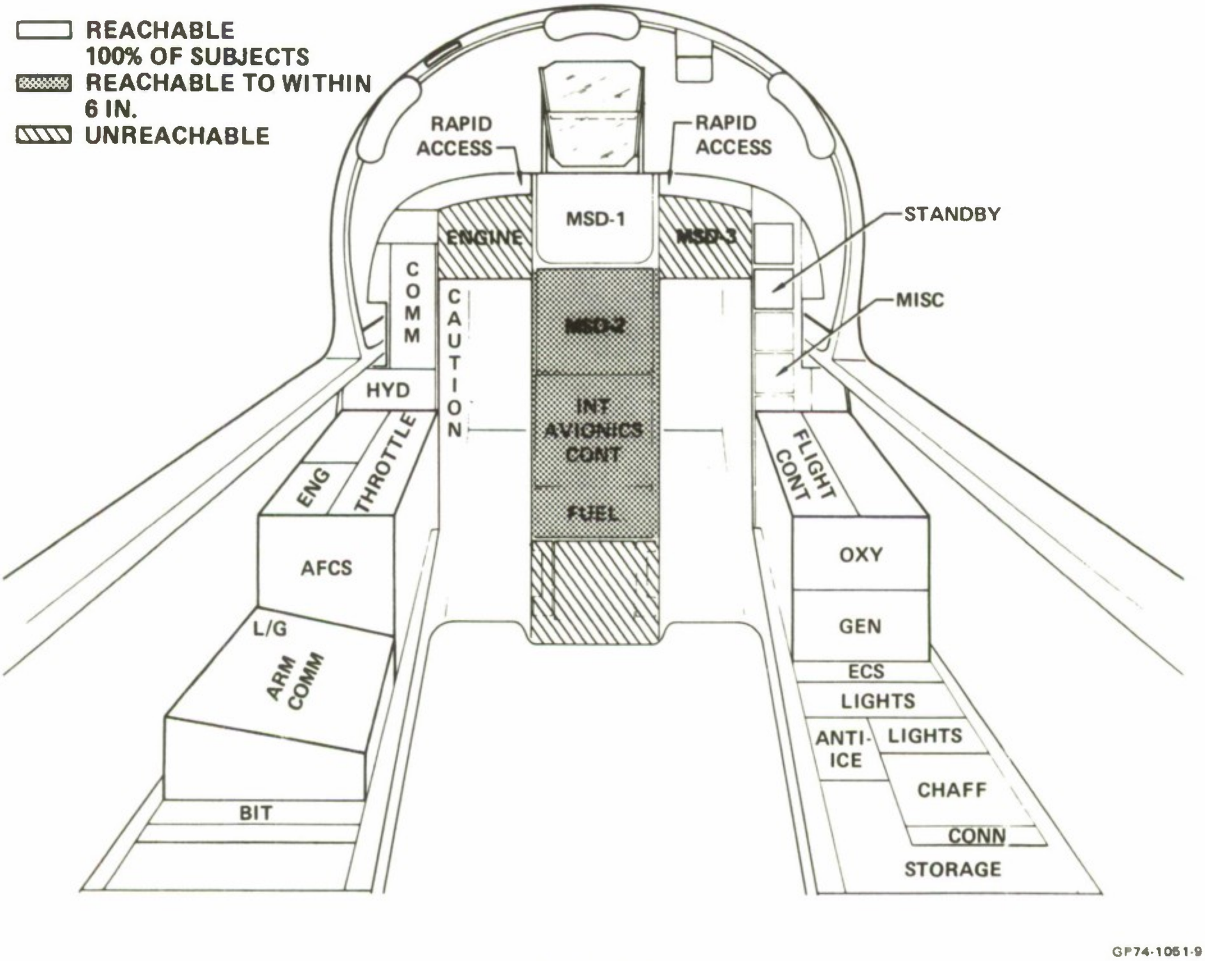

FIGURE 11
REACH ENVELOPE
Seat Upright Shoulders Against Backrest

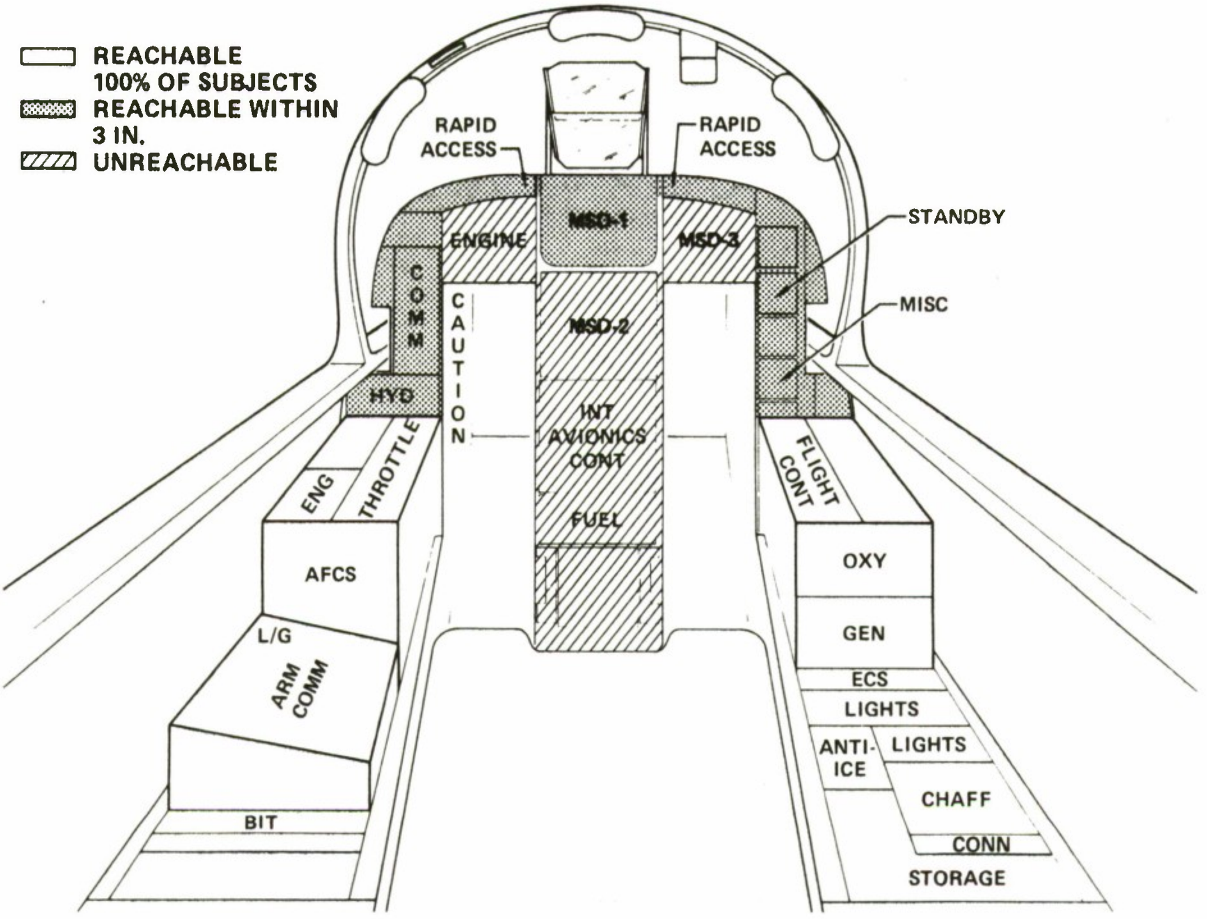

FIGURE 12
REACH ENVELOPE
Seat Reclined Shoulders Against Backrest

The panel area which some pilots could not reach when they were restricted to maintain contact with the back rest was reachable by minor stretching or leaning forward in both the upright and reclined seat positions. Unreachable areas of the cockpit include the recessed panels (which are designed for displays only) and that portion of the center console which is restricted due to seat articulation.

MISSION SCENARIO

The mission scenario was presented by the test conductor, who called out the tasks as well as specific design features. The objective was to evaluate the control/display configuration in terms of impact on pilot performance. The test subject's response (which describes his ability to do the task) was recorded and scored on a "yes," "no," "maybe" scale. The pilot was able to express his opinion or expand his comment and rating as he felt appropriate at any time throughout the test. Prior to the mission scenario the primary cockpit functions to be evaluated were described to each pilot. Visual aids were used to illustrate sensor display modes and improve the pilot's capability to evaluate the cockpit utility.

Each test subject, wearing his flight gear, completed four segments of a mission -- cruise, SAM Evasion, LGB Delivery, and Air-to-Air Combat. Only tasks critical to the mission segment were evaluated. The seat was in the upright position for cruise segment and the reclined position for the SAM Evasion, LGB Delivery, and Air-to-Air Combat segments.

Cruise Tasks

A brief cruise segment was performed by the pilot with the seat in the upright position. Tasks primarily centered on flight control system checkout and avionics set-up. The tasks performed during the cruise phase which received negative responses (maybe or no) from the pilots are listed in Table 3. Primarily the problem areas centered on using the Fly-By-Wire (FBW) panel and the integrated avionics panel. For pilots with shorter reach the throttles were adjusted aft which obscured the FBW panel and made its operation difficult. Reach presented a similar problem with the avionics panel in that some pilots were required to lean forward to operate the controls. Redesign of the throttle and improved comm status, FBW and avionics panel accessibility will eliminate 63 of the 66 maybe responses and all 16 of no responses. The three remaining maybe tasks center on the need for arm rests which is a potential R&D area.

SAM Penetration/Evasion Tasks

For this segment pilot tasks involved threat detection, evasion, and ECM countermeasures. Negative responses received in this segment are presented in Table 4. The task which received the largest negative response was "Monitor Threat Display". This response was primarily due to partial obscuring of the recessed display in the right leg cutout with the seat reclined. With the seat in the upright seat position displaying TEWS on MSD-2 as a map overlay would potentially alleviate this problem. In the reclined position TEWS may be displayed on MSD-1 using the mode select. Activating ECM also presented a problem in that some pilots felt that the switch was difficult to reach and operate. By locating the TEWS on MSD-2 and performing initial SAM detection in the upright position in conjunction with a redesign of the throttle grip/switch location 28 of the 33 maybe responses and 3 of the 5 no responses would be eliminated. The remaining 5 maybe and 2 no responses concern the head rest and arm support which are candidate R&D areas for the HAC

TABLE 3
CRUISE TASKS
Receiving Negative Responses

TASK	RESPONSES			NEGATIVE COMMENTS
	YES	MAYBE	NO	
MONITOR FBW STATUS	28	9	3	Obscured by throttles
ACTIVATE FBW DFC, MVR, FUS AIM	31	5	4	Interference from throttles
USE DLF/DSF AS REQUIRED	39	1	0	Arm rests required
DISENGAGE FBW VEL VEC	38	1	1	Interference from throttles
CONTROL NEW ALTITUDE (AS REQ'D)	38	2	0	Need arm support
SELECT NAV	38	2	0	Reach too short, does not want to lean forward
SELECT COMM/AAI	36	4	0	Put comm controls on left front panel
SELECT CHAN SEL	34	5	1	Buttons too small, reach too short
DEPR KEYS TO SELECT UHF CHANNEL	35	4	1	Reach too short
MONITOR CHANNEL	39	1	0	Difficult to see readout
ADJUST COMM VOLUME	39	1	0	Reach too short
SELECT MAP RDR MODE	32	6	2	Reach too short
SELECT NAV	34	5	1	Reach too short
POSITION CURSOR OVER DESTINATION VIDEO RETURN	34	5	1	Difficult to operate, sill interference
DEPRESS UPDATE (BEST PRESENT POSITION)	32	7	1	Reach too short
DEPRESS CLEAR (PRESENT POSITION NOT DESIRED)	31	8	1	Reach too short
TOTAL	558	66	16	
CORRECTABLE THROUGH REDESIGN		63	16	
CANDIDATE R&D AREA o ARM SUPPORT		3	0	

TABLE 4
SAM PENETRATION/EVASION TASKS
Receiving Negative Responses

TASK	RESPONSES			NEGATIVE COMMENTS
	YES	MAYBE	NO	
MONITOR THREAT DISPLAY	26	13	1	O_2 mask blockage, must have on MSD-1, part of display obscured
PERFORM JINKING MANEUVER	38	2	0	Need better arm support
DETECT ENEMY RDR LOCKED ON	39	1	0	Display obscured
COMM ENEMY RDR PAINT	38	2	0	Move comm button higher
ACTIVATE ECM	30	9	1	Small hands - difficult to reach, switch IFF & ECM; sill interference
DETECT SAM	36	3	1	Head rest blocks vision
PERFORM EVASIVE MANEUVERS	39	0	1	Need better arm support
MONITOR THREAT DISPLAY	39	1	0	Use of 3rd display may be a problem
COMM CLEAR, JOIN UP	37	2	1	Should not be required to move hand, G suit could activate button
TOTAL	322	33	5	
CORRECTABLE THROUGH REDESIGN		28	3	
CANDIDATE R&D AREAS				
o HEAD REST		3	1	
o ARM SUPPORT		2	1	

concept. The switches on the throttle and flight controller were the subject of an additional questionnaire. Responses, including suggested modifications, are presented in following sections.

Laser Guided Bomb Delivery Tasks

The bomb delivery was performed in the reclined position. A slide presentation of a ground target was employed to improve static simulation realism. Those tasks which received negative responses were primarily centered on reach problems. The frequency of response for the tasks receiving negative replies is presented in Table 5. Improved access to the top portions of the instrument panel with possible relocation of controls and redesign of the throttles eliminates 11 of the 14 maybe responses. The remaining negative responses (3 maybe, 1 no) can be resolved through redesign of the armament status display.

Air-To-Air Combat Tasks

In the air-to-air segment the cockpit utility in both gun and missile combat situations was evaluated. Pilot tasks included typical combat elements ranging from threat detection and radar designation through gun and missile release. Primary emphasis was placed on the mission segment where the operational benefits of a high acceleration cockpit should be most pronounced. For this mission phase no single task received more than three negative responses which is due to the cockpit being designed primarily for the air-to-air combat role. Reach and throttle design problems were again encountered for some tasks as noted in Table 6. Redesign to improve reach and throttle switch location as noted above will eliminate 12 of the 15 maybe responses (head rest vision blockage and automatic seat are subjects for R&D effort).

TABLE 5
LASER GUIDED BOMB DELIVERY TASKS
Receiving Negative Responses

TASK	RESPONSES			NEGATIVE COMMENTS
	YES	MAYBE	NO	
SELECT EO	37	3	0	Reach too short
COMM ALPHA	39	1	0	Relocate switch
ACTIVATE A/G MASTER MODE	39	1	0	Reach too short
DEPRESS MASTER ARM ON	37	3	0	Reach too short
VERIFY ARM POSITIONS	36	3	1	Does not like location, wants all stations on display
SELECT EO FOR MSD 1	38	2	0	Reach too short
COMM CHARLIE	39	1	0	Relocate switch
TOTAL	265	14	1	
CORRECTABLE THROUGH REDESIGN		14	1	

TABLE 6
AIR-TO-AIR COMBAT TASKS
Receiving Negative Responses

TASK	RESPONSES			NEGATIVE COMMENTS
	YES	MAYBE	NO	
SELECT TEWS ON MSD 1 MODE CONT	37	2	1	Short reach
CONDUCT OUTSIDE SEARCH	39	1	0	Head rest blocks vision
SELECT RDR DESIG MODE	38	2	0	Short reach
DEPR/HOLD INTERROGATION BUTTON FOR PER	39	1	0	Difficult to reach button
RECEIVE WING COMM CHARLIE	39	1	0	G suit interference
SELECT SRM WPN MODE	39	1	0	G suit interference
ACTIVATE MASTER ARM TO ARM	39	1	0	Reach too short
POSITION SEAT FOR HIGH G	38	2	0	Wants automatic seat
DEPR MISSILE UNCAGE SWITCH	39	1	0	Difficult to reach
SELECT GUN WPN MODE	38	2	0	Difficult to reach - wrist pad interference
SELECT GUN FIRE RATE HIGH	39	1	0	Reach too short
TOTAL	424	15	1	
CORRECTABLE THROUGH REDESIGN		12	1	
CANDIDATE R&D AREAS				
o AUTOMATIC SEAT*		2	0	
o HEAD REST		1	0	

*Based on pilot questionnaires and discussion, a seat which reclines automatically at same predetermined G level is not a desirable feature.

QUESTIONNAIRES

Two sets of questionnaires were completed to evaluate specific design aspects of the design aid and evaluate "in an overall sense" the utility of the cockpit in typical fighter aircraft mission roles. The "in cockpit" questionnaire was administered by the test conductor following the mission scenario evaluation phase. The pilots were then given an additional questionnaire which was completed prior to the debriefing.

Responses to the questions were requested based on the nine point rating scale shown in Figure 13. This scale represents a slightly modified version of the Cooper-Harper rating scale. Results of the questionnaire are tabulated in Table 7. This questionnaire delt mainly with specific design features of the cockpit, with emphasis on the throttle and flight controller. In no case did an item receive a "mean" rating in the unacceptable range.

1	Excellent; Highly adequate	Superior in meeting all requirements and expectations	Acceptable and Satisfactory
2	Good	Pilot compensation not a factor for desired performance	
3	Fair	Adequate for mission without improvement. Minimal pilot compensation for desired performance	
4	Reluctantly acceptable	Minor but annoying deficiencies. Improvement requested. Moderate pilot compensation for desired performance	Acceptable but Unsatisfactory
5	Poor	Moderately objectionable deficiencies. Improvement needed. Considerable pilot compensation for desired performance	
6	Borderline acceptability	Very objectionable deficiencies. Major improvement needed. Extensive pilot compensation for desired performance	
7	Bad	Major deficiencies. Improvement mandatory. Maximum pilot compensation for minimum acceptable performance	Unacceptable
8	Very Bad	Major deficiencies. Improvement mandatory. Inadequate performance even with maximum pilot compensation	
9	Totally unacceptable	Cannot be used at all for significant portion of required operation	

FIGURE 13
NINE POINT RATING SCALE

The location of the engine instrument group was downgraded by some pilots due to partial obscuring of the engine oil pressure gages and fuel gages. If these items were redesigned to improve visibility the rating should increase to the satisfactory range.

TABLE 7
IN COCKPIT QUESTIONNAIRE

9 Point Scale

AREA EVALUATED	MEAN RATING	STANDARD DEVIATION	PILOT COMMENTS
1. Location of engine instrument group with upright seat operation.	3.62	1.65	Portions of engine oil pressure and fuel gage obscured - Basic location acceptable
2. Location of Push to Jettison for upright seat operation.	1.92	0.81	Would like separate tank jettison and relocate selective jettison rotary. Basic location of control good.
3. Shape and location of Weapon Mode Select switch on throttle.	3.72	1.82	Some pilots had difficulty reaching switch - should be different shape than rudder trim/weapons uncage switch.
4. Shape and location of Rudder Trim/Weapons Uncage switch on throttle.	4.13	1.66	Same comments as No. 3
5. Shape and location of ECM control on throttle.	4.58	1.73	Difficult to actuate with little finger would be better if ECM and IFF controls switched, reshape ECM switch head more like toggle.
6. Location of communications control on throttle.	2.61	1.11	Location would be improved if switched with speed brake control but location is good.
7. Shape and location of engine cutoff controls on throttle.	2.69	1.10	Based on function and frequency of use location is fair to good.
8. Orientation of throttles.	3.54	1.76	Basic orientation good but some interference with sill noted by pilots - need more.
9. General contour or shape of throttles.	2.51	1.29	Well liked by majority of the pilots - a small percentage with large hands felt that the grip was too small.
10. Shape and location of Speed Brake/Modulated Drag Control on throttle.	2.21	1.06	Location fine, however many pilots felt that comm control should be located in this area. Reshape speed brake switch head like slide switch.
11. Location of radar elevation control on throttle.	2.85	1.22	Some interference with the sill was noted when operating this rotary.
12. Location of radar designate control on throttle.	3.97	1.64	Index or forefinger location would improve rating. If comm and speed brake/modulated drag functions interchanged there is adequate internal grip space for index finger location.

See Figure 4 for Control/Display Layout
5 for Flight Controller
6 for Throttle

TABLE 7 (Continued)
IN COCKPIT QUESTIONNAIRE

AREA EVALUATED	MEAN RATING	STANDARD DEVIATION	PILOT COMMENTS
13. Location of IFF control on throttle.	3.36	1.39	Somewhat difficult to actuate but based on frequency of use location acceptable.
14. Number of controls on throttle.	3.08	1.06	With experience pilots felt that quantity of controls would not present a problem.
15. Number of functions per control on the throttle.	3.51	1.43	Integration of dual functions on same switch disliked by some pilots.
16. General contour or shape of flight controller.	2.26	1.01	Very well liked - only a small percentage of pilots with large hands downgraded shape.
17. Location of trim control on flight controller.	3.53	1.60	Location acceptable - pilots want dedicated trim control
18. Location of fuselage aiming mode on flight controller.	2.74	1.02	Location acceptable - new head like illustration in Figure 4 more desirable.
19. Shape and location of seat position switch on flight controller.	2.64	0.93	Location good - reshape head more like toggle - many pilots preferred to pull switch to recline as opposed to pushing.
20. Location of Emergency Speed Brake with seat upright.	4.05	1.49	Major downgrading due to elbow interference with sill and seat when operating this control - move forward to improve accessibility. (Located under left sill)
21. Location of Decoy Dispenser Programmer with seat upright.	3.05	1.05	Location acceptable based on use as compared to other panels. (Located on right console)
22. Location of Engine Control Panel with seat upright.	3.31	1.44	Some downgrading due to interference with landing gear control. (Located outboard of throttles)
23. Location of Landing/Taxi Lights with seat upright.	3.41	1.94	Some downgrading due to interference with landing gear control - difficult to see with throttles adjusted full aft. (Located below throttles)
24. Location of AFCS Panel with seat upright.	3.99	2.09	With throttle location pilot adjusted aft, panel was difficult to see and operate - caused low rating by pilots with short reach. (Located below throttles)

See Figure 4 for Control/Display Layout
5 for Flight Controller
6 for Throttle

TABLE 7 (Continued)
IN COCKPIT QUESTIONNAIRE

AREA EVALUATED	MEAN RATING	STANDARD DEVIATION	PILOT COMMENTS
25. Location of fuel control panel with seat upright.	2.89	1.39	Location good for IFR and fuel dump/transfer functions
26. Switch design, layout and identification on fuel control panel.	2.87	0.92	Reshape center toggles for more switch differentiation

Many of the switch functions on the throttle received an unsatisfactory rating including the weapons mode select, rudder trim/weapons uncage, ECM, radar designate, and IFF functions. Although it may prove impractical to raise all ratings to the satisfactory range, these ratings can be improved by slightly increasing the size of the throttles thereby permitting better location of the switches. Improved switch head design would also improve the ratings. Increasing the size of the throttles would require a slightly wider sill width. The remaining switch locations, including the basic shape of the throttles, received satisfactory ratings but there is potential for improvement as noted in Table 7.

Areas evaluated relative to the flight controller received satisfactory ratings except for the trim function. Although the question on the trim control was concerned only with location, many pilots gave a poor rating due to the integration of the trim function with the center isometric control. By providing a dedicated trim control the rating would be satisfactory. The shape of the flight controller received a very good rating by nearly all pilots.

Other areas receiving unsatisfactory ratings include the location of the emergency speed brake control and those items obscured by the throttles at idle (engine control panel, Landing/Taxi Lights, AFCS panel). These ratings can be improved by redesigning the throttle/console layout in the areas affected and moving the emergency speed brake control forward.

Following the cockpit evaluation the pilots were given a questionnaire which included evaluation of mission related features in the reclined position and specific design features. The results of this questionnaire are summarized in Tables 8 and 9.

The accessibility to essential flight and propulsion controls received a satisfactory rating for all mission phases. The visibility of these functions was slightly downgraded by the pilots with visibility during cruise receiving the poorest rating. As the question specifically related only to the reclined position, the rating for cruise would improve if asked for the upright seat position. For air-to-air combat, which was the primary design criteria in the reclined position, both the visibility and accessibility of flight and propulsion controls received satisfactory ratings.

The visibility of essential threat warning, sensor, and weapon delivery displays received satisfactory ratings for all mission phases. Accessibility to these functions was slightly downgraded due to problems encountered by small pilots when activating master mode controls on the small panels located over the leg cutouts. By moving these panels aft 1-2 inches this rating would significantly improve.

TABLE 8
POST COCKPIT QUESTIONNAIRE
Mission Phase Ratings

9 Point Scale	MEAN	STANDARD DEVIATION
1. Accessibility to essential flight control and propulsion controls with seat reclined during:		
a) Cruise	2.71	1.69
b) LGB Delivery	2.69	1.58
c) SAM Penetration	2.71	1.78
d) Air-To-Air Combat	2.49	1.04
2. Visibility of essential flight control and propulsion displays with seat reclined during:		
a) Cruise	3.57	1.70
b) LGB Delivery	3.14	1.67
c) SAM Penetration	3.20	1.26
d) Air-To-Air Combat	2.82	1.22
3. Visibility to essential threat warning, sensor, and weapon delivery displays with seat reclined during:		
a) Cruise	2.66	1.47
b) LGB Delivery	2.77	1.19
c) SAM Penetration	2.86	1.40
d) Air-To-Air Combat	2.43	1.17
4. Accessibility to essential threat warning, sensor, and weapon delivery controls with seat reclined during:		
a) Cruise	2.86	1.40
b) LGB Delivery	3.34	1.49
c) SAM Penetration	3.23	1.55
d) Air-To-Air Combat	3.03	1.82
5. Adequacy of external rear visibility with seat reclined during:		
a) Cruise	2.77	1.50
b) LGB Delivery	2.80	1.66
c) SAM Penetration	3.31	1.91
d) Air-To-Air Combat	3.60	1.99
6. Adequacy of external forward visibility with seat reclined during:		
a) Cruise	1.97	0.66
b) LGB Delivery	2.03	0.78
c) SAM Penetration	2.03	0.75
d) Air-To-Air Combat	2.00	0.84
7. Adequacy of external side visibility with seat reclined during:		
a) Cruise	2.31	0.90
b) LGB Delivery	2.34	0.99
c) SAM Penetration	2.60	1.26
d) Air-To-Air Combat	2.46	1.04

TABLE 9
POST COCKPIT QUESTIONNAIRE
Design Feature Ratings

9 Point Scale	MEAN	STANDARD DEVIATION
1. Adequacy of rudder pedal design with seat reclined.	3.26	1.72
2. Use of a pilot-actuated switch only, to position seat.	2.46	1.07
3. Use of a G-sensor-actuated switch only, to position seat.	7.14	2.09
4. Provisions for both pilot actuation and G-sensor actuation of seat positioning mechanism.	4.94	3.00
5. Considering focus efficiency, how would you rate the design concept of placing displays on the main instrument panel at differing depths?	2.97	1.40
6. If you had to land the aircraft while in the reclined position, how would you rate accessibility to controls and displays needed?	3.26	1.44
7. How do you feel about using the seat without the arm rests?		
7.1 while in the upright position?	4.20	2.15
7.2 while in the reclined position?	5.94	2.22
8. Location of flight controller with seat reclined	2.54	1.42
9. Location of throttles with seat reclined	2.83	1.48
10. Number of multipurpose displays (MSDs)	2.49	1.01
11. Clearance between arm rests and frequently used or critical controls and displays	3.74	1.82
12. Adequacy of rudder pedal design with seat upright	2.85	1.68
13. Adequacy of leg space with seat reclined	3.09	1.44
14. Comfort of seat in the reclined position	2.05	1.21
15. Adequacy of head rest with seat reclined	3.66	1.91
16. Adequacy of arm rests with seat reclined	2.80	1.41
17. Location of avionics panel with seat upright	2.40	0.88
18. Integration of INS functions on avionics panel	2.05	0.68
19. Design, layout and identification of controls and displays on avionics panel	2.28	0.66

TABLE 9 (Continued)
POST COCKPIT QUESTIONNAIRE
Design Feature Rating

	MEAN	STANDARD DEVIATION
20. Concept of integrating functions on avionics panel	2.00	0.59
21. Display of navigation data on the avionics panel instead of a separate panel	2.23	0.84
22. Number of controls on the flight controller	3.03	1.52
23. Number of functions per control on the flight controller	3.34	1.80
24. Adequacy of head rest with seat upright	2.63	1.24
25. Adequacy of leg space with seat upright	2.09	0.66
26. Comfort of seat in upright position	2.26	0.92
27. Location of flight controller with seat upright	2.17	0.71
28. Location of throttles with seat upright	2.60	1.33
29. Overall design and layout of the cockpit	2.71	1.13

External visibility (rear, forward, side) in the reclined position was evaluated by the pilots. Concern by the pilots centered on rear visibility during SAM penetration and air-to-air combat. Improved rear visibility requirements were discussed by the pilots during all phases of the testing and indicates that this is a R&D area. Improvements may be obtained through smaller head rests, rollers to ease head motion, and smaller, lighter helmets.

Pilot ratings for specific design features as summarized in Table 9 can be categorized into the following three classes:

(1) Acceptable and Satisfactory (1-3 Rating)

QUESTION	
2	Pilot actuated switch only for reclining
5	Variation in panel depth
8&27	Location of flight controller (upright and reclined)
9&28	Location of throttles (upright and reclined)

QUESTION	
10	Number of MSDs
12	Adequacy of rudder pedal design upright
14&26	Seat comfort upright and reclined
16	Adequacy of arm rests when reclined
17-21	Location, integration aspects, and design of integrated avionics panel
24	Adequacy of head rest upright
25	Adequacy of leg space upright
29	Overall design and cockpit layout

(2) Acceptable but Unsatisfactory (4-6 Rating)

QUESTION	
1	Adequacy of rudder pedal design when reclined Design Solution - Short throw pedals with isometric overtravel or automatic readjust during articulation
4	Use of pilot actuated seat with G-sensor actuation option Design Solution - Pilot actuated only
6	Accessibility to controls and displays during landing if reclined Design Solution - Redundant mechanization to return seat to upright position
7	Use of seat without arm rests upright and reclined Design Solution - Provide arm rests
11	Clearance between arm rests and critical controls and displays Design Solution - Larger cockpit, improved arm rest design
12	Adequacy of leg space when reclined Design Solution - Part of the lack of leg space was due to the rudder pedal installation see Question 1
15	Adequacy of head rest when reclined Design Solution - Smaller head rest, evaluation of rollers to improve head mobility
22&23	Number of controls and functions per control on flight controller Design Solution - Quantity of controls and functions are required for head-up combat operation. Pilot familiarity with concept should improve rating.

(3) Unacceptable (7-9 Rating)

QUESTION	
2	Use of G-sensor switch only to position seat Design Solution - Use only pilot actuated switch

This questionnaire also included two essay type questions. Since many of the replies were similar, a representative cross section of the replies are summarized below:

The pilots were asked if they would consider reclining the seat (not necessarily to 65°) during missions other than air combat types, and if so, in which type missions (or phases of missions) would they recline the seat. The following replies were received:

"Would be excellent to reduce fatigue on ferry missions - prefer slightly raised position for all flights."

"Any time - its for sure comfortable."

"It's very comfortable, all phases."

"On long missions (ferry, extended CAP, high enroute penetration, etc.) varying seat angle would definitely relieve pilot fatigue. For air-to-ground missions my gut feeling is to keep the seat at 20°. However, such a feeling may be more from experience and usage. Given the opportunity I would definitely try reclined seat weapons delivery."

"Yes - It may be better for air-to-ground, also depending on HUD display - Great for ferry flights!"

"No, I would not consider reclining the seat for missions other than air-to-air combat. If new developments in tactics require SAM evasive maneuvers in excess of 6-7 Gs, then I might consider reclining the seat for SAM threats."

The pilots were also asked if they had any doubts as to the practicability of the high acceleration cockpit concept, and if so, to express their doubts in terms of philosophy, design aspects, pilot comfort and/or utility. The following replies were received.

"It must be accomplished in spite of engineering difficulties."

"I feel the reclined seat is an excellent idea. Rollers should be added to the head rest for high G ACM maneuvers."

"Doubts about ejection mechanization when bailing out from reclined position."

"Good concept and very acceptable design. Fly the seat as much as possible in air-to-air and air-to-ground simulations for best evaluation under as real as possible situations."

"The philosophical concept is outstanding! I have my doubts about some of the engineering aspects such as ejection from the reclined position, the placement of some switches and the need for a bulky head rest."

"No, but believe 65° may be overkill."

"Yes, a few. The premise that the man has been the limiting factor in the G limits to which aircraft have been designed is, I think, a faulty one. It may be that as we acquire more and more higher performance machines and fly them operationally we will find that G-tolerance is a problem with the conventional seat, but as long as we're talking of 10G airframes, I don't think so. When you can put an average fighter jock in a centrifuge at 8Gs for 45 seconds and have him track with a 40 lb stick force, I'm convinced he can handle the short term 8-10G square corner and track with no problem with decent flight controls even in a conventional seat. Reducing G induced fatigue is a worthwhile project, but I don't think it is a critical problem.

"It is unfortunate that the high G cockpit approach is being constrained by current ejection seat technology for upright ejection. If I have any fear at all of Gs, it is the onset of Gs associated with ejection and the very real hazards of poor ejection posture. The only reason I can see that we've stayed with our current ejection systems is that the alternative to a bad system is death and by comparison with that even a bad system looks good.

"The requirement for upright ejection forces too many compromises into the cockpit engineering problem. Rather than try to make a two position seat, I'd like to see the same amount of effort put into a fixed reclined seat with high G compatible ejection capability in the transverse posture. This would require a magnum improvement in cockpit design - well beyond the innovations of the current test cockpit, but probably well within existing technology. I envision a single control panel located behind the throttles with a digital encoder and a bank of mode and control switches which would allow left-handed heads up management of engine controls, weapons selection and management, communications, navigation, lighting, etc. A row of CRT/MAP displays would sit directly below the glareshield and the HUD would be 150-180° across the top of the glareshield with the center section for conventional HUD displays and the sides for other information of a lower priority such as to reflect the inputs being made on the master control panel. (See Figure 14 for diagram).

"This master control panel idea may seem an overly ambitious concept, but if everything from TACAN channels and headings to UHF frequencies can be set in by the digital encoder or an analog slew system such as the throttle isometric button, then the pilot could gain a proficiency with this system that would be better than trying to "find a place" for each separate system in the cockpit and trying to put them all within reach."

"I have no doubts as to the necessity of a high G cockpit to keep pace with the increased G capability of new aircraft. I feel that many problems of the mockup could be solved by a very small sacrifice in fuselage cross section so cockpit side volume could be slightly increased."

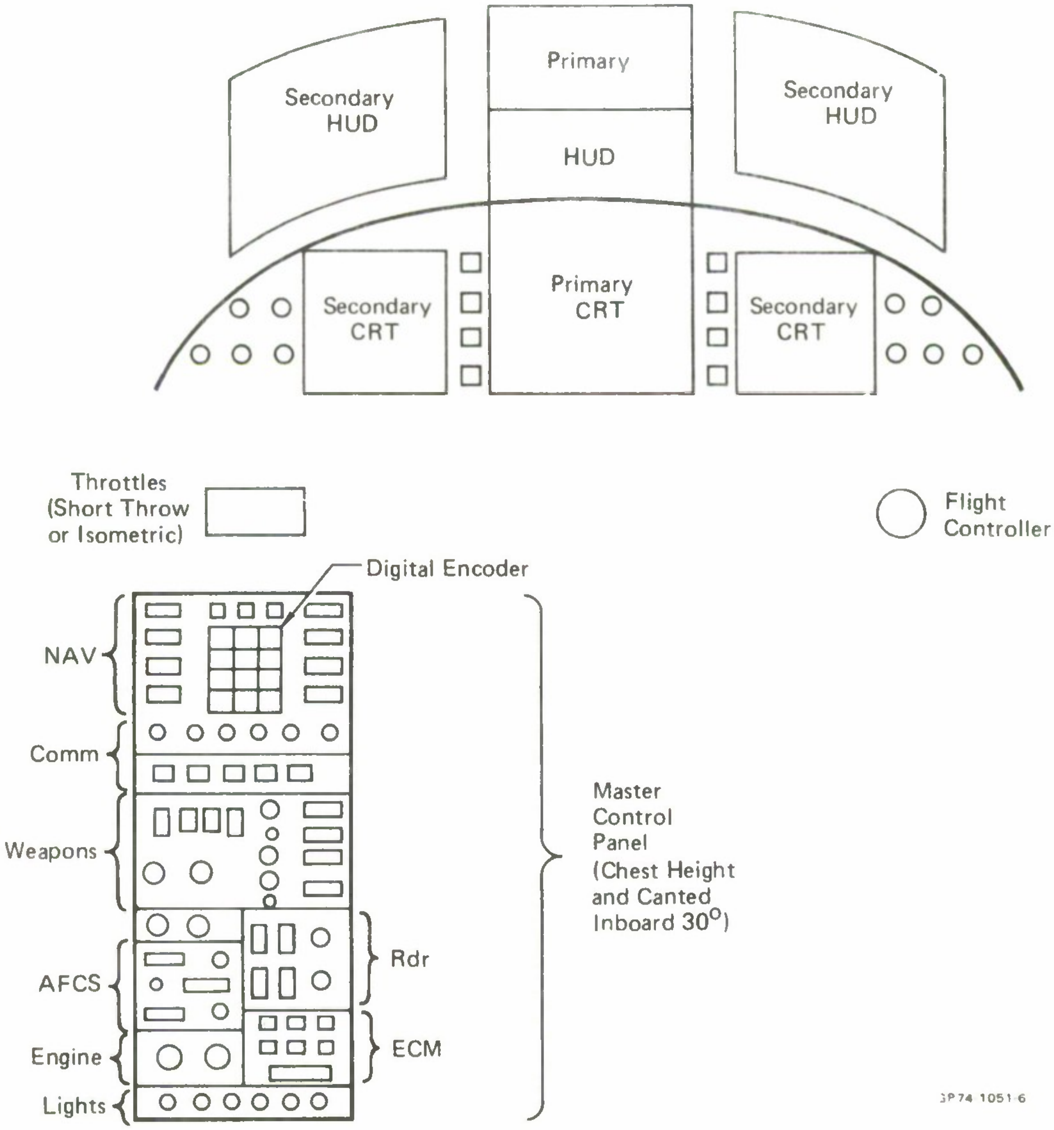

FIGURE 14
SUGGESTED CONTROL/DISPLAY LAYOUT

"None! It's a must if we want to take full advantage of the performance of our new aircraft (F-15/LWF)."

DEBRIEFING

A one hour debriefing was held at each Air Force base to elicit pilot opinions on the testing and the HAC concept. Generally the pilots felt that this type of evaluation provided realistic operational considerations early in the design phase, and was necessary to insure a high level of pilot acceptance and utility for future weapon systems. The primary concern of the pilots was rear visibility.

Discussion in this area brought forth the following points related to rear vision.

o HEAD REST SIZE - Reduce size as far as practical to enable easier lookaround capability

o HEAD REST ANGLE - Increase angle to improve overhead and aft visibility while maintaining necessary internal visibility

o SIDE STICK - Having side stick flight controller may make it difficult to check 6 to 9 o'clock as one cannot shift hands on the flight controller and gain leverage with the right hand under G loads when checking this quadrant. With center sticks the pilot can fly with the left hand while using grab handles or other structure to check the rear quadrant

o REAR VISION - Study under G loads

o HELMETS - The current bulky/heavy helmet in conjunction with protrusions will make rolling the head on the head rest very difficult under high G loading. Efforts should be made to reduce weight and recontour the helmet.

The pilots again expressed the need for arm rests in both the upright and reclined seat positions. In the upright position an arm rest is necessary to provide a point of reference for minor flight path corrections during precision flying and to relieve fatigue. For the throttles the need for an arm rest in the upright position was not considered essential.

Numerous other specific comments and suggestions were obtained relative to specific design features. These have been covered in the questionnaire section which notes pilot recommendations to improve the cockpit concept.

REFERENCES

1. J. M. Sinnett, et al., "High Acceleration Cockpits for Advanced Fighter Aircraft," Volumes I, II, III and IV, AFFDL-TR-74-48, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, May 1974.

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