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Date 21 December 1990

TA-7C AIRPLANE HUMAN FACTORS EVALUATION

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Marshall Atkins

21 December 1990

DISCLAIMER

The technical data included in this thesis are actual flight test data collected during a limited scope flying qualities and performance evaluation of a United States Navy TA-7C airplane. All enhancing characteristics and deficiencies attributed to the aircraft and its systems are the sole opinion of the author, and do not necessarily represent the official position of the Naval Air Test Center, the Naval Air Systems Command, or the United States Navy. Similarly, the recommended corrections to the documented deficiencies are presented by the author for the sole purpose of fulfilling the requirements of this thesis, and are not attributable to any of the aforementioned authorities.

ABSTRACT

Developmental testing of the TA-7C airplane to determine its suitability for the light attack mission with emphasis on the interface provisions between man and airplane was conducted during 6.0 hours of ground tests and 4 flights totaling 6.0 hours. Flying qualities and performance testing as it pertained to man-machine coordination was conducted on production representative airplanes emphasizing typical mission utilization and the man-machine interface.

Test results showed that the easy to operate UHF radio frequency/channel controls and the excellent location of the UHF frequency/channel readout will allow the pilot to maintain a heads up scan during all flight phases and are enhancing characteristics. The inaccessible location of the emergency power package handle with the pilot's shoulder harness locked may prevent quick deployment of the Emergency Power Package and is a major deficiency. The obscured and poorly located master caution and fire warning lights, the extremely restricted rear quarter field of view, the provisions for emergency ground egress, and the hidden location of the emergency fuel switch and monitor lights are also major deficiencies which must be corrected prior to the airplane's delivery to fleet units. Flight testing also revealed several deficiencies which, based on funding, should be corrected as soon as practicable.

The TA-7C airplane demonstrated fair potential for the light attack mission and will be satisfactory upon correction of the major deficiencies. An updated cockpit and provisions for the interface between the pilot and airplane are required to correct the deficiencies.

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INTRODUCTION

1. SCENARIO

The F/A-18 airplane has been shown not to meet the operational range and endurance requirements for the carrier based light attack mission. Airplane improvements in that area would only increase the already excessively high unit cost of the airplane. This thesis will evaluate the feasibility of replacing the F/A-18 with the inexpensive and proven A-7E airplane. The tests for this evaluation were conducted in the TA-7C airplane primarily and the A-7E when available. Both aircraft are similar in handling qualities and performance. The evaluation was performed at the Naval Air Test Center (NATC) Patuxent River, Maryland.

2. PURPOSE

The purpose of the evaluation was to conduct a limited scope cockpit and flying qualities evaluation of the TA-7C airplane and the provisions by which it is controlled by the pilot (man-machine interface). The TA-7C airplane was evaluated for the carrier-based light attack mission.

3. DESCRIPTION OF TEST AIRPLANE

The TA-7C Corsair, manufactured by Ling-Temco-Vought (LTV), is a two seat (tandem), light weight, attack airplane with tricycle landing gear, nose wheel steering, an antiskid brake system, catapult launch and arrested landing provisions, and a parachute located directly below the rudder to augment the brake system during landings on runways. The airplane, shown in appendix D, figures 1 and 2, has a high wing which has 35 degrees of aft sweep (1/4 cord) and 5 degrees of negative dihedral. It has six wing stations for carrying external stores. The outboard 9 ft of the wing folds vertically for carrier operations. The airplane was designed to operate from a carrier or land base and is used to train replacement pilots in all phases of the light attack mission. The TA-7C is powered by an Allison (General Motors/Rolls-Royce) TF41-A-402D turbofan engine which produces 15,300 pounds of thrust (sea level standard day, uninstalled). Empty weight is 20,500 lb with maximum internal fuel load of 10,200 lb, with an external fuel capacity of 8,000 lb.

The irreversible flight control system is powered by two independent 3100 psi hydraulic systems (3 independent systems in the A-7E) which control the ailerons, rudder, Unit Horizontal Tail (UHT) and spoilers. It is actuated by control sticks and rudder pedals in each cockpit. UHT deflection response is designed to increase with an increase of longitudinal stick displacement from trim. Longitudinal trim is accomplished by moving the entire horizontal stabilizer (UHT). Lateral control is accomplished through the ailerons and the spoilers. The spoilers are designed to increase roll control by proportionally deflecting when aileron deflection exceeds 2 1/2 degrees. The spoilers are not deflected during lateral trimming, only the ailerons are repositioned. Directional control is provided by a conventional rudder and maximum deflection is determined by the right landing gear door position. Rudder throw is restricted to ±6 degrees of neutral when in the cruise (clean) configuration and is designed to increase to ±24 degrees of neutral when the right landing gear door is opened. Yaw trim is accomplished through the Automatic Flight Control System (AFCS). Trim tabs are not installed on any flight control surface. Secondary flight controls consist of hydraulically powered leading edge and trailing edge flaps, a hydraulically powered speedbrake mounted under the center fuselage, and Automatic Maneuvering Flaps (AMF). A detailed description of the airplane is found in references 1 and 2. The test airplanes (TA-7C Bureau Number (BUNO's): 154477, 154379, 154402; A-7E BUNO: 159296) were representative of production TA-7C and A-7E airplanes.

4. DESCRIPTION OF TEST WEAPONS SYSTEM

The TA-7C weapon system permits carriage of external stores on eight external stations. An internally mounted 20-millimeter gun is installed on the lower forward left side of the fuselage. The navigation and avionics portion of the weapons system, presented in appendix F, is designed to aid the pilot in navigating to and from the target and accurately delivering a weapon on target. Automatic weapons release functions are provided by the Tactical Computer in conjunction with the Master Function Attack Mode selector and Armament Controls. Steering and targeting information is presented on the Heads-Up display. A detailed description of the weapons system and its components is presented in references 1 and 2. The weapons system as installed in the TA-7C airplane BUNO 154402 was representative of production TA-7C and A-7E airplanes.

5. <u>SCOPE OF TEST</u>

The TA-7C airplane's man-machine interface qualities as they related to flying qualities and airborne systems were evaluated during takeoffs, accelerated and unaccelerated flight, instrument approaches and in the visual landing pattern. The tests were conducted during 4 hours of ground testing and during 4 test flights totaling 6 hours in the Patuxent River operating area in Visual Meteorological Conditions (VMC). Test day weather conditions are listed in appendix G, table I. A summary of tests and test conditions is presented in appendix G, table II. The test envelope for the tests is presented in table I. Test loading was with two pilots in the TA-7C (one pilot in the A-7E) and full internal fuel. Test flight 2 also included 8 MK-82 inert bombs and test flight 4 included 6 MK-76 practice bombs.

TABLE I

TA-7C TEST ENVELOPE

Parameter	Limit Values
Altitude	Surface to 30,000 ft MSL[1]
Airspeed	0 KIAS[2] (TAKEOFF RUN) to 470 KOAS[3]
Mach Number	0 (TAKEOFF RUN) to 0.82 IMN[4]
Load Factor (Normal Acceleration, "g")	-0.2 to +6.0
Gross Weight	22,012 lbs to 34,632 lbs
Center of Gravity	27.15% MAC[5] to 29.0% MAC

Notes:
1. Mean Sea Level
2. Knots Indicated Airspeed
3. Knots Observed Airspeed
4. Indicated Mach Number
5. Mean Aerodynamic Chord

TA-7C takeoff gross weight was 31,312 pounds with a center of gravity of 27.15%. Evaluation Center of Gravity (CG) ranged between 27.15% to 29.0% MAC, which was within the airplane CG limits of 18% to 33.5% MAC. Only a relatively small CG range was tested due to the limited time, scope and funding for the evaluation. A-7E takeoff gross weight was 31,200 pounds with a center of gravity of 27.6%. The test airplane (TA-7C) with six wing pylons and no wing stores has a drag count of 35 per reference 1, a drag count of 65 for 2 Triple Ejector Racks (TER) and 6 MK-76 practice bombs, and a drag count of 138 for 2 Multiple Ejector Racks (MER) and 8 inert MK-82 bombs. Drag count is a dimensionless term assigned to the aircraft with external stores. It is a relative number based on total aircraft drag. Sample weight and balance sheets are presented in appendix G, tables III and IV. Aircraft configurations are presented in table II. All limitations and airspeeds (as recommended by references 1 and 2 and the Strike Aircraft Test Directorate Standard Operating Procedures, Instruction 3710.12A, 27 August 1986, (reference 3) were observed. The airplane was evaluated as a Class IV-C airplane as defined in Military Specification MIL-F-8785C, 5 November 1980, (reference 4). The TA-7C airplane was evaluated against the requirements of Military Specifications MIL-F-8785C, MIL-D-8708B, and MIL-STD-203F (references 4, 5 and 6) hereafter referred to as the

TABLE II
TA-7C Test Configurations

CONFIGURATION	GEAR	FLAPS TE/LE (DEG)	SPEEDBRAKES	POWER
GROUND (GR)	DOWN	UP/UP	IN	OFF
TAKEOFF (TO)[1]	DOWN	25/26	IN	MIL
CRUISE (CR)	UP	UP/UP	IN	TLF[2]
POWER (P)	UP	UP/UP	IN	MIL
MANEUVER (M)	UP	15/26	IN	MIL
GLIDE (G)	UP	UP/UP	IN	IDLE
DESCENT (D)	UP	UP/UP	40	IDLE
WAVEOFF (WO)	DOWN	40/26	IN	TLF[3]
APPROACH (PA)	DOWN	40/26	IN	TLF
LAND (L)	DOWN	40/26	IN	IDLE[4]

Notes:
1. NATOPS recommended 5 degrees Nose Up trim
2. Thrust for Level Flight
3. Thrust for Level Flight (simulate 150 KIAS during CV Case III Approach)
4. Ground idle

Specifications. The test airplane was also evaluated against the TA-7C Detailed Specification.

6. METHOD OF TEST

The tests were conducted as outlined in references 7 and 8 and the Naval Air Test Center Project Test Plan for the Technical Evaluation of the Weapon Systems Installed in the Advanced Fixed-Wing Medium Attack Airplane, 15 February 1983 (reference 9). All stick forces and displacements were measured using a hand held force gauge, stop watch, and tape measure from the front cockpit. Rudder pedal forces and displacements were estimated. Special instrumentation included a sensitive accelerometer. Recommended speeds for takeoff, climb, cruise, descent, and landing were used in establishing flight conditions for performance data. Hand held data cards and a portable cassette voice recorder were used to record data. Handling qualities ratings were assigned per the Cooper-Harper Handling Qualities Rating Scale presented in reference 11 and appendix C. Deficiencies, as described in appendix B, were assigned in accordance with NATC Instruction 5213.3F, "Report Writing Handbook", dated 16 August 1984 (reference 10). Chase airplane requirements were filled by the U.S. Naval Test Pilot School during flights in the TA-7C and by Strike Aircraft Test Directorate during the flight in the A-7E.

7. MISSION DESCRIPTION

The typical mission required of the TA-7C will consist of operations from the deck of a forward deployed aircraft carrier in day and night Visual Meteorological Conditions (VMC). In the strike fighter role, the airplane must be able to accurately deliver air to ground weapons while having the maneuverability and the flexibility to protect itself during the low level ingress to and egress from the target with air to air weapons. It must also have the range to deliver a variety of air to surface weapons.

RESULTS AND DISCUSSION

COCKPIT EVALUATION

8. GENERAL

The cockpit Field of View (FOV), controls, and displays were evaluated inflight and during four ground evaluations. Normal and emergency procedures prescribed in reference 1, were performed. The seat was positioned for the Design Eye Position (DEP) during FOV plot measurements. The evaluator's anthropometric measurements are presented in appendix A. A rectilinear total vision envelope plot of the pilot's station (front cockpit) is presented in appendix E. Seat position during other tests was at a position the evaluator found to be most comfortable and allowed optimum cockpit instrumentation view or external FOV and ranged from a 1/2 inch above the DEP to the full down position. The evaluator wore the flight gear presented in table III. The ejection seat harness was locked during all takeoffs and landings.

FIELD OF VIEW

9. Forward Field of View

The forward Field of View (FOV) was evaluated for the light attack mission during ground operations and in flight during formation flight, the weapons delivery pattern,

TABLE III

FLIGHT GEAR

Item	Federal Serial Number
Coveralls	9D8415-01043-9529
Boots	9D8430-01-161-7039
Gloves	9D8415-01-029-0112
Torso Harness	1670-01-130-3121
Helmet	1RM8475-01-078-0061
Anti-blackout Suit	1R8475-01-037-2010
Life Preserver	1RD4220-01-138-4329
Survival Vest	9D8415-00-139-6174
Kneeboard	8465-00-433-2073

cruise flight, and landings. The upper forward FOV was restricted by windscreen supports, the HUD camera, HUD assembly, and canopy bow. Upper FOV was totally obscured from 5 to 23 degrees above the horizon and within 20 degrees either side of the airplane's nose. The evaluators weapons delivery roll in technique had to be modified to keep the target out of the blind cone by using shallow dive angles (less than 45 degrees). The limited upper forward quarter field of view may result in the pilot becoming very predictable during roll in maneuvers by trying to maintain the target out of the large blind area thus making himself easy to track by surface to air weapons.

10. Rear Field of View

The rear Field of View (FOV) was evaluated during ground operations and in flight during simulated air to air defensive maneuvering. The rear quarter FOV was restricted by the pilot's ejection seat, canopy bow and airplane structure (wings, vertical tail, and fuselage). The rear FOV was blocked from 20 degrees above and below the horizon to 55 degrees either side of the tail. Rear FOV was slightly improved (5 degrees) by leaning the evaluator's head to either side until coming in contact with the canopy. Clearing the rear quarter blind cone required frequent 30 degree turns and 90 to 120 degree bank angle changes. During low altitude ingress to the target, the extremely restricted rear quarter field of view may restrict the pilot's ability to detect threat airplanes in his rear quarter. The obvious fallout of this is the possibility of the TA-7C being shot down.

11. WING FLAP HANDLE

The wing flap handle was evaluated for normal operation during ground evaluations and throughout the inflight test envelope. The wing flap handle is located on the left console, next to the bulkhead as shown in figure 1.

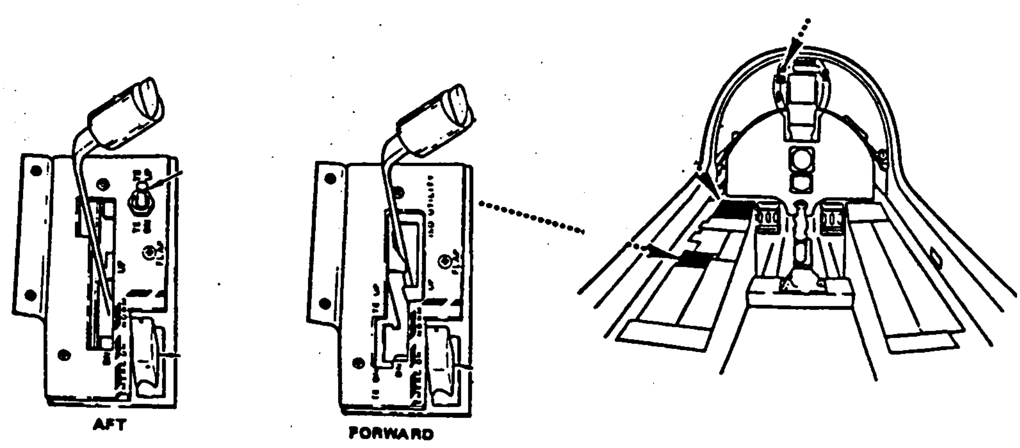


Figure 1

WING FLAP HANDLE

The three position handle commanded both the trailing and leading edge flaps during normal operation and in the automatic maneuvering flap mode. The handle also provided mechanical isolation of the utility hydraulic system to prevent hydraulic pressure loss in the event of component failure. The trailing edge flaps could be positioned in any position between 0 to 40 degrees by momentarily holding the handle out of the neutral position to the trailing edge up or down position and then releasing. Automatic maneuvering flaps became available when the flap handle was moved to the most forward (isolation) position. The handle was hard to reach and operate. The handle moves within a housing with several position bellows. The bellows were closely spaced and made flap position selection difficult. Moving the handle from the isolation position to the flaps down position required several lateral and aft movements. During all transitions, the evaluator had to look at the handle to move it to a desired position. During a formation instrument approach, the complicated operation and inaccessible location of the wing flap handle may result in the pilot having to take his eyes off of the lead airplane as he moves the handle to the down position resulting in him possibly losing sight of the lead aircraft.

12. EMERGENCY FUEL SWITCH AND MONITOR LIGHTS

The emergency fuel switch and monitor lights were evaluated for location during simulated fuel system emergencies in configuration GR. The switch assembly was located along the forward bulkhead above the left console as shown in figure 2. The switch and lights could not be seen as the evaluator sat with his back against the ejection seat. To view the switch and lights, the evaluator had to rotate his body forward 6 inches and turn his head 45 degrees to the left. No other indication of emergency fuel switch position was provided. The hidden location of the emergency fuel switch and monitor lights may lead to the pilot forgetting the emergency fuel switch position resulting in engine fuel starvation.

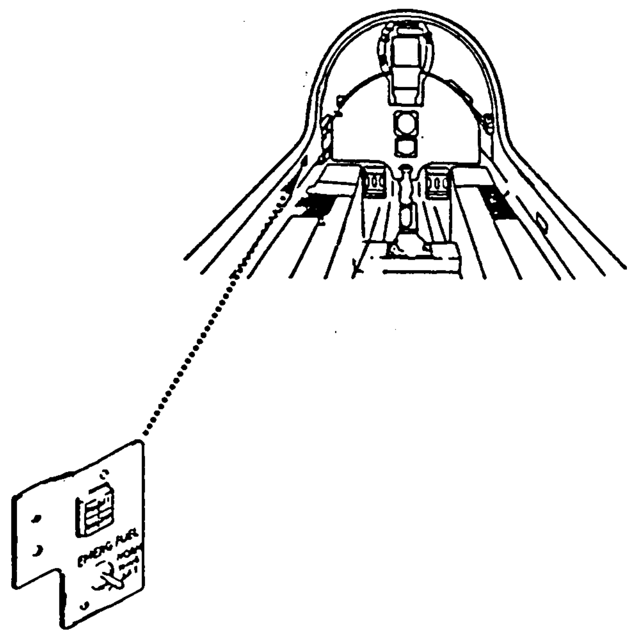


Figure 2

EMERGENCY FUEL TRANSFER SWITCH AND MONITOR LIGHTS

13. EMERGENCY POWER PACKAGE HANDLE

The emergency power package handle, as shown in figure 3, was evaluated for accessibility. The emergency power package handle was located on the lower left side of the instrument panel. Strapped into the ejection seat and with the harness locked, the evaluator (possessing a 99 percentile reach) could reach the handle, but could not wrap his fingers around the handle to actuate it. With the harness unlocked, no difficulty was experienced reaching and activating the handle with a slight forward movement (1 1/2 inches) of the torso. Unlocking the harness required an average of three seconds. With a total electrical failure and the harness locked during a night catapult launch from an aircraft carrier, the inaccessible location of the

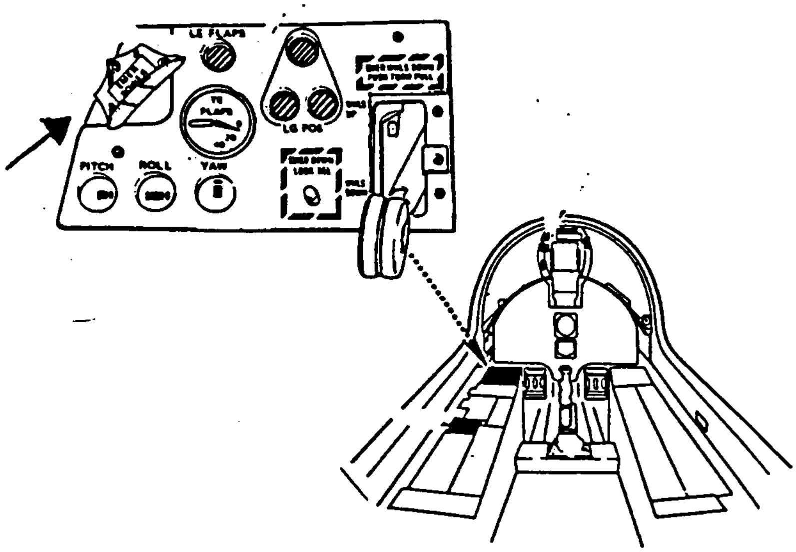


Figure 3

EMERGENCY POWER PACKAGE HANDLE

emergency power package handle, will lead to the loss of all cockpit lighting and primary flight instruments. This may result in pilot disorientation and water impact.

14. UHF COMMAND RADIO CONTROLS AND FREQUENCY/CHANNEL READOUT

The UHF command radio controls and frequency/channel readout were evaluated for operation, use, and location in all configurations. The UHF command radio controls and readout, as presented in figure 4, were located on the left

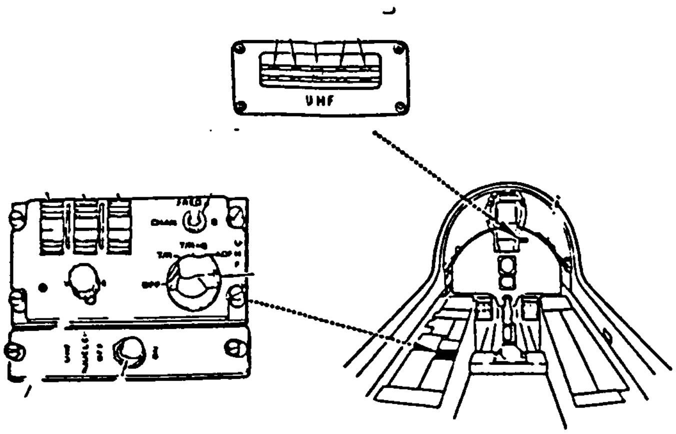


Figure 4

UHF COMMAND RADIO CONTROLS AND DISPLAY

console and upper right instrument panel. To reach the radio controls, the evaluator had only to move his hand aft and right from the throttle. To change radio frequencies, the pilot had only to select frequency mode and press the appropriate rocker switches. Making a channel change was easy, in that the evaluator could use any one of the three rocker switches after selecting the channel mode. The rocker switches worked in the normal sense, in that forward depression increased and aft depression decreased frequency/channel selection. The frequency/channel readout was within a 15 degrees cone centered on the DEP and could be easily scanned while maintaining a heads up posture. During low level formation flight, the pilot may be able to change frequencies without having to lower his head to look into the cockpit thus preventing a midair or ground impact. The extremely easy to operate UHF command radio controls and excellent UHF frequency/channel readout location are enhancing characteristics.

15. WEAPON SYSTEM CONTROLS AND DISPLAYS

The weapons system controls and displays were evaluated for location during simulated and actual ground attack weapons deliveries. The weapons system controls and displays, presented in figure 5, were located around the cockpit with no apparent organizational scheme. Viewing the controls required the pilot to move his scan around the cockpit as shown in table IV.

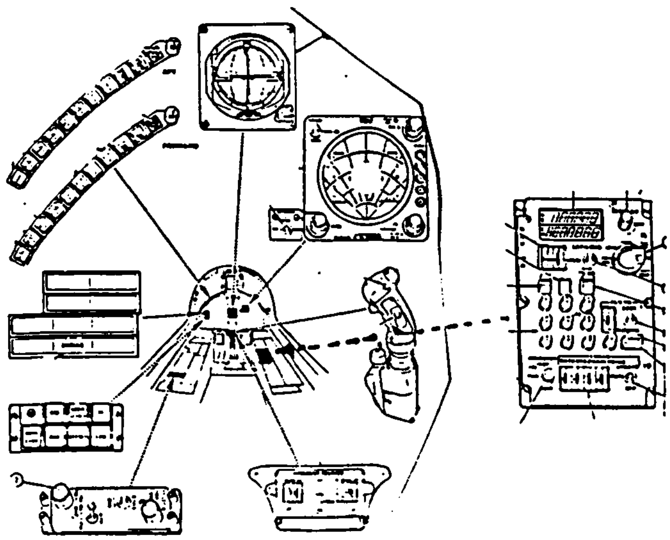


Figure 5

WEAPONS SYSTEM CONTROLS AND DISPLAYS

Weapons management was confusing and hard because of the wide dispersion in the cockpit of controls and displays. While maneuvering at low altitude, the indiscriminate location of weapons system controls and displays will force the pilot to continually divert his attention from flying to weapons system management which may result in incomplete weapons selections (i.e., releasing the weapon safe) or the release of the wrong weapon.

16. MASTER CAUTION AND FIRE WARNING LIGHTS

The master caution and fire warning lights were evaluated for location. The master caution and fire warning lights, as shown in figure 6, were located below the HUD controls in the center of the instrument panel. The HUD

TABLE IV
WEAPONS SYSTEM CONTROLS AND DISPLAYS

Component	Displacement From DEP (degrees) Horizontal (left/right)	Vertical (up/down)
Weapon Armament Advisory Lights	20 left	25 down
Master Function Selector	20 left	30 down
Arm Release Panel	0	35 down
Arm Advisory Light Panel	15 right	15 down
Strike Control Panel	10 right	30 down
Station Select, Master Arm, Fuzing	All across the inst. visor	

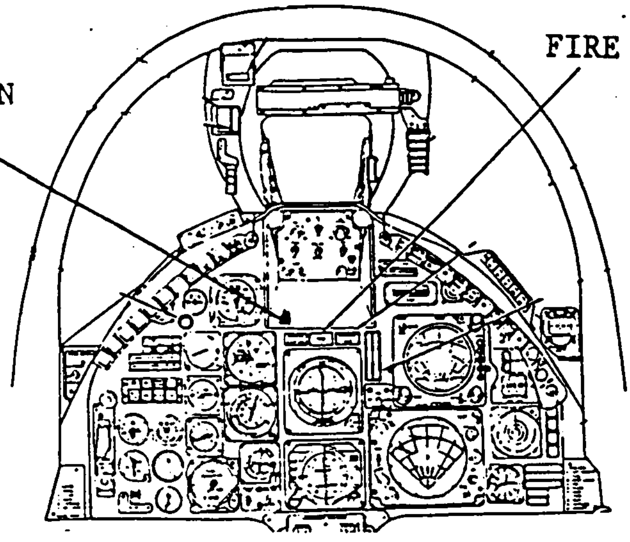


Figure 6

MASTER CAUTION AND FIRE WARNING LIGHTS

control panel protruded outward 4 inches and partially obscured the warning lights. The warning lights were located 30 degrees down from the DEP. In direct sunlight, the warning lights flash intensity was low and did not attract the evaluator's attention. To see the lights, he had to look directly at them. During simulated weapons delivery and simulated emergencies (initiated from the rear seat) with indirect sunlight, the warning lights were not seen until the pilot looked 10 degrees either side of the lights and less than 5 degrees up from the horizon. In the heads up environment of low altitude flight, the pilot may not see the obscured and poorly located master caution and/or fire warning lights resulting in a safety hazard to the pilot.

17. TACTICAL COMPUTER SET CONTROL PANEL

The Tactical Computer Set (TCS) control panel was evaluated for location and accessibility. The TCS control panel, as shown in figure 7, was located on the right forward console. The panel was 30 degrees to the right and 60 degrees down from the DEP. Viewing the control panel resulted in the evaluator having no peripheral vision outside the airplane. Making inputs on the panel took an average of 10 seconds for flyover updates. Changing or making new coordinate inputs required more time depending on the number of inputs. A pilot, while using the TCS, will use a lookout-lookdown visual scan pattern to make repeated inputs. This disjointed technique will require a longer time to input information and that information may not be accurate resulting in a confused navigation picture.

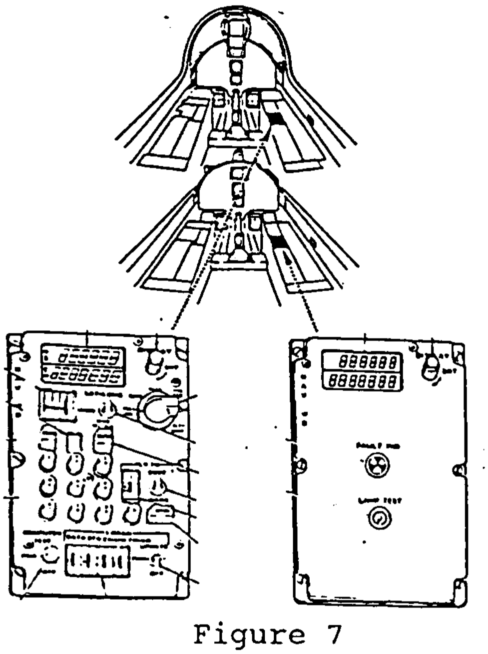


Figure 7

TACTICAL COMPUTER SET CONTROL PANEL

18. EMERGENCY GROUND EGRESS

Emergency ground egress was evaluated with the canopy fully opened, ejection seat safed and crew boarding ladder stowed. Pulling the harness release handle was simulated. The evaluator was able to stand and disengage himself from the ejection seat and airplane quickly, but he had to avoid hitting his head on the canopy which was directly overhead. The evaluator, in the sitting position, had 2 1/2 ft. of canopy clearance. The left canopy rail was 9 1/2 feet from the ground. The right side of the airplane could not be used because of canopy interference, as shown in figure 8.

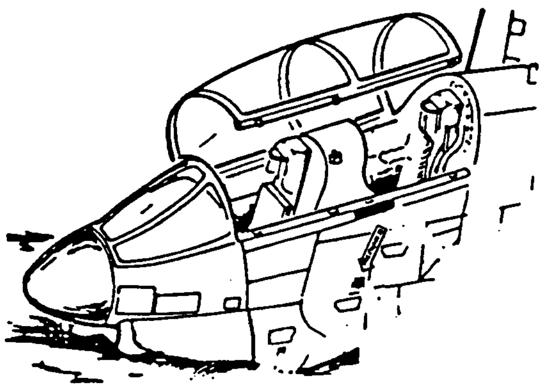


Figure 8

CANOPY OPEN POSITION

Exiting the airplane over the nose was evaluated to be more difficult because there was nothing for the pilot to grab except the pitot probes which may be hot. The simulation was terminated prior to the evaluator having to jump down from the canopy rail and risking possible injury from the fall. The inadequate provisions for getting the pilot to the ground during an actual emergency ground egress may result in the pilot being injured in a fall from the canopy rail. The pilot is further inhibited during ground egress from a lack of available exit options.

GROUND HANDLING

19. AUTOMATIC FLIGHT CONTROL SYSTEM PREFLIGHT

The Automatic Flight Control System (AFCS) preflight procedures were evaluated for ease of performance in configuration TO. The AFCS preflight procedures were performed per reference 1. The procedures were long, requiring five minutes to complete. The AFCS actuator position indicators were required to move in different directions on each test, requiring the evaluator to refer to the checklist to determine the validity of the indication. The procedures required the evaluator to have his head down in the cockpit the entire time preventing him from viewing commands, emergency or normal, from the plane captain. The extensive time required to perform an AFCS preflight check may cause the pilot to omit the checks and launch with a questionable AFCS which may result in loss of airplane control when the system is engaged. The complexity of operation from a human factors point of view may determine the system's utility.

20. EMERGENCY BRAKE

The emergency brake was qualitatively evaluated in configuration TO and L for operation as an emergency means of stopping the airplane. The evaluation was conducted with anti-skid off at a pre-takeoff gross weight of 29,412 lbs and post landing gross weight of 22,112 lbs. Operating the emergency brake handle at all taxi speeds (10 to 60 KOAS) resulted in an abrupt, immediate airplane deceleration. Emergency brake handle sensitivity was very high in that a 1/2 inch of aft handle movement abruptly applied high brake pressure. Brake pressure within the 1/2 inch handle position could not be accurately controlled, either the evaluator received approximately full braking or no braking at all. The evaluator felt that handle sensitivity could lead to blown tires with moderate to rapid use. Controlling airplane deceleration rate with the emergency brake was very hard, requiring several (3 to 4) cycles every 5 seconds of very slow aft brake handle movement until brake pressure onset followed by forward handle movement to prevent blowing the main tires (HQR-6). The excessively sensitive emergency brake system may result in blown main tires during a taxi emergency.

21. IDLE POWER RESIDUAL THRUST

Idle power residual thrust was evaluated in configurations TO and L. Idle power residual thrust at high airplane gross weights (above 29,000 lbs) did not affect airplane ground handling performance. At low airplane gross weights (below 22,500 lbs) idle power provided more thrust than was required for taxi. When left unchecked, the taxi speed quickly increased 10 Knots Observed Ground Speed

(KOGS) in 10 to 15 seconds. Maintaining a 10 KOGS taxi speed ± 10 KOAS at light airplane gross weights was difficult, requiring a brake application every 4 to 7 seconds (HQR-4). After flight, the high engine idle power residual thrust in configuration L may lead to brake riding to keep taxi speed under control resulting in excessive brake wear and/or hot brakes.

FLYING QUALITIES

CONTROL SYSTEM MECHANICAL CHARACTERISTICS

22. General

Control system mechanical characteristics were evaluated during ground test in configuration GR and verified in flight in configuration CR at 20,000 ft Mean Sea Level (MSL) and 300 Knots Observed Airspeed (KOAS). Data are presented in appendix H, figures 1 and 2 and in table V.

23. Longitudinal

Longitudinal control breakout including friction forces were light, which allowed for smooth and precise control inputs, but were adequate to prevent inadvertent stick motion. Friction away from trim (1 1/2 lbs) and freeplay (1/8 inch) were both small and resulted in no adverse longitudinal control effects. Control stick centering was positive, returning the stick to within 1/16 inch of center when longitudinal control force was gradually relaxed. Longitudinal control stick oscillation was essentially deadbeat, resulting in no residual oscillations being transmitted into airplane motion. The stick force versus stick deflection gradient of 5 lbs per inch in the push direction and 3 lbs per inch in the pull direction varied smoothly and provided adequate force cues. Longitudinal

TABLE V

CONTROL SYSTEM MECHANICAL CHARACTERISTICS

ONTROL YSTEM	BREAKOUT INCLUDING FRICTION (LBS)				FREEPLAY (INCHES)	CENTERING (INCHES)	DAMPING
	MEASURED HANDHELD		SPECIFICATION LIMITS				
	Left/Aft	Right/Fwd	MIN	MAX			
ONGI-UDINAL	2	2	1/2	3	1/8	POSITIVE ESSENTIALLY ABSOLUTE	ESSENTIALLY DEADBEAT
ATERAL	1 1/2	1 1/2	1/2	2	1/16	POSITIVE ESSENTIALLY ABSOLUTE	ESSENTIALLY DEADBEAT
IREC-IONAL	9	9	1	7	3/8	POSITIVE ESSENTIALLY ABSOLUTE	ESSENTIALLY DEADBEAT

stick forces felt high during maneuvering and nonmaneuvering flight but were not objectionable. The longitudinal control system mechanical characteristics are satisfactory and met the requirements of the Specification as described in Table V. The Specification also requires that controls not result in objectional flight characteristics.

24. Lateral-Directional

Lateral breakout including friction forces were light but were high enough to permit the pilot to rest his hand on the stick and prevent inadvertent lateral stick movement. Directional breakout including friction forces were high, but were not objectional to the evaluator during any phase of flight. Control centering in both axis was positive and essentially absolute and the freeplay bands were small. The rudder pedal and lateral stick response to a rap was well-damped and did not excite airplane motion. The gradients for lateral control force versus deflection from trim, left and right, were essentially linear at 7 lbs per inch. Lateral control forces were high but not objectional. Rudder control force versus deflection was estimated to be 45 lbs per inch. The directional control mechanical characteristics failed to meet the requirements of the Specification, paragraph 3.5.2.1, in that the rudder breakout including friction force exceeded the maximum allowable of 7 lbs by 2 lbs (29%). The lateral-directional mechanical characteristics, even though they failed to meet the requirements of the Specification as described in Table V, were satisfactory for the light attack mission. Meeting the requirements of the Specification in no case assures that a system is adequate, however, it provides a ruler by which an evaluator may evaluate a system. As stated in the Specification, final determination of compliance with requirements will be made by the procuring/evaluation activity.

25. ENGINE RESPONSE

Engine response to throttle movement in configuration PA was qualitatively evaluated during instrument and visual approaches and formation flight. Starting from level flight at 87% engine RPM, 22,612 lbs gross weight and 125 KOAS trim airspeed (on speed), 4 seconds was required after a rapid full throttle input (jam accel) for the engine to accelerate to military RPM (99%). Engine acceleration after waveoff initiation resulted in the loss of 75 feet. Engine deceleration rates were as long as the acceleration rates. It was impossible to find the neutral thrust point (that one power setting, at unaccelerated flight, which will maintain the airplane in position with the lead aircraft) while flying formation or during an approach. Maintaining normal military formation position in configuration PA, ± 5 ft was hard requiring large, repeated throttle inputs (HQR-5).

During a visual approach, it was hard to determine what throttle setting was required to maintain glide path which lead the evaluator to the improper carrier landing technique of setting a throttle position and maintaining glide slope with longitudinal stick inputs. During actual instrument formation approaches, maintaining position will be very difficult and could result in losing sight of the lead airplane.

MISCELLANEOUS LONGITUDINAL CHARACTERISTICS

26. Trimmability

Trimmability was evaluated during the ground test and throughout the test envelope in configurations CR and PA. Trim rate was constant over the full range of trim at 2 1/4 deg/sec (measured from the cockpit trim gauge). The full trim range was 16 degrees. Trimming the airplane in level flight in configuration PA was difficult. Trim inputs were always too large even when using the smallest trim input (trim beep). The high trim rate along with the slow engine response required 4 trim inputs to bracket the desired airspeed, with a 3 to 7 second time interval between inputs to determine the airplane's steady state condition. In configuration CR, trimming to a precise airspeed above 300 KOAS was hard. Again, the smallest input resulted in a large (300 ft/min or greater) rate of climb or descent. Establishing trim altitude ±100 ft and trim airspeed ±5 KOAS was difficult requiring several (5 to 7) trim beeps in opposite directions and taking over 30 seconds (HQR-6). The oversensitive longitudinal trim rate will be annoying and will require continual attention by the pilot as he changes airspeeds during instrument cruise flight. The longitudinal trim rate in configurations PA and CR failed to meet the requirements of the Specification, paragraph 3.6.1.2, in that the trim rate was too sensitive. The Specification requires that trim devices operate rapidly enough to enable the pilot to maintain low control forces under changing conditions normally encountered in service. The rates, however, should not be so high as to cause oversensitivity or trim precision difficulties under any conditions.

27. Wing Flap Operation

Pitch trim changes due to wing flap operation were evaluated in configuration L at 5,000 ft MSL, at a trim airspeed of 200 KOAS in level flight at 24,512 lbs gross weight and CG of 28.0% MAC. Lowering the wing flaps and maintaining level flight caused a 7 to 10 lb increase in longitudinal stick force and a large forward stick displacement of 2 to 3 inches. Controls free response of the airplane to lowering the flaps was a steady, moderate rate longitudinal pitch up to 10 degrees nose up. Maintaining pitch attitude during flap extention ± 2 degrees was fairly difficult requiring one continual nose down longitudinal trim input followed by 2 or 3 small nose up trim inputs (HQR-4). As a result of the large pitch trim changes during flap operation, the pilot will have an increased workload trying to maintain position while controlling the longitudinal control forces and attempting to trim them out. Longitudinal trim change during flap operation in configuration L failed to meet the requirements of the Specification, paragraph 3.6.3, in that the maximum peak forces were excessive. The Specification specifically states "the transients and steady-state trim changes for normal operation of secondary control devices (such as throttle, thrust reversers, flaps, slats, speedbrakes, deceleration devices, dive recovery devices, wing sweep and landing gear) shall not impose excessive control forces to maintain the desired heading, altitude, attitude, rate of climb, speed or load factor without use of the trimmer control."

28. LATERAL-DIRECTIONAL TRIMMABILITY

Lateral-directional trimmability was evaluated qualitatively in configurations CR and PA throughout the test envelope. Lateral-directional trim rate and sensitivity were sufficient to reduce control forces quickly and precisely. Trim holding in both axis was good with no irreversibilities noted. There was no rudder trim indicator in the cockpit. Airspeed changes required a slight change in rudder trim. The sideslip indicator moved 1/2 of a ball during accelerations from 300 KOAS to 400 KOAS. Maintaining zero sideslip ±2 degrees with rudder trim during level accelerations was easy requiring small random and infrequent (2 to 3) trim inputs (HQR-3). During instrument and cruising flight, the lateral-directional trim characteristics should not require extensive attention from the pilot. The lateral-directional trim system characteristics are satisfactory for the light attack mission and met the requirements of the Specification which states that trimming devices shall be capable of reducing all cockpit control forces.

29. LATERAL SENSITIVITY IN CONFIGURATION PA

Lateral sensitivity was qualitatively evaluated in configuration PA during instrument and visual approaches. During lateral stick inputs, airplane response was very abrupt and unpredictable. Lateral oversensitivity resulted in a mild pilot induced oscillation as the airplane felt very ratchety during aggressive angle of bank changes. Establishing and maintaining a 30 degree bank angle (±5 degrees) during formation flight was hard requiring several (4 to 5) lateral inputs in opposite directions to bracket the desired attitude (HQR-5). During formation flight, the oversensitive lateral control may cause the pilot to establish a mild pilot induced oscillation when rolling into and out of bank angles resulting in increased pilot workload and degraded pilot-airplane performance.

POTENTIAL SOLUTIONS TO DEFICIENCIES

SAFETY OF FLIGHT/MISSION ACCOMPLISHMENT DEFICIENCIES

GENERAL

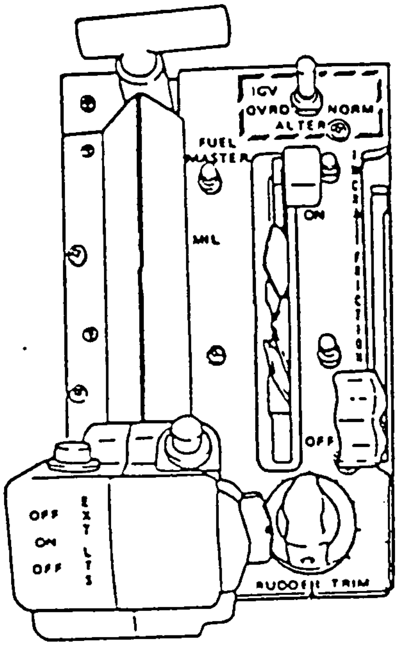
30. As addressed in reference 12, the key to compatibility lies in a satisfactory solution to user's problems of interfacing with all elements of the system. Because of the opportunities that modern technology offers, it is important to address human factors on a broad scale. Primary areas of human factors consideration are psychological factors, system integration, and maintenance. Five deficiencies discovered during this limited scope investigation would require correction prior to the airplane's delivery to the fleet. These deficiencies are either safety related, which will result in the loss of airplane and/or aircrew, or they adversely affect the airplane/aircrew's ability to accomplish the mission thus not satisfying the requirements for which the airplane was designed. Each deficiency will be addressed in order of its relative severity as determined by the evaluator.

31. EMERGENCY POWER PACKAGE HANDLE

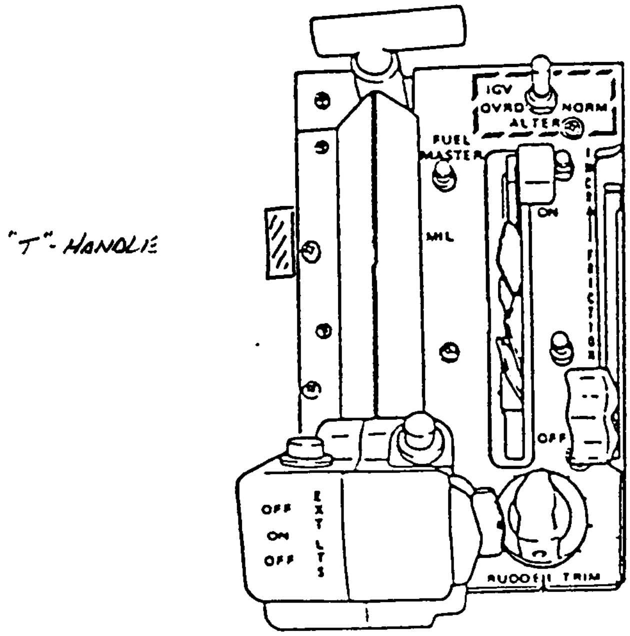
The current location of the emergency power package handle prevents the pilot from operating it with his shoulder harness locked. To remedy this deficiency, it is recommended that the handle be moved to the throttle quadrant area and retain its mechanical operating properties. The new handle location is presented in figure 9. A follow-on engineering investigation will be required to perform a form, fit and function evaluation. Relocating the handle in this manner places it in close proximity to where the pilot's left hand will be during times when the ejection seat harness is locked. This will also meet the requirements of the Specification, in that emergency equipment be readily accessible and easy to operate. Reference 12 points out the human factors considerations which were not incorporated in to pre-1980's airplanes but have become the safety and functional standard of modern airplanes. There should also be a provision to automatically deploy the emergency power package in the event of an electrical emergency, thus allowing the pilot to concentrate on flying the airplane. Again, the maximization of modern technology. A correction of this nature will lead to a moderate cost penalty which is, however, far exceeded by the safety benefits.

32. LOCATION OF THE MASTER CAUTION AND FIRE LIGHTS

The placement of the master caution and fire lights can be improved by repositioning them to the upper left side of the instrument panel (along the upper left portion of the HUD control panel). This would place the lights in the pilot's primary visual and instrument scan, reference 6.



CURRENT CONFIGURATION



PROPOSED CONFIGURATION

Figure 9
EMERGENCY POWER PACKAGE HANDLE

FAA regulations and reference 12 state the requirement for conspicuity of all essential instrument and failure warning devices. Master caution and fire light intensity would have to be increased to allow for readability in direct sunlight. Augmenting the lights with an aural signal would further improve the pilot's situational awareness. The aural tone should be a female voice to quickly gain the pilot's attention and allow him to discriminate it from the predominately male voices heard over the radio. The voice would say exactly what the problem was, as in the case of an engine fire, the voice would say "fire, engine fire". This voice system could be expanded in the future to provide other indications.

33. EMERGENCY FUEL SWITCH AND MONITOR LIGHTS

The emergency fuel switch and monitor lights discrepancy could be easily corrected by the addition of a caution light on the caution light panel. This would require an electrical tap from the switch to activate the proposed caution panel light. This is a relatively inexpensive fix/improvement, but one which increases the pilot's situational awareness during inflight emergencies.

34. EMERGENCY GROUND EGRESS

Most Navy jet airplanes have poor provisions for emergency ground egress of aircrew and the TA-7C is no exception. By replacing the aft cockpit with a fuel cell/avionics bay package and incorporating an aft hinged wrap-around canopy (paragraph 35), the pilot will be able to raise the canopy and egress the airplane to either left, right or forward. Once out of the cockpit, the pilot will use the foot/hand slots placed along either side of the fuselage. The slots would be covered with spring hinged covers mounted flush with the airplane's outer skin. The step slots will replace the present manually operated ladder/stairs positioned on the port side. A study of the available space behind the outer skin along the fuselage on both the port and starboard side needs to be conducted to determine the exact placement of the step slots. A structural analysis would also have to be performed to determine if any of the airplane's structural integrity would be breached. The Navy now requires, in the form of specifications, ease in aircraft ingress and egress under both normal and emergency conditions.

35. REAR FIELD OF VIEW

Field of view (FOV) has and will continue to be a major design headache. To obtain an optimum FOV, you have to sacrifice the effects of drag on a raised cockpit and the overall effects on airplane structure. For the TA-7C airplane, it is recommended that the aft cockpit be removed and replaced with a fuel cell/avionics compartment package.

This should be coupled with a modern two piece canopy. The fuel cell/avionics compartment top structure should be sloped slightly downward to the canopy. This will provide the pilot with the ability to look directly behind the airplane by looking around his ejection seat and over the top of the airplane fuselage. There would be no need to raise the cockpit or adopt another major redesign alternative. The aft cockpit aft bulkhead is a major support structure and alteration to it will require investigation, but appears to be economically feasible. The canopy windscreen combination would be of the single construction wrap-around type. This will eliminate the canopy and windscreen bows traditionally used for support except for the point where the canopy and windscreen meet. Economics is a very critical issue in this case. Proposed structural modifications would require a moderate structural redesign. Reference 16 has several examples of the benefits of the above recommendation.

PILOT WORKLOAD IMPAIRMENT

36. GENERAL

These deficiencies impair the pilot's ability, to some degree, to perform the mission of the airplane. These are areas where the man-airplane interface come particularly to light. Because these problem areas do not adversely affect the safety or prevent mission accomplishment, they traditionally have gained only limited attention during post developmental test evaluations. Today, however, the threat environment of the tactical pilot requires that the machine in which he must work, work with him, not against him. There must be some appreciation for "...the degree and the duration of the mental concentration required", reference 12. These potential solutions are not arranged in any order of precedence.

37. TACTICAL COMPUTER SET CONTROL PANEL

To correct this deficiency, replace the current Heads-up Display (HUD) control panel with a smaller, more versatile panel which not only controls the HUD, but is also the interface for the tactical computer. By doing this, waypoints, weapons selection, and target information can be entered and changed while maintaining a heads up scan. In the low level environment, the pilot can use either hand to make entries into the panel. F-18 NATOPS flight manual and the U.S. Naval Test Pilot School Class Notes, "Heads Up Display Characteristics", dated November 1977, provide insight into the benefits of an integrated control unit. The support structure for the current HUD control panel can be used to support the replacement panel. The electrical requirements will require testing to determine optimum routing and power needs. Future additions to the panel may be incorporated to control such items as the Tactical Air Navigation (Tacan), Identification Friend or Foe (IFF), and Automatic Carrier Landing System (ACLS). The benefit of off-the-shelf technology makes this airframe addition cost effective. The F-15, F-16, and F-18 each incorporate a variation of what is called an Up Front Control panel. Either could be used in the TA-7C, however, the panel in the F-18 would take advantage of the support present in the Navy supply system.

38. WING FLAP HANDLE

The wing flap handle deficiency can be corrected by changing the beveling within the flap control panel without changing the control authority or sense. References 6 and 12 require that the sense of motion involved in the operation of controls must correspond to the sense of the effort of the operation. This correction will result in minimal expense and can be accomplished at the operational level by installing a prefabricated kit.

39. WEAPONS SYSTEM CONTROLS AND DISPLAYS

All controls can and should be organized/grouped by system function. To correct this deficiency will require a major cockpit change. Many of the weapons systems components can be collocated in a Multiple Function Display (MFD). A committee of operational pilots, experimental test pilots, Naval Air Systems Command representative, and a cockpit design contractor (i.e. McDonald Douglas or General Dynamics) would have to weigh the cost aspect against what the current and projected needs are. Again, the cockpits of the "Teen" fighters (F-14, F-15, F-16 and F-18) offer a great starting point to visualize improvements.

40. ENGINE RESPONSE

One proposal to increasing engine response would be to increase the drag on the airplane in configuration PA. Higher drag requires higher thrust, which results in higher engine RPM and usually better engine response. Increasing the parasitic drag is the best option. Speedbrakes, spoilers, larger flap deflections or a combination of these. The location and size of the current speedbrake prevent its use. The addition of a fuselage mounted speedbrake would require significant structural changes. Increasing the trailing edge wing flap deflection may be the best option. Testing would have to be conducted to evaluate the effects on flight path stability, handling characteristics, and waveoff performance. Maintaining sufficient clearance with weapons racks is a consideration in determining optimum deflection. Split ailerons similar to those employed on the A-10 aircraft may be considered. Replacing the engine is also another option but is considerably more expensive and time consuming. In any event these options are available if the increase in flap deflection proves unsatisfactory.

41. POSTSCRIPT

Many of the corrections are interrelated, in that if one item were corrected, it makes correcting something else easier. Looking at the corrections as a package as opposed to isolated areas, will lead to continuity.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

42. Within the scope of this test, the TA-7C airplane demonstrates fair potential for the carrier based light attack mission. With improvements to the interfaces between the pilot and airplane, the potential level would be higher.

SUMMARY OF DEFICIENCIES AND RECOMMENDATIONS

43. The extremely easy to operate UHF command radio controls and excellent UHF frequency/channel readout location is an enhancing characteristic and should be applied to all tactical aircraft.

44. The emergency power package handle is inaccessible with the shoulder harness locked. The author recommends relocating the handle to the throttle quadrant.

45. The master caution and fire warning lights were obscured and poorly located. Repositioning the lights and incorporating an aural indicating system would correct this deficiency.

46. The provisions for getting the pilot to the ground during an emergency ground egress are inadequate. Moving the canopy hinge point and incorporating integral hand and foot supports are recommended.

47. The emergency fuel switch and monitor lights are in a hidden location, but can be corrected by the addition of a caution light to the caution light panel.

48. The rear quarter field of view is extremely restricted. Several structural modifications would improve this deficiency, but may require a moderate funding requirement.

49. The tactical computer set control panel is in an inconvenient location. Incorporation of an Up Front Control Unit is recommended.

50. The complicated operation and inaccessible location of the wing flap handle can be corrected by simplifying the wing flap handle beveling within the flap control panel.

51. The poor engine response in configuration PA can be corrected by increasing aircraft drag by increasing the trailing edge wing flap deflection.

52. The location of weapons system controls and displays are random and illogical. The author recommends grouping and organizing the controls and displays by function.

SPECIFICATION COMPLIANCE

53. The TA-7C airplane met all the Specification (MIL-F-8785C) requirements against which it was tested except those listed below:

a. Paragraph 3.5.2.1, in that the rudder breakout including friction force exceeded the maximum allowable of 7 lbs by 2 lbs (29%).

b. Paragraph 3.6.1.2, in that the trim rate was too sensitive.

c. Paragraph 3.6.3, in that the maximum peak forces were excessive.

d. Paragraph 3.3.3, in that mild pilot induced oscillations were induced.

54. The TA-7C airplane met all the detailed specification requirements against which it was tested.

REFERENCES

1. TA-7C NATOPS Flight Manual, NAVAIR 01-45AAF-1, 15 January 1979, changed 15 June 1985

2. A-7E NATOPS Flight Manual, NAVAIR 01-45AAE-1, 1 December 1979, changed 15 May 1985

3. Strike Aircraft Test Directorate Standard Operating Procedures, Instruction 3710.12A, 27 August 1986

4. Military Specification for Flying Qualities of Piloted Airplanes, MIL-F-8785C, 5 November 1980

5. MIL-D-8708B, "Military Specification Demonstration Requirements for Airplanes", dated 31 January 1969

6. MIL-STD-203F, "Military Requirements for Aircrew Stations", dated 28 December 1973

7. U.S. Naval Test Pilot School Flight Test Manual - Fixed Wing Stability and Control, Theory and Flight Test Techniques, (FTM-103), 1 Jan 1975, changed October 1984

8. U.S. Naval Test Pilot School Flight Test Manual - Fixed Wing Performance, Theory and Flight Test Techniques, (FTM-104), July 1977

9. Naval Air Test Center Project Test Plan for the Technical Evaluation of the Weapon Systems Installed in the Advanced Fixed-Wing Medium Attack Airplane, 15 February 1983

10. Report Writing Handbook, Naval Air Test Center Patuxent River, Maryland, Instruction 5213.3F, 16 August 1984

11. Cooper-Harper Handling Qualities Rating Goals, (NASA TND-5153) April 1969, "The use of Pilot Rating in the Evaluation of Aircraft Handling Qualities"

12. Human Factors Design Handbook, Wesley E. Woodson

13. Mil-H-46855 Human Engineering Requirements for Military Systems, Equipment, and Facilities

14. Mil-STD-1472 Human Engineering Design Criteria for Military Systems, Equipment and Facilities

15. Ergonomics; Making Products and Places Fit People. Kathlyn Gay

16. Janes "All the Worlds Aircraft", 1989-1990. John W. R. Taylor

17. Human Factors in Engineering and Design, E. J. McCormick

18. Janes "Avionics", 1988-1989. Stephen R. Breadbent

19. Phase II-A Developmental Testing of the TA-7C Airplane, LT Marshall Atkins, USN. 5 June 1987. Naval Air Systems Command Official Document.

20. Federal Aviation Administration (FAA) Regulation 25.1523 and 25.777

APPENDICES

ANTHROPOMETRIC MEASUREMENTS

APPENDIX A

ANTHROPOMETRIC MEASUREMENTS OF
LT. MARSHALL ATKINS, USN

Measurement	Distance/ Weight (in/lbs)	Percentile (1) (%)
Weight	185	75
Stature	72.5	85
Sitting Height	37.4	95.39
Trunk Height	25.1	90
Should Width	19.4	75
Functional Reach	35.3	99
Buttock-Knee Length	26.3	98
Eye Height	32.3	82.13

NOTE: (1) Percentiles based on NATC Technical Report SY-121R-81. "The Naval and Marine Corps Aviation and Anthropometric Survey," 20 November 1981.

DEFINITION OF DEFICIENCIES

APPENDIX B

DEFINITION OF DEFICIENCIES

<u>Safety of Flight/Mission Accomplishment Deficiency</u>

A deficiency, the correction of which is necessary because it adversely affects:

a. Airworthiness of the aircraft.

b. The ability of the aircraft to accomplish its primary or secondary mission.

c. The effectiveness of the crew as an essential subsystem.

d. The safety of the crew or the integrity of an essential subsystem. In this regard, a real likelihood of injury or damage must exist. Remote possibilities or unlikely sequences of events shall not be used as a basis for safety items.

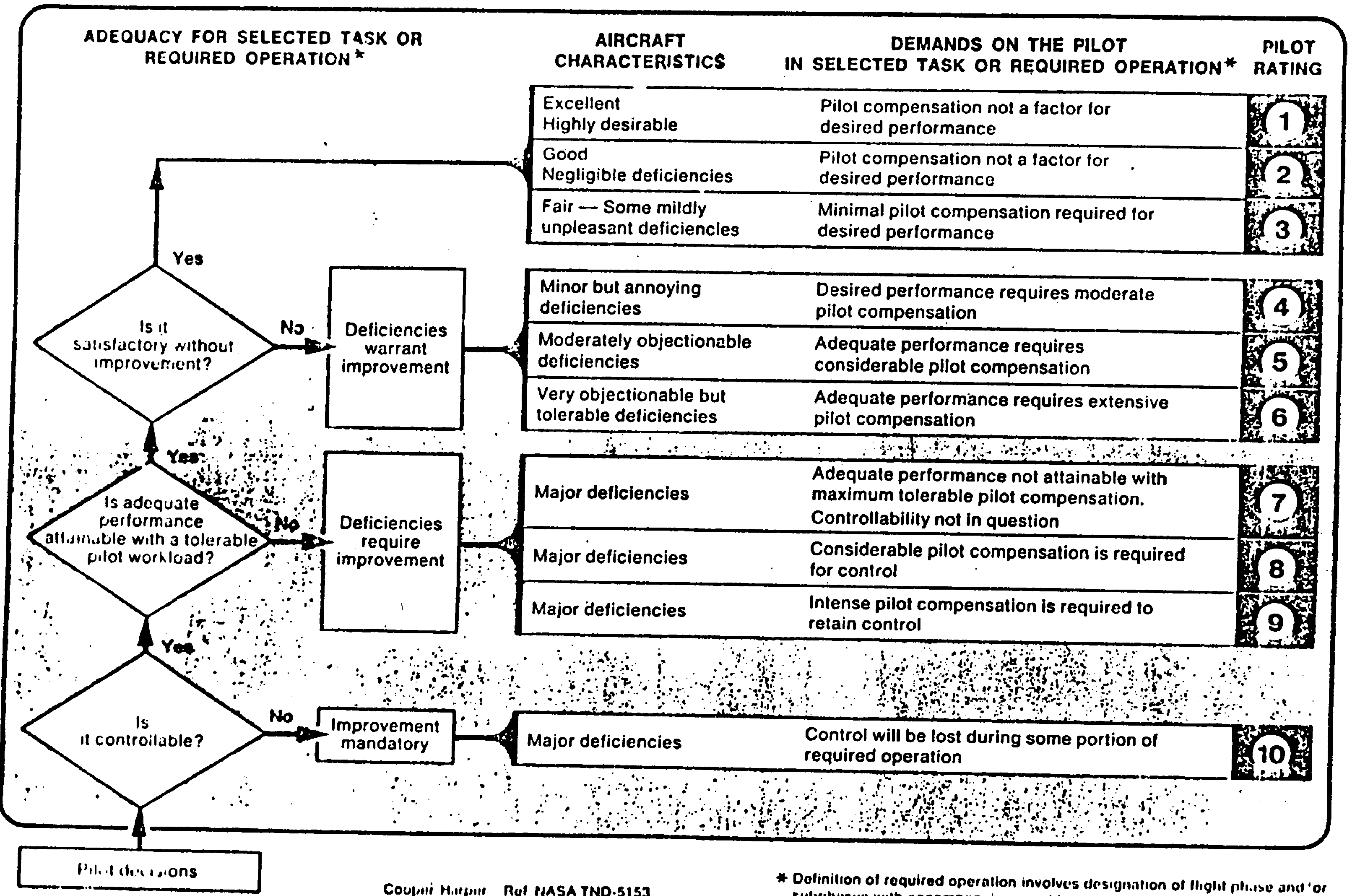
<u>Safety Pilot Compensation Deficiency</u>

A deficiency of lesser severity than safety of flight, which does not substantially reduce the ability of the aircraft to accomplish its primary or secondary mission, but the correction of which will result in significant improvement in the effectiveness maintainability, or safety of the aircraft.

COOPER-HARPER RATING SCALE

APPENDIX C

HANDLING QUALITIES RATING SCALE



Cooper Harper Ref NASA TND-5153

* Definition of required operation involves designation of flight phase and/or subphases with accompanying conditions

APPENDIX C

COOPER-HARPER RATING SCALE

PHOTOGRAPHS

APPENDIX D

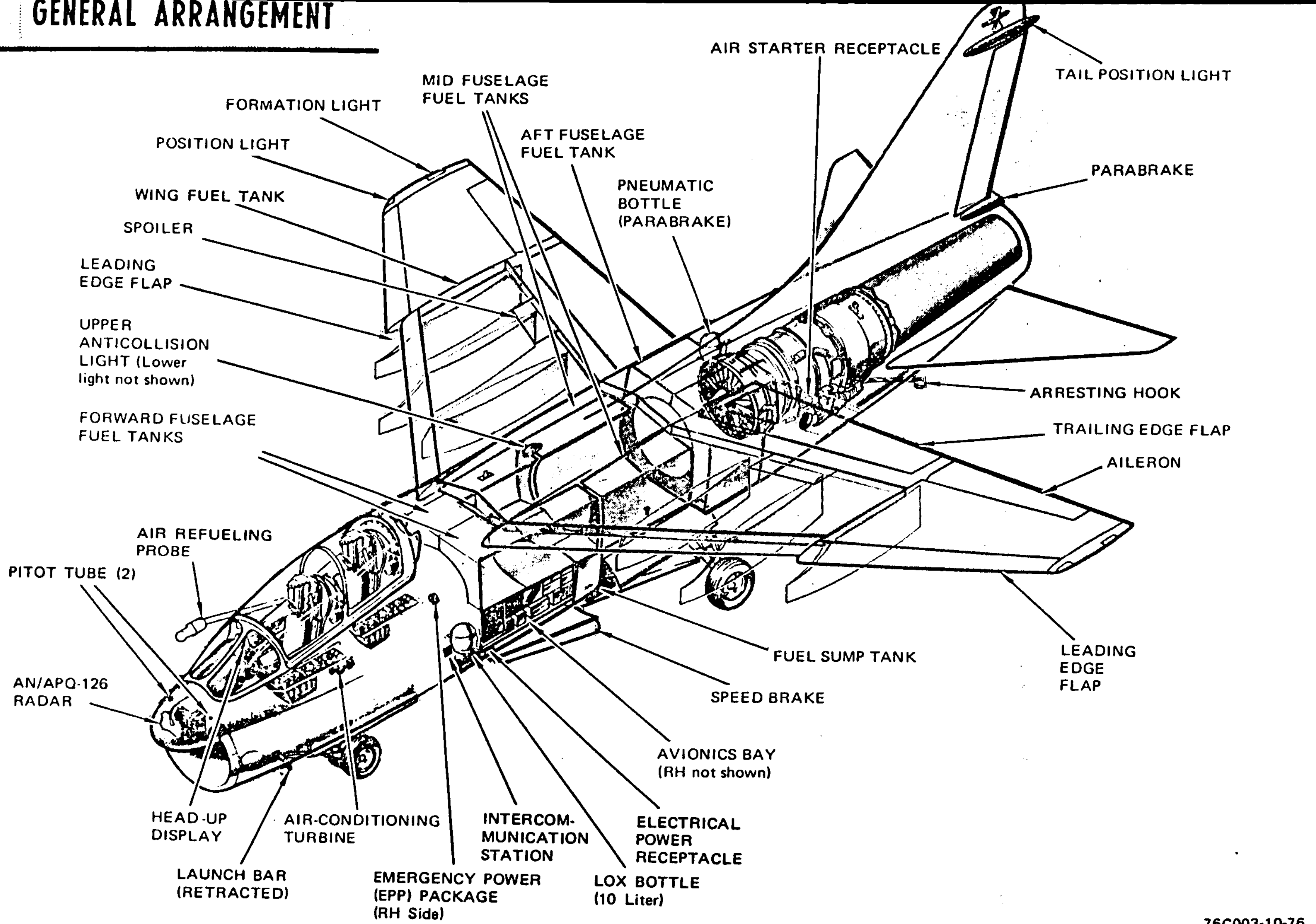
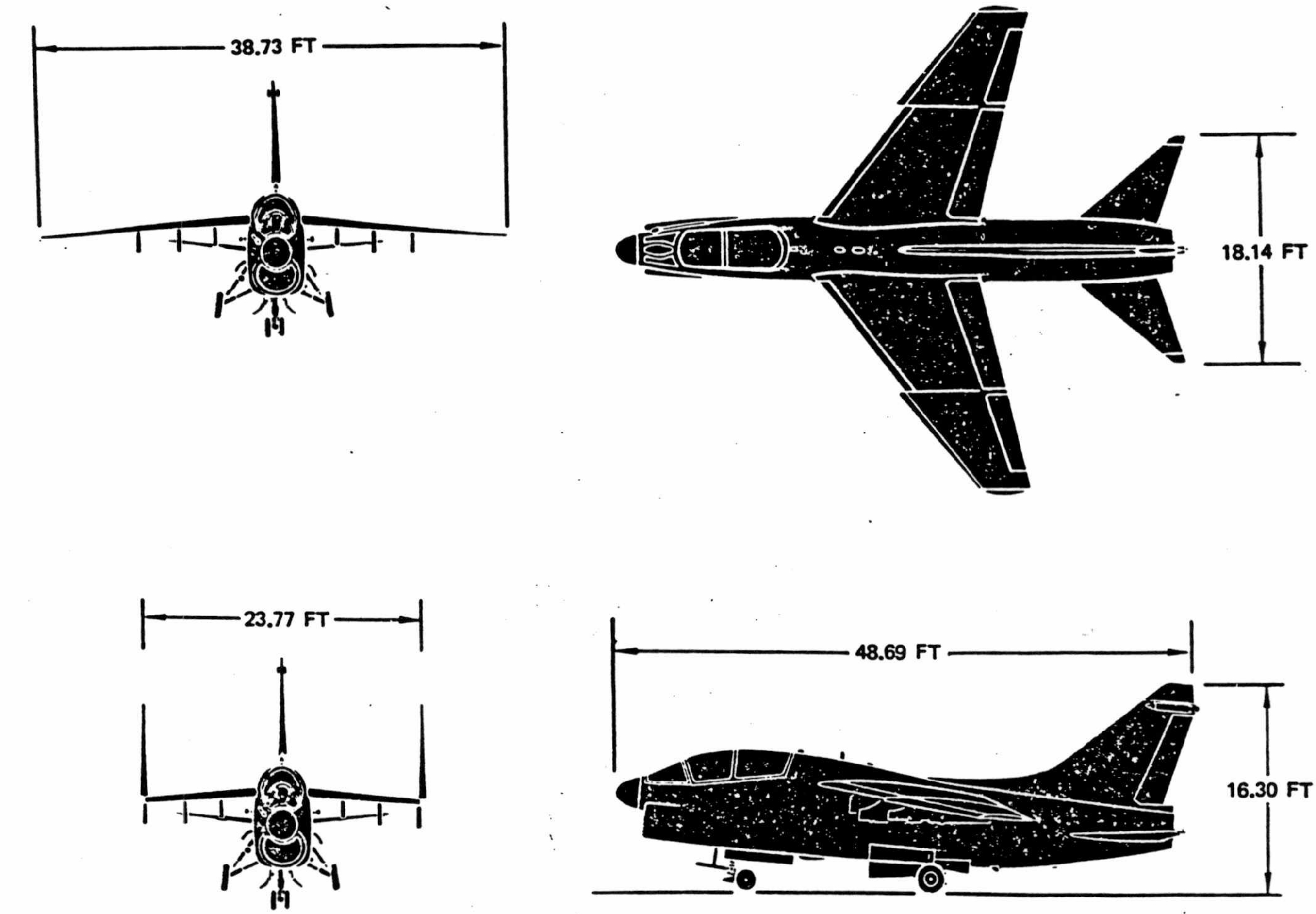


Figure 1–2

Figure 1

PRINCIPAL DIMENSIONS



OTHER DIMENSIONS

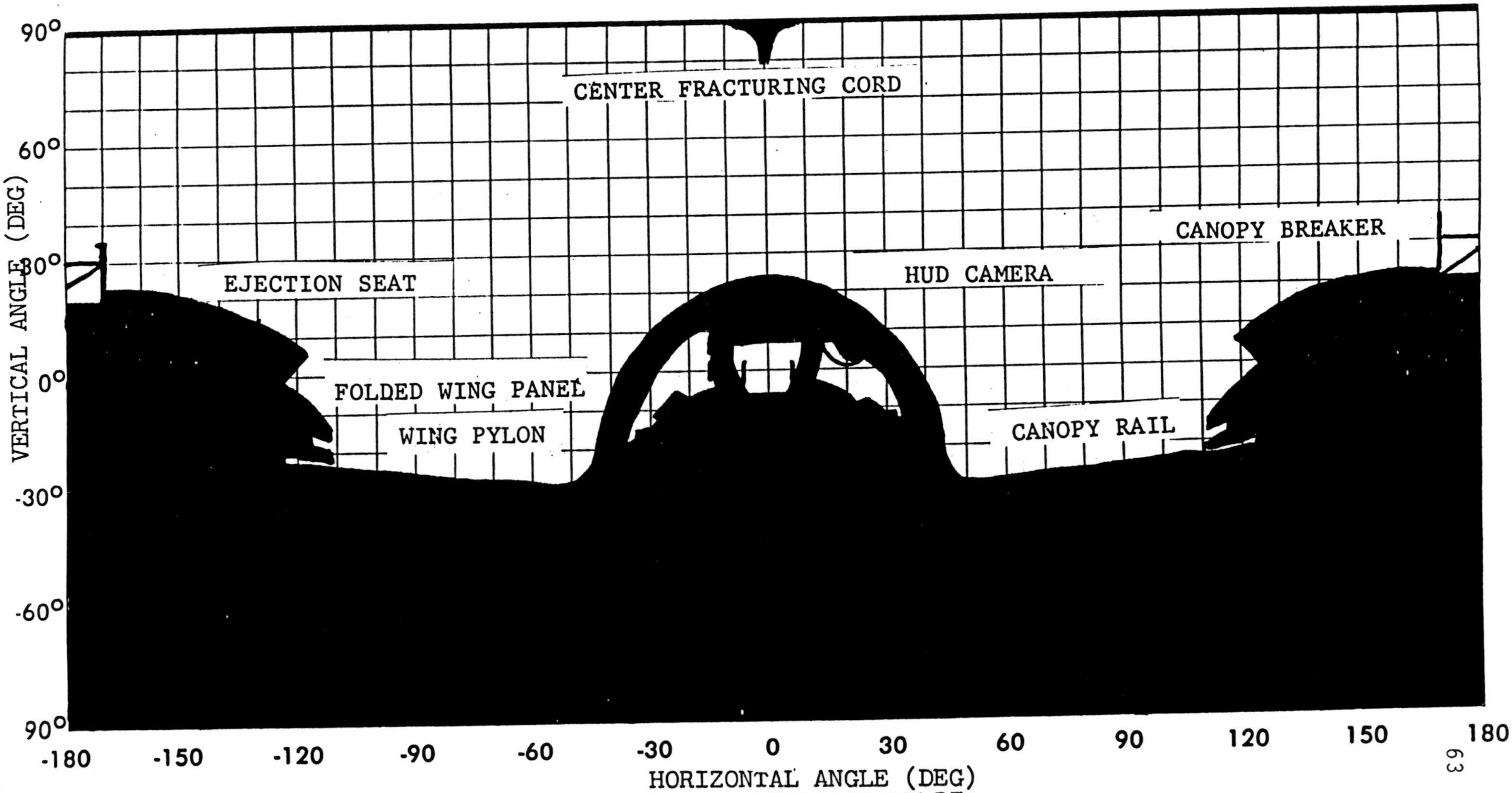
WING		HORIZONTAL STABILIZER		VERTICAL STABILIZER	
Area	375.00 sq ft	Area	93.75 sq ft	Area	115.20 sq ft
Aspect ratio	4	Sweep 1/4 chord	45°	Sweep	43°9 min
Incidence (root and tip)	–1°	Dihedral	5° 25 min		
Sweep 1/4 chord	35°				
Dihedral	–5°				

Figure 2

RECTILINEAR TOTAL VISION ENVELOPE PLOT

APPENDIX E

TA-7C TOTAL FIELD OF VIEW PLOT



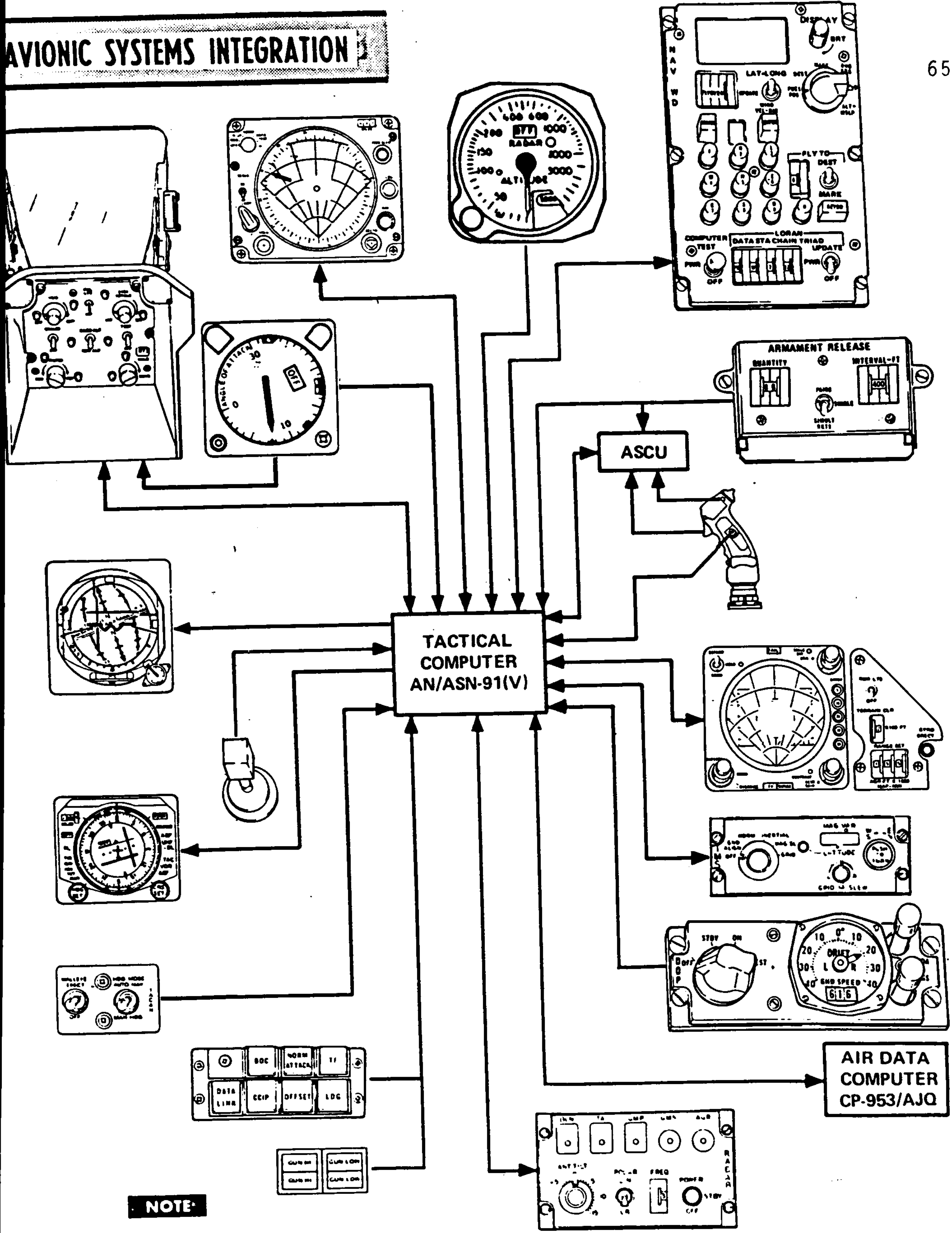
TOTAL VISION ENVELOPE PLOT

APPENDIX E

WEAPON SYSTEM INTEGRATION

APPENDIX F

AVIONIC SYSTEMS INTEGRATION



NOTE

Arrowheads denote direction of signal flow

TABLES

APPENDIX G

Table I
TA-7C DT-11A TEST DAY WEATHER

Date	Ceiling/ Sky Cover	Visibility (nm)	Altimeter (in. of Hg)	Winds (deg/kits)
11 May 1987	Clear	7	29.92	140/10
12 May 1987	Clear	7	29.95	160/09
18 May 1987	Clear	6	29.96	330/08
22 May 1987	2,500 OVR	5 FH	30.05	010/05

Table II
TA-7C TESTS AND TEST CONDITIONS

Test	Altitude (ft MSL)	Trim Airspeed (KIAS)	Configuration	Remarks
Ground Tests	20	0	GR,TX,L	Cockpit - Safety of Flight Shoulder Harness locked and unlocked. Flight Controls. Cockpit Displays. Mechanical Characteristics
T/O	20-500	0-250	TO	Rudder effectiveness (>60 KIAS) NWS sensitivity Qualitative eval of T/O Cockpit Displays NWS OFF at 60 KIAS
Simulated Dive Bombing	3,500 - 12,000	250-450	P	Trim System irreversibility Qualitative Overshoots - Gross and Fine tracking. Control Sensitivity
Simulated Air to Air	5,000 - 20,000	250-450	P	Trim System irreversibility Qualitative Overshoots - Gross and Fine tracking Control Sensitivity
Simulated Instrument Approach (TACAN, GCA)	200 - 10,000	17.5 units-250	CR-PA	Control Harmony Control Trimmability Qualitative
Stalls	20,000 - 25,000	200 150	CR,M,PA	AFCS Disengaged No ailerons above 22 units AOA Power Off (<80%) <1 KIAS/sec decel Control Forces Characteristics Flight Man. Proced. for Recovery Departure Tendency Recovered by 10,000

Table II
TA-7C TESTS AND TEST CONDITIONS

Test	Altitude (ft MSL)	Trim Airspeed (KIAS)	Config- uration	Remarks
echanical harac- eristics	20,000	300	CR	Ground Eval Verification Aileron Rudder UHT
tatic ongitu- inal tability	20,000 8,000	300 132	CR PA	Speed stability +15% or +50 KIAS
light ath tability	8,000	132	PA	Speed stability +15% or +50 KIAS
hugoid	25,000 8,000	245 130	CR PA	15 kts slower and 15 kts faster than Vtrim
hort eriod	13,000 8,000	400 150	CR WO	Sinusoidal Stick pump Pitch Doublet
tatic at-Dir	20,000 8,000	300 134	CR PA	Adverse/Proverse Yaw Rudder only turn (Dihedral) Aileron Only Turn SHSS (1/4 rudder increments)
ynamic at- ir	13,000 8,000	250,300, 365 130	CR PA	Dutch Roll Spiral Stab Roll Mode Time Constant
aneuver- ng tability	10,000 8,000	325 150	P WO	Steady Pulls Steady Turns Steady Push
ynamic ontrol orces	10,000 8,000	325 150	P WO	Sudden Pulls (Buildup with Small Deflections at Damped Natural Frequency)

Table II
TA-7C TESTS AND TEST CONDITIONS

Test	Altitude (ft MSL)	Trim Airspeed (KIAS)	Config-uration	Remarks
oll erfor-ance	13,000	250,300, 365	CR	Full Deflection Rolls (small deflect buildups to full deflection) Qualitative (<360 deg roll in CR)
oll oupling	13,000	300	CR	Qualitative (3.0g)
evel ccel-ration	15,000 5,000	170-444 300-470	P	AMF Deactivated
evel urn	15,000 5,000	250,300 400	P	Sustained Turn
ind-Up urn	15,000 5,000	250,300 400	P	Instantaneous Turn Qualitative
ange nd ndurance	25,000 1,000	190-365	CR, P	Test Day Data with 8 MK 82 Bombs
ecom-ended limb Flight anual)	5,000-30,000	0.55 Mach to 20,000 then 0.78	P	Test Day Data
ecom-ended lide escent	30,000-15,000	240 KIAS	G	Test Day Data
enetra-ion escent	15,000-5,000	250	D	Test Day Data
ormation aneuvers	2,000-25,000	140-400	P,CR,WO PA	Configuration Change FOV Parade Trial Cruise Tail Chase

Table II
TA-7C TESTS AND TEST CONDITIONS

Test	Altitude (ft MSL)	Trim Airspeed (KIAS)	Config-uration	Remarks
ir to ir Man	10,000-30,000	200-400	P, CR	Tail Chase FOV Maneuverability
omb elivery	3,500-10,000	250-450	P	30 deg dive MK-76 Practice MK-82 Inert (Hannabal Target)
ow evel AV		200-450	CR	Gust Response Maneuverability FOV Pilot Workload
ir to round adar	15,000	200-250	CR	Weapon System Integration
pproach	0-1,500	130-134	PA	Turbulence Effect Heading Control Altitude Control Airspeed Control Engine Response
aveoff	200-1,000	130-200	PA-WO	Attitude Control Engine Effect
anding	500-0	130-134	PA-L	Stopping Distance

TA-7C WEIGHT AND BALANCE FORM

(USE REVERSE FOR TRANSPORT MISSIONS)

AN 01-1B-2

DATE	AIRPLANE TYPE	FROM	HOME STATION
	TA-7C		NATC PAX
MISSION/TRIP/FLIGHT/NO.	SERIAL NO.	TO	PILOT
Local	154402		

REMARKS

420.31

130.13

COMPUTER PLATE NO. (If used)

REF	ITEM				WEIGHT	INDEX OR MOM/
1	BASIC AIRPLANE (From Chart C)				19661	9063
2	OIL (Gal.) Inc. in Basic Wt.					
3	DISTRIBUTION OF LOAD					
COMPT.	CREW NO.	CREW WEIGHT	BAGGAGE	CARGO AND MISC.		
	1	178	PILOT	FWD	178	44
	1	178	Pilot	AFT	178	55
	PYLONS		1+8		380	184
	PYLONS		2+7		382	173
	PYLONS		3+6		320	142
	Gear down locks				13	4
			457.80	28.81%		
4	OPERATING WEIGHT ZFGW				21112	9665

Pertinent instructions to the pilot for shifting load and crew during takeoff and landing should be noted above.

CORRECTIONS (Ref. 11)

COMPT.	ITEM	CHANGES (+ or −) WEIGHT	INDEX OR MOM/
	TOTAL WEIGHT REMOVED	−	−
	TOTAL WEIGHT ADDED	+	+
	NET DIFFERENCE (Ref. 11)		

LIMITATIONS

GROSS WT. TAKEOFF (lb.)		GROSS WT. LANDING (lb.)
PERMISSIBLE C. G. TAKEOFF	FROM 18.0	TO (% M.A.C. or IN.) 33.5%
PERMISSIBLE C. G. LANDING	FROM 18.0	TO (% M.A.C. or IN.) 33.5%

1 Enter constant used.
2 Enter values from current applicable T. O.
3 Applicable to gross weight (Ref. 12).
4 Applicable to gross weight (Ref. 15).

REF		ITEM			WEIGHT	INDEX OR MOM/
5	AMMUNITION	COMPT.	ROUNDS	CALIBER		
6	BOMBS, ROCKETS, ETC.	FORWARD				
		AFT				
		EXTERNAL				
		ROCKETS				
7	FUEL	BUILT IN (1500 Gal.)			10200	4602
		BOMB BAY (Gal.)				
		EXTERNAL (Gal.)				
8		WATER INJ. FLUID (Gal.)				
9		JATO OR RATO				
10		TAKEOFF CONDITION (Uncorrected)				
11		CORRECTIONS (If required)				
12		TAKEOFF CONDITION (Corrected)			31312	14267
13		TAKEOFF C. G. IN % M. A. C. OR IN.			455.64	27.15%
14	LESS EXPENDABLES	JATO OR RATO				
		BOMBS				
		AMMUNITION				
		FUEL				
		BINGO			1500	632
15		ESTIMATED LANDING CONDITION			22612	10297
16		ESTIMATED LANDING C. G. IN % M. A. C. OR IN.			455.38	26.95%

COMPUTED BY (Signature)

WEIGHT AND BALANCE AUTHORITY (Signature)

PILOT (Signature)

DD

APPENDIX G

72

A-7E WEIGHT AND BALANCE FORM

NATC PAX RIV

ION, TRIP, FLIGHT NO	RIAL NO	TO	PILOT
OCAL	159296		

ARKS

REF	ITEM	WEIGHT	INDEX OR MOM/1000
1	BASIC AIRPLANE (From Chart C)	19258	8856.4
2	OIL (PART OF BASIC ACFT		
3	DISTRIBUTION OF LOAD		

COMPT.	CREW NO	CREW WEIGHT	BAGGAGE	CARGO AND MISC	WEIGHT	INDEX OR MOM/1000
	1	200	PILOT		200	53.0
	PYLON STA 1 & 8				380	183.6
	PYLON STA 2 & 7				406	184.0
	PYLON STA 3 & 6				320	142.0
	BRU 10 STA 1 & 8				200	94.6
	BRU 10 STA 2 & 7				200	88.6
	BRU 10 STA 3 & 6				200	86.8
			458.28	29.18%		

MPUTER PLATE NO. (If used)

REF	ITEM			WEIGHT	INDEX OR MOM/1000
4	OPERATING WEIGHT ZFGW			21164	9599.0
5 AMMUNITION	COMPT.	ROUNDS	CALIBER		
6 BOMBS, ROCKETS, ETC.	FORWARD				
	AFT				
	EXTERNAL				
	ROCKETS				
7 FUEL	BUILT IN (1476 Gal.)			10036	4585.1
	BOMB BAY (Gal.)				
	EXTERNAL (Gal.)				
8	WATER INJ. FLUID (Gal.)				
9	JATO OR RATO				
10	TAKEOFF CONDITION (Uncorrected)				
11	CORRECTIONS (If required)				
12	TAKEOFF CONDITION (Corrected)			31200	14234.1
13	TAKEOFF C. G. IN % M. A. C. OR IN.			456.22	27.60%
14 LESS EXPENDABLES	JATO OR RATO				
	BOMBS				
	AMMUNITION				
	FUEL BINGO			1500	631.15
15	ESTIMATED LANDING CONDITION			22664	10380.5
16	ESTIMATED LANDING C. G. IN % M. A. C. OR IN.			455.81	27.28%

ertinent instructions to the pilot for shifting load and ew during takeoff and landing should be noted above.

CORRECTIONS (Ref. 11)

MPT.	ITEM	CHANGES (+ or −) WEIGHT	INDEX OR MOM/
	TOTAL WEIGHT REMOVED	−	−
	TOTAL WEIGHT ADDED	+	+
	NET DIFFERENCE (Ref. 11)		

LIMITATIONS

GROSS WT. TAKEOFF (lb.)	GROSS WT. LANDING (lb.)	
PERMISSIBLE C. G. TAKEOFF	FROM 20%	TO % M. A. C. 33.5%
PERMISSIBLE C. G. LANDING	FROM 20%	TO % M. A. C. 33.5%

Enter constant used.
Enter values from current applicable T. O.
Applicable to gross weight (Ref. 12).
Applicable to gross weight (Ref. 15).

COMPUTED BY (Signature) D. Schuhart

WEIGHT AND BALANCE AUTHORITY (Signature) [illegible]

PILOT (Signature)

DD FORM 1 SEPT 54 365F

APPENDIX G

NAVAIR 01-1B-40

FUEL CONSUMPTION DATA

BASED ON MIL-F-5624C (JP-5) TYPE FUEL AT 6.8 LBS./GAL. AVERAGE DENSITY.

WEIGHT (POUNDS)	MOMENT/1000 INTERCONNECTED WING & FUSELAGE TANKS 1500 GAL. ARM - VARIES	WEIGHT (POUNDS)	MOMENT/1000 INTERCONNECTED WING & FUSELAGE TANKS 1500 GAL. ARM - VARIES	WEIGHT (POUNDS)	MOMENT/1000 INTERCONNECTED WING & FUSELAGE TANKS 1500 GAL. ARM - VARIES
100	41.4	3500	1573.6	6900	3163.0
200	82.8	3600	1624.3	7000	3208.1
300	124.2	3700	1675.4	7100	3253.2
400	165.6	3800	1727.1	7200	3298.3
500	207.0	3900	1776.8	7300	3342.7
600	250.1	4000	1827.2	7400	3387.0
700	295.0	(***)4100	1877.8	7500	3432.0
800	340.7	4200	1922.8	7600	3475.5
900	382.6	4300	1967.7	7700	3519.7
1000	424.1	4400	2012.1	7800	3563.8
1100	465.6	4500	2056.5	7900	3607.9
1200	507.1	4600	2100.8	8000	3652.0
1300	548.7	4700	2145.6	8100	3696.0
1400	590.2	4800	2189.8	8200	3740.8
1500	631.7	4900	2233.9	8300	3784.8
1600	673.3	5000	2278.5	8400	3828.7
1700	714.7	5100	2325.1	8500	3872.6
1800	756.0	5200	2373.8	8600	3916.4
1900	797.6	5300	2422.1	8700	3960.2
2000	838.8	5400	2469.4	8800	4004.0
2100	880.3	5500	2516.8	8900	4047.7
2200	921.6	5600	2564.2	9000	4091.4
2300	963.2	5700	2611.2	9100	4135.0
2400	1014.7	5800	2658.1	9200	4178.6
2500	1066.0	5900	2704.6	9300	4222.2
2600	1115.9	6000	2751.0	9400	4265.7
2700	1166.4	6100	2797.5	9500	4309.2
2800	1217.4	(***)6200	2843.3	9600	4351.7
2900	1267.9	6300	2889.8	9700	4395.1
3000	1320.0	6400	2935.7	9800	4437.4
3100	1370.2	6500	2981.6	9900	4480.7
3200	1420.8	6600	3026.8	10000	4523.0
3300	1471.8	6700	3072.6	10100	4566.2
3400	1521.8	6800	3117.8	(**)(*)10200	4602.2

NOTES:

This aircraft is equipped with capacitor type fuel gages which are calibrated in pounds. Aircraft fuel varies in weight, dependent upon the specific gravity and temperature of the fuel; therefore, the notation "full" does not appear on the fuel quantity gages. Variations should be anticipated in gage readings when the systems are full.

(*) Single asterisk indicates "FULL" gage readings at 6.8 lb./gal. - pressure reading.

(**) Double asterisk indicates normal fuel level for most fwd C.G.

(***) Triple asterisk indicates normal fuel level for most aft C.G.

CENTER OF GRAVITY TABLE

MOMENT/1000

Gross Weight Pounds	*18.0% MAC (443.73)	20.0% MAC (446.34)	22.0% MAC (448.94)	24.0% MAC (451.54)	26.0% MAC (454.15)	28.0% MAC (456.75)	28.5% MAC (457.40)	29.0% MAC (458.05)	30.0% MAC (459.35)	31.4% MAC (461.17)	32.0% MAC (461.95)	32.8% MAC (462.99)	33.0% MAC (463.25)	33.5% MAC (463.91)
20100	8932.1	8971.4	9023.7	9076.0	9128.4	9180.7	9193.7	9206.8	9232.9	9269.5	9285.2	9306.1	9311.3	9324.6
20200	8976.4	9016.1	9068.6	9121.1	9173.8	9226.4	9239.5	9252.6	9278.9	9315.6	9331.4	9352.4	9357.7	9371.0
20300	9020.8	9060.7	9113.5	9166.3	9219.2	9272.0	9285.2	9298.4	9324.8	9361.8	9377.6	9398.7	9404.0	9417.4
20400	9065.2	9105.3	9158.4	9211.4	9264.7	9317.7	9331.0	9344.2	9370.7	9407.9	9423.8	9445.0	9450.3	9463.8
20500	9109.6	9150.0	9203.3	9256.6	9310.1	9363.4	9376.7	9390.0	9416.7	9454.0	9470.0	9491.3	9496.6	9510.2
20600	9153.9	9194.6	9248.2	9301.7	9355.5	9409.1	9422.4	9435.8	9462.6	9500.1	9516.2	9537.6	9543.0	9556.5
20700	9198.3	9239.2	9293.1	9346.9	9400.9	9454.7	9468.2	9481.6	9508.5	9546.2	9562.4	9583.9	9589.3	9602.9
20800	9242.7	9283.9	9338.0	9392.0	9446.3	9500.4	9513.9	9527.4	9554.5	9592.3	9608.6	9630.2	9635.6	9649.3
20900	9287.1	9328.5	9382.8	9437.2	9491.7	9546.1	9559.7	9573.2	9600.4	9638.5	9654.8	9676.5	9681.9	9695.7
21000	9331.4	9373.1	9427.7	9482.3	9537.2	9591.8	9605.4	9619.1	9646.4	9684.6	9701.0	9722.8	9728.3	9742.1
21100	9375.8	9417.8	9472.6	9527.5	9582.6	9637.4	9651.1	9664.9	9692.3	9730.7	9747.1	9769.1	9774.6	9788.5
21200	9420.2	9462.4	9517.5	9572.6	9628.0	9683.1	9696.9	9710.7	9738.2	9776.8	9793.3	9815.4	9820.9	9834.9
21300	9464.5	9507.0	9562.4	9617.8	9673.4	9728.8	9742.6	9756.5	9784.2	9822.9	9839.5	9861.7	9867.2	9881.3
21400	9508.9	9551.7	9607.3	9663.0	9718.8	9774.4	9788.4	9802.3	9830.1	9869.0	9885.7	9908.0	9913.6	9927.7
21500	9553.3	9596.3	9652.2	9708.1	9764.2	9820.1	9834.1	9848.1	9876.0	9915.2	9931.9	9954.3	9959.9	9974.1
21600	9597.7	9640.9	9697.1	9753.3	9809.6	9865.8	9879.8	9893.9	9922.0	9961.3	9978.1	10000.6	10006.2	10020.5
21700	9642.0	9685.6	9742.0	9798.4	9855.1	9911.5	9925.6	9939.7	9967.9	10007.4	10024.3	10046.9	10052.5	10066.8
21800	9686.4	9730.2	9786.9	9843.6	9900.4	9957.2	9971.3	9985.5	10013.8	10053.5	10070.5	10093.2	10098.9	10113.2
21900	9730.8	9774.8	9831.8	9888.7	9945.9	10002.8	10017.1	10031.3	10059.8	10099.6	10116.7	10139.5	10145.2	10159.6
22000	9775.2	9819.5	9876.7	9933.9	9991.3	10048.5	10062.8	10077.1	10105.7	10145.7	10162.9	10185.8	10191.5	10206.0
22100	9819.5	9864.1	9921.6	9979.0	10036.7	10094.1	10108.5	10122.9	10151.6	10191.9	10209.1	10232.1	10237.8	10252.4
22200	9863.9	9908.7	9966.5	10024.2	10082.1	10139.9	10154.3	10168.7	10197.6	10238.0	10255.3	10278.4	10284.2	10298.8
22300	9908.3	9953.4	10011.4	10069.3	10127.5	10185.5	10200.0	10214.5	10243.5	10284.1	10301.5	10324.7	10330.5	10345.2
22400	9952.7	9998.0	10056.2	10114.5	10173.0	10231.2	10245.8	10260.3	10289.4	10330.2	10347.7	10371.0	10376.8	10391.6
22500	9997.0	10042.7	10101.1	10159.7	10218.4	10276.9	10291.5	10306.1	10335.4	10376.3	10393.9	10417.3	10423.1	10438.0
22600	10041.4	10087.3	10146.0	10204.8	10263.8	10322.6	10337.2	10351.9	10381.3	10422.4	10440.1	10463.6	10469.5	10484.4
22700	10085.8	10131.9	10190.9	10250.0	10309.2	10368.2	10383.0	10397.7	10427.2	10468.6	10486.3	10509.9	10515.8	10530.8
22800	10130.1	10176.6	10235.8	10295.1	10354.6	10413.9	10428.7	10443.5	10473.2	10514.7	10532.5	10556.2	10562.1	10577.1
22900	10174.5	10221.2	10280.7	10340.3	10400.0	10459.6	10474.5	10489.3	10519.1	10560.8	10578.7	10602.5	10608.4	10623.5
23000	10218.9	10265.8	10325.6	10385.4	10445.4	10505.3	10520.2	10535.2	10565.1	10606.9	10624.9	10648.8	10654.8	10699.9
23100	10263.3	10310.5	10370.5	10430.6	10490.9	10550.9	10565.9	10581.0	10611.0	10653.0	10671.0	10695.1	10701.1	10716.3
23200	10307.6	10355.1	10415.4	10475.7	10536.3	10596.6	10611.7	10626.8	10656.9	10699.1	10717.2	10741.4	10747.4	10762.7
23300	10352.0	10399.7	10460.3	10520.9	10581.7	10642.3	10657.4	10672.6	10702.9	10745.3	10763.4	10787.7	10793.7	10809.1
23400	10396.4	10444.4	10505.2	10566.0	10627.1	10688.0	10703.2	10718.4	10748.8	10791.4	10809.6	10834.0	10840.1	10855.5
23500	10440.8	10489.0	10550.1	10611.2	10672.5	10733.6	10748.9	10764.2	10794.7	10837.5	10855.8	10880.3	10886.4	10901.9
23600	10485.1	10533.6	10595.0	10656.3	10717.9	10779.3	10794.6	10810.0	10840.7	10883.6	10902.0	10926.6	10932.7	10948.3
23700	10529.5	10578.3	10639.9	10701.5	10763.4	10825.0	10840.4	10855.8	10886.6	10929.7	10948.2	10972.9	10979.0	10994.7
23800	10573.9	10622.9	10684.8	10746.7	10808.8	10870.7	10886.1	10901.6	10932.5	10975.8	10994.4	11019.2	11025.4	11041.1
23900	10618.2	10667.5	10729.7	10791.8	10854.1	10916.3	10931.9	10947.4	10978.5	11022.0	11040.6	11065.5	11071.7	11087.4
24000	10662.6	10712.2	10774.6	10837.0	10899.6	10962.0	10977.6	10993.2	11024.4	11068.1	11086.8	11111.8	11118.0	11133.8
24100	10707.0	10756.8	10819.4	10882.1	10945.0	11007.7	11023.3	11039.0	11070.3	11114.2	11133.0	11158.1	11164.3	11180.2
24200	10751.4	10801.4	10864.3	10927.3	10990.4	11053.4	11069.1	11084.8	11116.3	11160.3	11179.2	11204.4	11210.7	11226.6
24300	10795.7	10846.1	10909.2	10972.4	11035.8	11099.0	11114.8	11130.6	11162.2	11206.4	11225.4	11250.6	11257.0	11273.0
24400	10840.1	10890.7	10954.1	11017.6	11081.3	11144.7	11160.6	11176.4	11208.1	11252.5	11271.6	11297.0	11303.3	11319.4
24500	10884.5	10935.3	10999.0	11062.7	11126.7	11190.4	11206.3	11222.2	11254.1	11298.7	11317.8	11343.3	11349.6	11365.8
24600	10928.9	10980.0	11043.9	11107.9	11172.1	11236.1	11252.0	11268.0	11300.0	11344.8	11364.0	11389.6	11396.0	11412.2
24700	10973.2	11024.6	11088.8	11153.0	11217.5	11281.7	11297.8	11313.8	11345.9	11390.9	11410.2	11435.9	11442.3	11458.6
24800	11017.6	11069.2	11133.7	11198.2	11262.9	11327.4	11343.5	11359.6	11391.9	11437.0	11456.4	11482.2	11488.5	11505.0
24900	11062.0	11113.9	11178.6	11243.3	11308.3	11373.1	11389.3	11405.4	11437.8	11483.1	11502.6	11528.5	11534.9	11551.4
25000	11106.4	11158.5	11223.5	11288.5	11353.8	11418.8	11435.0	11451.3	11483.8	11529.3	11548.8	11574.8	11581.3	11597.8

Table IV (Continued)

CENTER OF GRAVITY TABLE

MOMENT/1000

Gross Weight Pounds	*18.0% MAC (443.73)	20.0% MAC (446.34)	22.0% MAC (448.94)	24.0% MAC (451.54)	26.0% MAC (454.15)	28.0% MAC (456.75)	28.5% MAC (457.40)	29.0% MAC (458.05)	30.0% MAC (459.35)	31.4% MAC (461.17)	32.0% MAC (461.95)	32.8% MAC (462.99)	33.0% MAC (463.25)	33.5% MAC (463.91)
25100	11150.7	11203.1	11268.4	11333.7	11399.2	11464.4	11480.7	11497.1	11529.7	11575.4	11594.9	11621.0	11627.6	11644.1
25200	11195.1	11247.8	11313.3	11378.8	11444.6	11510.1	11526.5	11542.9	11575.6	11621.5	11641.1	11667.3	11673.9	11690.5
25300	11239.5	11292.4	11358.2	11424.0	11490.0	11555.8	11572.2	11588.7	11621.6	11667.6	11687.3	11713.6	11720.0	11736.9
25400	11283.8	11337.0	11403.1	11469.1	11535.4	11601.5	11618.0	11634.5	11667.5	11713.7	11733.5	11759.9	11766.6	11783.3
25500	11328.2	11381.7	11448.0	11514.3	11580.8	11647.1	11663.7	11680.3	11713.4	11759.8	11779.7	11806.2	11812.9	11829.7
25600	11372.6	11426.3	11492.9	11559.4	11626.2	11692.8	11709.4	11726.1	11759.4	11806.0	11825.9	11852.5	11859.2	11876.1
25700	11417.0	11470.9	11537.7	11604.6	11671.7	11738.5	11755.2	11771.9	11805.3	11852.1	11872.1	11898.8	11905.5	11922.5
25800	11461.3	11515.6	11582.6	11649.7	11717.1	11784.2	11800.9	11817.7	11851.2	11898.2	11918.3	11945.1	11951.9	11968.9
25900	11505.7	11560.2	11627.5	11694.9	11762.5	11829.8	11846.7	11863.5	11897.2	11944.3	11964.5	11991.4	11998.1	12015.3
26000	11550.1	11604.8	11672.4	11740.0	11807.9	11875.5	11892.4	11909.3	11943.1	11990.4	12010.7	12037.7	12044.5	12061.7
26100	11594.5	11649.5	11717.3	11785.2	11853.3	11921.2	11938.1	11955.1	11989.0	12036.5	12056.9	12084.0	12090.8	12108.1
26200	11638.8	11694.1	11762.2	11830.3	11898.7	11966.9	11983.9	12000.9	12035.0	12082.7	12103.1	12130.3	12137.2	12154.4
26300	11683.2	11738.7	11807.1	11875.5	11944.1	12012.5	12029.6	12046.7	12080.9	12128.8	12149.3	12176.6	12183.5	12200.8
26400	11727.6	11783.4	11852.0	11920.7	11989.6	12058.2	12075.4	12092.5	12126.8	12174.9	12195.5	12222.9	12229.8	12247.2
26500	11771.9	11828.0	11896.9	11965.8	12035.0	12103.9	12121.1	12138.3	12172.8	12221.0	12241.7	12269.2	12276.1	12293.6
26600	11816.3	11872.6	11941.8	12011.0	12080.4	12149.6	12166.8	12184.1	12218.7	12267.1	12287.9	12315.5	12322.5	12340.0
26700	11860.7	11917.3	11986.7	12056.1	12125.8	12195.2	12212.6	12229.9	12264.6	12313.2	12334.1	12361.8	12368.8	12396.4
26800	11905.1	11961.9	12031.6	12101.3	12171.2	12240.9	12258.3	12275.7	12310.6	12359.4	12380.3	12408.1	12415.1	12432.8
26900	11949.4	12006.5	12076.5	12146.4	12216.6	12286.6	12304.1	12321.5	12356.5	12405.5	12426.5	12454.4	12461.4	12479.2
27000	11993.8	12051.2	12121.4	12191.6	12262.1	12332.3	12349.8	12367.4	12402.5	12451.6	12472.7	12500.7	12507.8	12525.6
27100	12038.2	12095.8	12166.3	12236.7	12307.5	12377.9	12395.5	12413.2	12448.4	12497.7	12518.8	12547.0	12554.1	12572.0
27200	12082.6	12140.4	12211.2	12281.9	12352.9	12423.6	12441.3	12459.0	12494.3	12543.8	12565.0	12593.3	12600.4	12618.4
27300	12126.9	12185.1	12256.1	12327.0	12398.3	12469.3	12487.0	12504.8	12540.3	12589.9	12611.2	12639.6	12646.7	12664.7
27400	12171.3	12229.7	12300.9	12372.2	12443.7	12515.0	12532.8	12550.6	12586.2	12636.1	12657.4	12685.9	12693.1	12711.1
27500	12215.7	12274.4	12345.8	12417.4	12489.1	12560.6	12578.5	12596.4	12632.1	12682.2	12703.6	12732.2	12739.4	12757.5
27600	12260.0	12319.0	12390.7	12462.5	12534.5	12606.3	12624.2	12642.2	12678.1	12728.3	12749.8	12778.5	12785.7	12803.9
27700	12304.4	12363.6	12435.6	12507.7	12580.0	12652.0	12670.0	12688.0	12724.0	12774.4	12796.0	12824.8	12832.0	12850.3
27800	12348.8	12408.3	12480.5	12552.8	12625.4	12697.7	12715.7	12733.8	12769.9	12820.5	12842.2	12871.1	12878.4	12896.7
27900	12393.2	12452.9	12525.4	12598.0	12670.8	12743.3	12761.5	12779.6	12815.9	12866.6	12888.4	12917.4	12924.7	12943.1
28000	12437.5	12497.5	12570.3	12643.1	12716.2	12789.0	12807.2	12825.4	12861.8	12912.8	12934.6	12963.7	12971.0	12989.5
28100	12481.9	12542.2	12615.2	12688.3	12761.6	12834.7	12852.9	12871.2	12907.7	12958.9	12980.8	13010.0	13017.3	13035.9
28200	12526.3	12586.8	12660.1	12733.4	12807.0	12880.4	12898.7	12917.0	12953.7	13005.0	13027.0	13056.3	13063.7	13082.3
28300	12570.7	12631.4	12705.0	12778.6	12852.4	12926.0	12944.4	12962.8	12999.6	13051.1	13073.2	13102.6	13110.0	13128.7
28400	12615.0	12676.1	12749.9	12823.7	12897.9	12971.7	12990.2	13008.6	13045.5	13097.2	13119.4	13148.9	13156.3	13175.0
28500	12659.4	12720.7	12794.8	12868.9	12943.3	13017.4	13035.9	13054.4	13091.5	13143.3	13165.6	13195.2	13202.6	13221.4
28600	12703.8	12765.3	12839.7	12914.0	12988.7	13063.1	13081.6	13100.2	13137.4	13189.5	13211.8	13241.5	13249.0	13267.8
28700	12748.2	12810.0	12884.6	12959.2	13034.1	13108.7	13127.4	13146.0	13183.3	13235.6	13258.0	13287.8	13295.3	13314.2
28800	12792.5	12854.6	12929.5	13004.4	13079.5	13154.4	13173.1	13191.8	13229.3	13281.7	13304.2	13334.1	13341.6	13360.6
28900	12836.9	12899.2	12974.4	13049.5	13124.9	13200.1	13218.9	13237.6	13275.2	13327.8	13350.4	13380.4	13387.9	13407.0
29000	12881.3	12943.9	13019.3	13094.7	13170.4	13245.8	13264.6	13283.5	13321.2	13373.9	13396.6	13426.7	13434.3	13453.4
29100	12925.6	12988.5	13064.1	13139.8	13215.8	13291.4	13310.3	13329.3	13367.1	13420.0	13442.7	13473.0	13480.6	13499.8
29200	12970.0	13033.1	13109.0	13185.0	13261.2	13337.1	13356.1	13375.1	13413.0	13466.2	13488.9	13519.3	13526.9	13546.2
29300	13014.4	13077.8	13153.9	13230.1	13306.6	13382.8	13401.8	13420.9	13459.0	13512.3	13535.1	13565.6	13573.2	13592.6
29400	13058.8	13122.4	13198.8	13275.3	13352.0	13428.5	13447.6	13466.7	13504.9	13558.4	13581.3	13611.9	13619.6	13639.0
29500	13103.1	13167.0	13243.7	13320.4	13397.4	13474.1	13493.3	13512.5	13550.8	13604.5	13627.5	13658.2	13665.9	13685.3
29600	13147.5	13211.7	13288.6	13365.6	13442.8	13519.8	13539.0	13558.3	13596.8	13650.6	13673.7	13704.5	13712.2	13731.7
29700	13191.9	13256.3	13333.5	13410.7	13488.3	13565.5	13584.8	13604.1	13642.7	13696.7	13719.9	13750.8	13758.5	13778.1
29800	13236.3	13300.9	13378.4	13455.9	13533.7	13611.2	13630.5	13649.9	13688.6	13742.9	13766.1	13797.1	13804.9	13824.5
29900	13280.6	13345.6	13423.3	13501.0	13579.1	13656.8	13676.3	13695.7	13734.6	13789.0	13812.3	13843.4	13851.2	13870.9
30000	13325.0	13390.2	13468.2	13546.2	13624.5	13702.5	13722.0	13741.5	13780.5	13835.1	13858.5	13889.7	13897.5	13917.3
30100	13369.4	13434.8	13513.1	13591.4	13669.9	13748.2	13767.7	13787.3	13826.4	13881.2	13904.7	13936.0	13943.8	13963.7
30200	13413.7	13479.5	13558.0	13636.5	13715.3	13793.9	13813.5	13833.1	13872.4	13927.3	13950.9	13982.3	13990.2	14010.1
30300	13458.1	13524.1	13602.9	13681.7	13760.7	13839.5	13859.2	13878.9	13918.3	13973.5	13997.1	14028.6	14036.5	14056.5
30400	13502.5	13568.7	13647.8	13726.8	13806.2	13885.2	13905.0	13924.7	13964.2	14019.6	14043.3	14074.9	14082.8	14102.9
30500	13546.9	13613.4	13692.7	13772.0	13851.6	13930.9	13950.7	13970.5	14010.2	14065.7	14089.5	14121.2	14129.1	14149.3

CENTER OF GRAVITY TABLE

MOMENT/1000

Gross Weight Pounds	*18.0% MAC (443.73)	20.0% MAC (446.34)	22.0% MAC (448.94)	24.0% MAC (451.54)	26.0% MAC (454.15)	28.0% MAC (456.75)	28.5% MAC (457.40)	29.0% MAC (458.05)	30.0% MAC (459.35)	31.4% MAC (461.17)	32.0% MAC (461.95)	32.8% MAC (462.99)	33.0% MAC (463.25)	33.5% MAC (463.91)
30600	13591.2	13658.0	13737.6	13817.1	13897.0	13976.6	13996.4	14016.3	14056.1	14111.8	14135.7	14167.5	14175.5	14195.6
30700	13635.6	13702.6	13782.4	13862.3	13942.4	14022.2	14042.2	14062.1	14102.0	14157.9	14181.9	14213.8	14221.8	14242.0
30800	13680.0	13747.3	13827.3	13907.4	13987.8	14067.9	14087.9	14107.9	14148.0	14204.0	14228.1	14260.1	14268.1	14288.4
30900	13724.4	13791.9	13872.2	13952.6	14033.2	14113.6	14133.7	14153.7	14193.9	14250.2	14274.3	14306.4	14314.4	14334.8
31000	13768.7	13836.5	13917.1	13997.7	14078.7	14159.3	14179.4	14199.6	14239.9	14296.3	14320.5	14352.7	14360.8	14381.2
31100	13813.1	13881.2	13962.0	14042.9	14124.1	14204.9	14225.1	14245.4	14285.8	14342.4	14366.6	14399.0	14407.1	14427.6
31200	13857.5	13925.8	14006.9	14088.0	14169.5	14250.6	14270.9	14291.2	14331.7	14388.5	14412.8	14445.3	14453.4	14474.0
31300	13901.8	13970.4	14051.8	14133.2	14214.9	14296.3	14316.6	14337.0	14377.7	14434.6	14459.0	14491.6	14499.7	14520.4
31400	13946.2	14015.1	14096.7	14178.4	14260.3	14342.0	14362.4	14382.8	14423.6	14480.7	14505.2	14537.9	14546.1	14566.8
31500	13990.6	14059.7	14141.6	14223.5	14304.7	14387.6	14408.1	14428.6	14469.5	14526.9	14551.4	14584.2	14592.4	14613.2
31600	14035.0	14104.3	14186.5	14268.7	14351.1	14433.3	14453.8	14474.4	14515.5	14573.0	14597.6	14630.5	14638.7	14659.6
31700	14079.3	14149.0	14231.4	14313.8	14396.6	14479.0	14499.6	14520.2	14561.4	14619.1	14643.8	14676.8	14685.0	14705.9
31800	14123.7	14193.6	14276.3	14359.0	14442.0	14524.7	14545.8	14566.0	14607.3	14665.2	14690.0	14723.1	14731.4	14752.3
31900	14168.1	14238.2	14321.2	14404.1	14487.4	14570.3	14591.1	14611.8	14653.3	14711.3	14736.2	14769.4	14777.7	14798.7
32000	14212.5	14282.9	14366.1	14449.3	14532.8	14616.0	14636.8	14657.6	14699.2	14757.4	14782.4	14815.7	14824.0	14845.1
32100	14256.8	14327.5	14411.0	14494.4	14578.2	14661.7	14682.5	14703.4	14745.1	14803.6	14828.6	14862.0	14870.3	14891.5
32200	14301.2	14372.1	14455.9	14539.6	14623.6	14707.4	14728.3	14749.2	14791.1	14849.7	14874.8	14908.3	14916.7	14937.9
32300	14345.6	14416.8	14500.8	14584.7	14669.0	14753.0	14774.0	14795.0	14837.0	14895.8	14921.0	14954.6	14963.0	14984.3
32400	14390.0	14461.4	14545.6	14629.9	14714.5	14798.7	14819.8	14840.8	14882.9	14941.9	14967.2	15000.9	15009.3	15030.7
32500	14434.3	14506.1	14590.5	14675.0	14759.9	14844.4	14865.5	14886.6	14928.9	14988.0	15013.4	15047.2	15055.6	15077.1
32600	14478.7	14550.7	14635.4	14720.2	14805.3	14890.1	14911.2	14932.4	14974.8	15034.1	15059.6	15093.5	15102.0	15123.5
32700	14523.1	14595.3	14680.3	14765.4	14850.7	14935.7	14957.0	14978.2	15020.7	15080.3	15105.8	15139.8	15148.3	15169.9
32800	14567.4	14640.0	14725.2	14810.5	14896.1	14981.4	15002.7	15024.0	15066.7	15126.4	15152.0	15186.1	15194.6	15216.2
32900	14611.8	14684.6	14770.1	14855.7	14941.5	15027.1	15048.5	15069.8	15112.6	15172.5	15198.2	15232.4	15240.9	15262.6
33000	14656.2	14729.2	14815.0	14900.8	14987.0	15072.8	15094.2	15115.7	15158.6	15218.6	15244.4	15278.7	15287.3	15309.0
33100	14700.6	14773.9	14859.9	14946.0	15032.4	15118.4	15139.9	15161.5	15204.5	15264.7	15290.5	15325.0	15333.6	15355.4
33200	14744.9	14818.5	14904.8	14991.1	15077.8	15164.1	15185.7	15207.3	15250.4	15310.8	15336.7	15371.3	15379.9	15401.8
33300	14789.3	14863.1	14949.7	15036.3	15123.2	15209.8	15231.4	15253.1	15296.4	15357.0	15382.9	15417.6	15426.2	15448.2
33400	14833.7	14907.8	14994.6	15081.4	15168.6	15255.5	15277.2	15298.9	15342.3	15403.1	15429.1	15463.9	15472.6	15494.6
33500	14878.1	14952.4	15039.5	15126.6	15214.0	15301.1	15322.9	15344.7	15388.2	15449.2	15475.3	15510.2	15518.9	15541.0
33600	14922.4	14997.0	15084.4	15171.7	15259.4	15346.8	15368.6	15390.5	15434.2	15495.3	15521.5	15556.5	15565.2	15587.4
33700	14966.8	15041.7	15129.3	15216.9	15304.9	15392.5	15414.4	15436.3	15480.1	15541.4	15567.7	15602.8	15611.5	15633.8
33800	15011.2	15086.3	15174.2	15262.1	15350.3	15438.2	15460.1	15482.1	15526.0	15587.5	15613.9	15649.1	15657.9	15680.2
33900	15055.5	15130.9	15219.0	15307.2	15395.7	15483.8	15505.9	15527.9	15572.0	15633.7	15660.1	15695.4	15704.2	15726.5
34000	15099.9	15175.6	15263.9	15352.4	15441.1	15529.5	15551.6	15573.7	15617.9	15679.8	15706.3	15741.7	15750.5	15772.9
34100	15144.3	15220.2	15308.8	15397.5	15486.5	15575.2	15597.3	15619.5	15663.8	15725.9	15752.5	15788.0	15796.8	15819.3
34200	15188.7	15264.8	15353.7	15442.7	15531.9	15620.9	15643.1	15665.3	15709.8	15772.0	15798.7	15834.3	15843.2	15865.7
34300	15233.0	15309.5	15398.6	15487.8	15577.3	15666.5	15688.8	15711.1	15755.7	15818.1	15844.9	15880.6	15889.5	15912.1
34400	15277.4	15354.1	15443.5	15533.0	15622.8	15712.2	15734.6	15756.9	15801.6	15864.2	15891.1	15926.9	15935.8	15958.5
34500	15321.8	15398.7	15488.4	15578.1	15668.2	15757.9	15780.3	15802.7	15847.6	15910.4	15937.3	15973.2	15982.1	16004.9
34600	15366.2	15443.4	15533.3	15623.3	15713.6	15803.6	15826.0	15848.5	15893.5	15956.5	15983.5	16019.5	16028.5	16051.3
34700	15410.5	15488.0	15578.2	15668.4	15759.0	15849.2	15871.8	15894.3	15939.4	16002.6	16029.7	16065.8	16074.8	16097.7
34800	15454.9	15532.6	15623.1	15713.6	15804.4	15894.9	15917.5	15940.1	15985.4	16048.7	16075.9	16112.1	16121.1	16144.1
34900	15499.3	15577.3	15668.0	15758.7	15849.8	15940.6	15963.3	15985.9	16031.3	16094.8	16122.1	16158.4	16167.4	16190.5
35000	15543.7	15621.9	15712.9	15803.9	15895.3	15986.3	16009.0	16031.8	16077.3	16141.0	16168.3	16204.7	16213.8	16236.9
35100	15588.0	15666.5	15757.8	15849.1	15940.7	16031.9	16054.7	16077.6	16123.2	16187.1	16214.4	16250.9	16260.1	16283.2
35200	15632.4	15711.2	15802.7	15894.2	15986.1	16077.6	16100.5	16123.4	16169.1	16233.2	16260.6	16297.2	16306.4	16329.6
35300	15676.8	15755.8	15847.6	15939.4	16031.5	16123.3	16146.2	16169.2	16215.1	16279.3	16306.8	16343.5	16352.7	16376.0
35400	15721.1	15800.4	15892.5	15984.5	16076.9	16169.0	16192.0	16215.0	16261.0	16325.4	16353.0	16389.8	16399.1	16422.4
35500	15765.5	15845.1	15937.4	16029.7	16122.3	16214.6	16237.7	16260.8	16306.9	16371.5	16399.2	16436.1	16445.4	16468.8
35600	15809.9	15889.7	15982.2	16074.8	16167.7	16260.3	16283.4	16306.6	16352.9	16417.7	16445.4	16482.4	16491.7	16515.2
35700	15854.3	15934.3	16027.1	16120.0	16213.2	16306.0	16329.2	16352.4	16398.8	16463.8	16491.6	16528.7	16538.0	16561.6
35800	15898.6	15979.0	16072.0	16165.1	16258.6	16351.7	16374.9	16398.2	16444.7	16509.9	16537.8	16575.0	16584.4	16608.0
35900	15943.0	16023.6	16116.9	16210.3	16304.0	16397.3	16420.7	16444.0	16490.7	16556.0	16584.0	16621.3	16630.7	16654.4
36000	15987.4	16068.2	16161.8	16255.4	16349.4	16443.0	16466.4	16489.8	16536.6	16602.1	16630.2	16667.6	16677.0	16700.8

CURVES

APPENDIX H

MODEL TA-7C AIRPLANE
BUNO 154477

Configuration: GR
Method: Ground Test

Stabilizer Trim: 0 degrees
Stab Aug: On

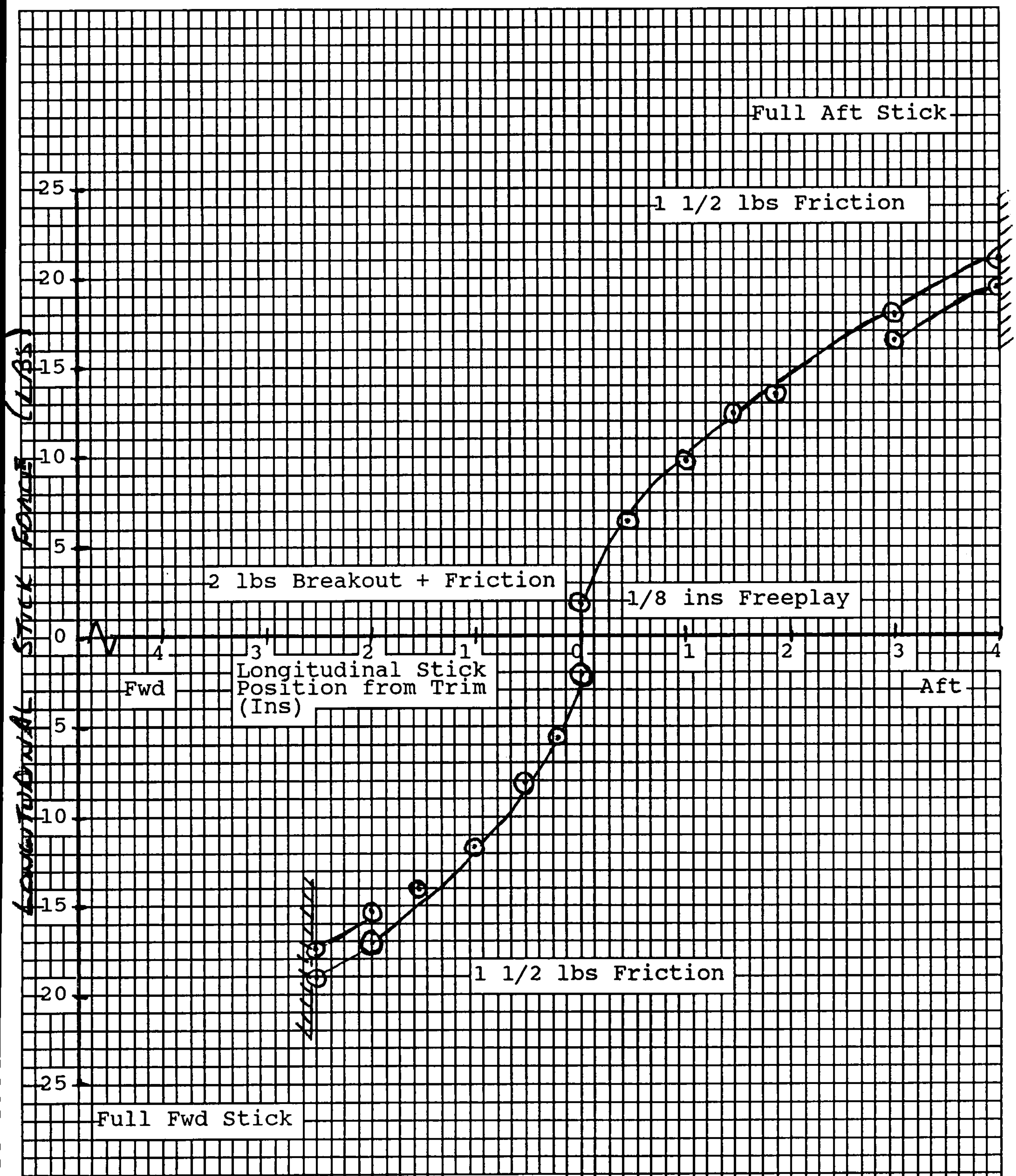


Figure 1

TA-7C Longitudinal Control System Mechanical Characteristics

MODEL TA-7C AIRPLANE
BUNO 154477

Configuration: GR
Method: Ground Test
Trailing Edge Flaps: Up

Stabilizer Trim: 0 degrees
Stab Aug: On

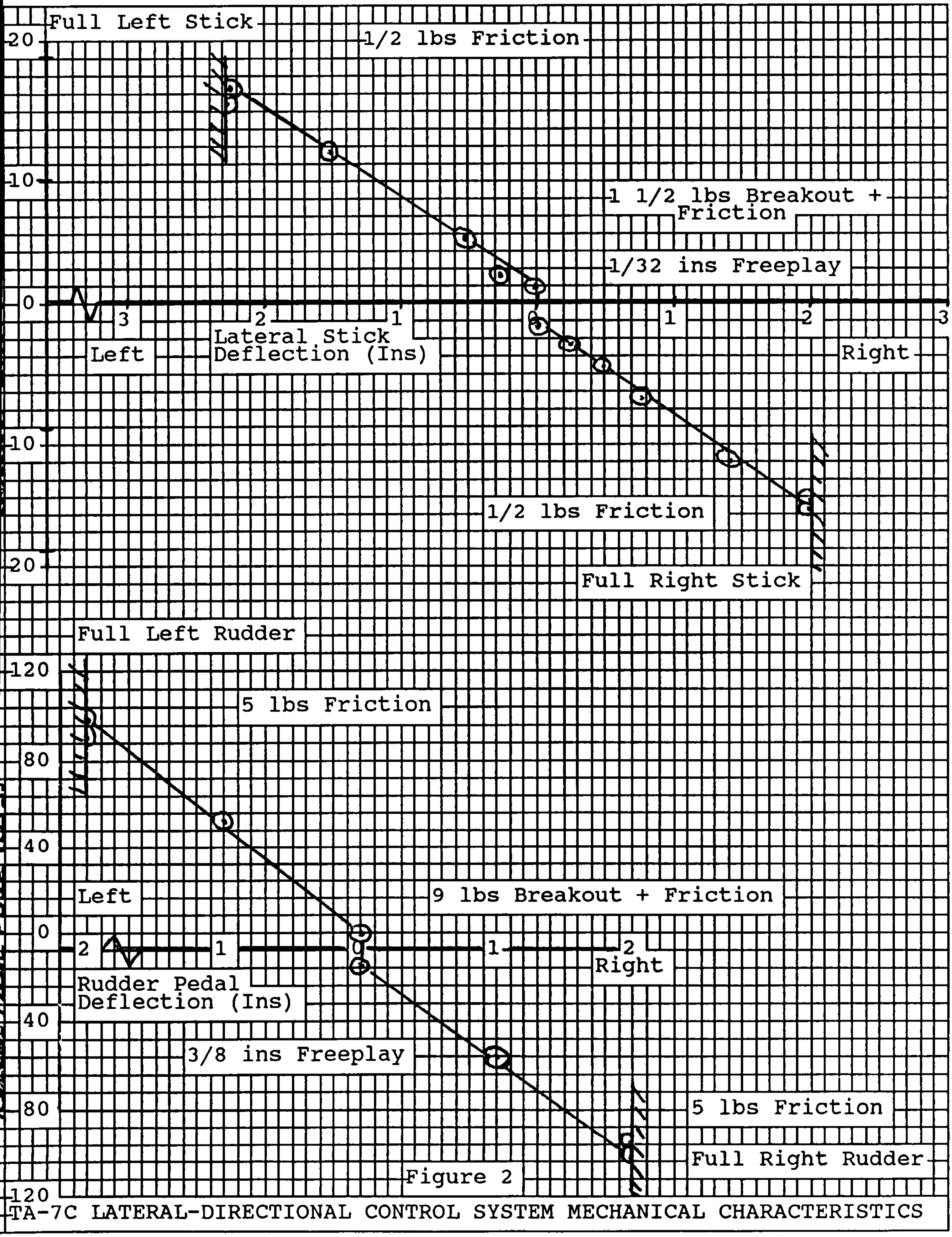


Figure 2

TA-7C LATERAL-DIRECTIONAL CONTROL SYSTEM MECHANICAL CHARACTERISTICS

GLOSSARY OF TERMS

GLOSSARY OF TERMS

AERODYNAMIC CENTER. That point on a wing or aircraft body at which the total lift may be assumed to act.

ANTHROPOMETRIC MEASUREMENTS. A person's physical measurements (i.e. total sitting height, sitting eye height, functional reach, etc.) as compared to a data base. For the purpose of this thesis, the data base was a sampling of Naval Aviators compiled by the U.S. Navy Aviation Physiology Department.

BREAKOUT PLUS FRICTION. The sum of the pre-loaded flight control force (breakout) and the friction, this is the maximum force exerted by the pilot before movement of the flight control from trim.

COMBAT RADIUS. The total distance that the aircraft can fly and still have enough fuel to perform the mission upon reaching the target and adequate fuel reserve upon return.

CONTROL CENTERING. Positive centering is the tendency for a flight control to return to a trimmed position following displacement. Absolute centering occurs when the control stick or rudder returns to the exact position from which it was displaced.

CONTROL FORCE GRADIENT. The force required per increment of control displacement once a flight control has been displaced from trim. The average gradient is the slope of the average variation of force versus displacement.

CONTROL OSCILLATIONS. The resultant motion of a flight control following a release from a given amount of displacement.

CONTROL SENSITIVITY. The angular acceleration of aircraft response generated by a specific amount of flight control input.

DESIGN EYE POSITION. The point in space located at the sitting eye height dimension of the "average" aviator (50th percentile - 31.5 in. above the seat). Design eye position is the source of measurement for control reach, display visibility, cockpit space accommodation, etc.

FIELD OF VIEW. Binocular field of regard of the human eyes focused at infinity.

GLOSSARY OF TERMS (Continued)

FREEPLAY. The lost motion that exists between a cockpit control and the corresponding aircraft control surface.

HANDLING QUALITIES RATING. A subjective conclusion reached as to the performance or desirability of a handling feature with regard to the pilot's ability to perform a task within certain tolerances.

HEADS UP DISPLAY. An optical device mounted near the windscreen which provides airplane heading, altitude, speed and weapon release information to the pilot. Allows the pilot to monitor airplane and weapon system performances while continuing to monitor the external environment.

HUD INSTANTANEOUS FIELD OF VIEW. A "snapshot" view of HUD information. Size of instantaneous field of view is dependent on exit optic size, distance from eyes to HUD, lateral and vertical position of eyes relative to HUD.

INDICATED AIRSPEED. The aircraft velocity value corrected for instrument error, but not for position, compressibility, or air density errors.

INSTRUMENT METEOROLOGICAL CONDITIONS. Meteorological conditions under which the pilot must rely solely upon aircraft instruments to maintain aircraft attitude and position.

IRREVERSIBLE FLIGHT CONTROL SYSTEM. A system which transmits pilot commands to the aircraft control surfaces via the flight controls, but which does not allow any control surface loads to be felt by the pilot.

MEAN SEA LEVEL ALTITUDE. Airplane altitude referenced to the average level of the ocean.

NORMAL ACCELERATION. That acceleration present in the airplane along the aircraft vertical axis. Often quantified as 'g' level or load factor.

PRESSURE ALTITUDE. The altitude measured when the barometric altimeter is set to standard day pressure conditions (29.92 in. Hg).

GLOSSARY OF TERMS (Continued)

RADAR ALTITUDE. Height of the aircraft above the ground as determined by an onboard system which transmits a radar signal towards the ground, measures the time for the signal to return, and thereby computes aircraft altitude.

RECTILINEAR TOTAL VISION PLOT. A compilation of the forward, side, and rear fields of view as measured from the design eye position. Includes information on obstructions for 180 degrees vertically and 360 degrees side to side with axes referenced to the nose of the aircraft (side-to-side) and the cockpit floor (vertically).

STANDARD DAY. Standard day sea level conditions defined as temperature = 59 deg F, air pressure = 29.92 in. hg, and air density = 0.0023769 slugs per cubic foot.

TRIMMED FLIGHT CONTROL POSITIONS. Flight control positions measured while in a stabilized flight condition.

TRUE AIRSPEED. The aircraft velocity value corrected for instrument, position, compressibility, and air density errors.

VISUAL METEOROLOGICAL. Meteorological conditions under which the pilot may rely upon outside references to maintain aircraft attitude and position.

LIST OF ABBREVIATIONS

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ACLS	Automatic carrier landing system
AFCS	Automatic flight control system
AGL	Above ground level
AMF	Automatic maneuvering flaps
BO+F	Break out plus friction
BuNo	Aircraft bureau number
Cdo	Coefficient of parasite drag
CG	Center of gravity
Clmax	Maximum coefficient of lift
deg	Degree
DEP	Design eye position
FOV	Field of view
ft	Foot
g	Normal acceleration due to gravity
Hg	Mercury
HQR	Handling qualities rating
hr	Hour
HUD	Heads up display
IFF	Identification, Friend or Foe
IMC	Instrument meteorological conditions
IMS	Inertial measurement set
in.	Inch
KOAS	Knots observed airspeed
kt	Knot
lb	Pound
Lmax	Maximum lift
MAC	Mean aerodynamic chord
MER	Multiple Ejector Rack which has provisions to carry up to 6 practice or live ordnance
min	Minute
MSL	Mean sea level
NATOPS	Naval air training and operating procedures standardization program
nmi	Nautical mile
Nz	Normal acceleration
Ps	Specific excess power
psi	Pounds per square inch
RPM	Revolutions per minute
sec	Second
STD	Standard
TACAN	Tactical Air Navigation
TER	Triple Ejector Rack which has provisions to carry up to 3 practice or live ordnance
UFC	Up front control
UHF	Ultra high frequency
USNTPS	United States Naval Test Pilot School
VMC	Visual meteorological conditions
Vmax	Maximum level flight airspeed
%	Percent

VITA

VITA

Marshall W. Atkins was born in Fort Knox, Kentucky on 4 April, 1957. He attended Seoul American High School in Seoul, Korea where he graduated in 1975. He attended the United States Naval Academy receiving a Bachelor of Science degree in Management in 1980.

Upon graduation, he was commissioned an officer in the U.S. Navy and attended flight training in Pensacola, Florida and Meridian, Mississippi. After designation as a naval aviator in April 1982, he spent three years as an S-3A pilot with VS-29, embarked in USS Carl Vinson and homeported in San Diego, California. He was selected to attend the United States Naval Test Pilot School in 1986. Following graduation from the School in June 1987, he was assigned to the Force Warfare Aircraft Test Directorate at the Naval Air Test Center, Patuxent River, Maryland. There he served as an engineering test pilot in S-3A/B, T-34C, and P-3C aircraft conducting carrier suitability, ordnance separation, and collision avoidance system testing. He is currently assigned to VA-36, homeported in Virginia Beach, Virginia where he flies the A-6E. He enrolled in the Graduate School of the University of Tennessee, Knoxville in December 1987. Marshall Atkins will continue his career in Naval Aviation upon graduation.