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Date 14 August 1989

FLYING QUALITITES AND PERFORMANCE EVALUATION OF THE A-7E AIRPLANE FOR THE SEA STRIKE MISSION

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Charles E. Smith

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DISCLAIMER

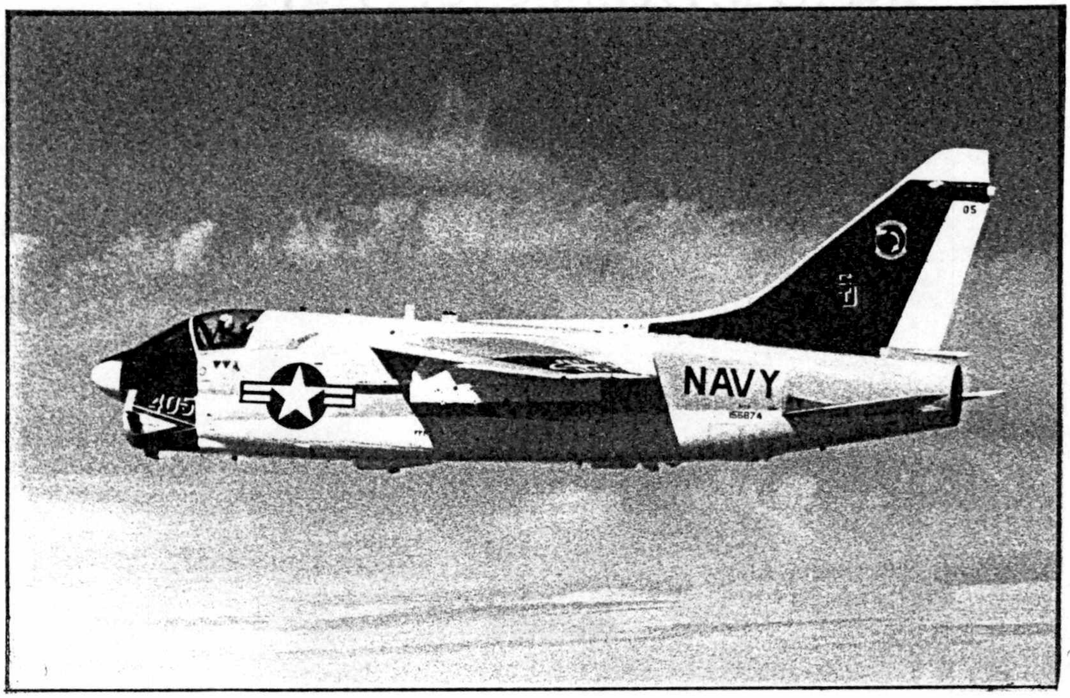
The technical data included in this thesis are actual flight test data collected during a limited scope flying qualities and performance evaluation of a United States Navy A-7E airplane. However, all deficiencies attributed to this aircraft, the aircraft systems, and/or the aircraft subsystems are the 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

Flying qualities and performance flight testing of the Navy A-7E airplane for the carrier based, sea strike mission were conducted during a 3.0 hour flight simulation phase, a 20 minute taxi test, and four test flights for a total of 5.7 flight hours. Test loading consisted of full internal fuel and wing pylons on stations 1,2,3,6,7 and 8, for a maximum takeoff gross weight of 31,155 pounds. Deficiencies identified during flight testing of the 1960's vintage airplane were evaluated to determine what specific improvements would be required to meet current and projected operational requirements.

The delayed engine response during waveoff will result in fouled deck landings and ramp strikes and is a Part I deficiency which should be corrected prior to further testing. The low specific excess power, low sustained load factor, and low instantaneous turn performance severly limit the capabilty for effective air combat maneuvering increasing the vulnerability to hostile fire and are also Part I deficiencies which should be corrected prior to further testing. A total of seven Part I, seven Part II and two Part III deficiencies were discovered relating to the flying qualities and performance of the current A-7E.

Within the scope of this evaluation, the A-7E airplane demonstrated limited potential for the sea strike mission. The A-7E will be satisfactory upon correction of the Part I deficiencies.



A-7E AIRPLANE

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NOMENCLATURE

Abbreviations

ACLS	Automatic carrier landing system
AB	After-burning engine
AFCS	Automatic flight control system
AGL	Above ground level
AMF	Automatic maneuvering flaps
AOA	Angle-of-attack
BUNO	Bureau number
CAP	Carrier air patrol
CG	Center of gravity
CL	Climb
CR	Cruise
CV	Aircraft carrier
EPP	Emergency power package
FCLP	Field carrier landing practice
GCA	Ground control approach
HSI	Horizontal situation indicator
HUD	Heads-up-display
INS	Inertial navigation system
IMN	Indicated mach number
ISO	Isolation hydraulic subsystem
KIAS	Knots indicated airspeed
KOAS	Knots observed airspeed
MAC	Mean aerodynamic center
MIL	Unit of angular measurement
MSL	Mean sea level
NM	Nautical mile
RPM	Revolutions per minute
OMN	Observed mach number
PA	Power approach
SSC	Surface search and control
SUCAP	Surface combat air patrol
TO	Takeoff
UHF	Ultra-high frequency
UHT	Unit horizontal tail
VMC	Visual meteorological conditions

Symbols

α	Angle-of-attack
β	Sideslip angle
Cd	Coefficient of drag
Cl	Coefficient of lift
Cl/Cd	Lift-to-drag ratio
D	Drag
Fs	Stick force
g	Normal acceleration
h_e	Energy height
i_T	Thrust vector angle
nz	Load factor
ϕ	Roll angle
Ps	Specific excess power
S	Surface area
Ta	Thrust available
T	Time to complete one full cycle
Ta/W	Thrust-to-weight ratio
ζd	Dutch roll damping ratio
V	Velocity
W	Weight
ωnd	Undamped natural dutch roll frequency
W/S	Wing loading
ϕ/β	Roll-to-yaw ratio
ρ	Density

1. INTRODUCTION

1.1 BACKGROUND

The last decade has seen a dramatic increase in the number and qualitiy of Soviet and Soviet backed air, surface and sub-surface units deployed throughout the globe threatening the capability of the United States and its NATO allies to sucessfully keep the sea lanes open in the event of hositilites. This decade of change has also seen cuts in defense spending, the demise of the 600 ship Navy and termination of major aircraft procurement programs for the U.S. Navy. The last new airplane development program for the operational Navy was the F/A-18 intended to replace the A-7E in the light attack role (a program generated in the previous decade). Current political and economic thinking has focused on improving existing fixed wing carrier based airplanes to keep up with the potential threat rather than persuing full scale replacement. Examples include; improved power plants for the F-14 and E-2C, a new wing for the A-6E and a new weapons system for the S-3.

This thesis examines the F/A-18's predecessor, the A-7E, in the current thinking of practical improvements to existing naval airplanes to meet the current generation of threat. The basis for this thesis is the authors final flight test evaluation for graduation from the United States Naval Test Pilot School, "Phase IIA Developmental Testing (DT-IIA) of the A-7E Airplane, 3 December 1986, Final

Report". The A-7E airplane was evaluated to fulfill the requirements of an all-weather, high performance, long range carrier based airplane capable of extended and independent operations to meet Surface Search and Control (SSC), Surface Combat Air Patrol (SUCAP), Carrier Air Patrol (CAP), power projection, mining and tanking requirements of the sea strike mission.

1.2 PURPOSE

The purpose of this thesis was to evaluate the flying qualities and performance characteristics of the A-7E airplane for the sea strike mission and to determine what specific improvements to the existing airplane systems would be required to meet current operational requirements. The decisions to modify the airplane were based on application of current technology, acceptable risk assements, and cost effectiveness in meeting the mission requirements.

1.3 DESCRIPTION OF TEST AIRPLANE

The Vought Company A-7E airplane, illustrated in appendix B, figure 1, is a single seat, carrier or land-based, high subsonic (645 KIAS) airplane with a swept shoulder-mounted wing with moderate negative dihedral. It is powered by one TF41-A-2 full-ducted turbofan gas turbine engine rated at 15,000 pounds of thrust,uninstalled. Airframe features include a chin mounted engine intake, six wing pylons (three on each wing), tricycle landing gear, foldable wings, launch bar, tailhook and holdback fitting for carrier operation, a retractable inflight refueling probe, and a clam shell canopy enclosing the cockpit and ESCAPAC 1G-2 ejection seat. Empty weight is approximately 21,500 pounds with an internal fuel capacity of 10,172 pounds and additional external fuel tank carriage for a maximum fuel load of 18,332 pounds of JP-5. An emergency power package (EPP) provides essential hydraulic and electric power if engine electirc power is lost. Primary flight controls are irreversible, mechanically actuated, hydraulically operated by three independent hydraulic systems and dual hydraulic power control cylinders. Controls consist of a unit horizontal tail (UHT) for pitch control, coordinated spoiler and aileron surfaces for roll control, and a conventional vertical tail and rudder for yaw control. Additional controls include an under fusealge speedbrake, leading and trailing edge flaps with an Automatic Maneuvering Flap (AMF) system, electrical trim in pitch, roll, and yaw, and an automatic flight control system (AFCS) with stability and control augmentation. System components include a heads-up display (HUD), air-to-ground radar, moving map display, inertial navigation (INS), doppler radar, UHF radio, and an integrated weapons delivery system. A complete flight control description can be found in appendix A and in the A-7E organizational maintenance manual, reference (1). A detailed description of the test airplane can be found in the "A-7E NATOPS Flight Manual", reference (2). Due to airplane availability and imposed time constraints, two of the four test flights were flown in a TA-7C instead of the A-7E. The TA-7C differed from the A-7E in that it had a two seat (tandem) arrangement, dual set of primary and secondary flight controls for A-7E training, a gross weight increase of 700 pounds, and only two independent hydraulic systems. Table I presents the test airplanes for this evaluation and the AMF status of each production model A-7E tested.

Table I
A-7E TEST AIRPLANES

BUNO	SIDE NUMBER	A-7/TA-7	AMF	TEST PHASE
156874	405	A-7E	No	Ground
160565	406	A-7E	Yes(1)	Flight/Systems
154477	420	TA-7C	Yes(1)	Taxi Test
154379	421	TA-7C	Yes(1)	Flight/Performance

Note: (1) AMF installed but inoperative for all flight tests.

For the purposes of this thesis, the A-7E and TA-7C test airplanes were considered identical and representative of production model airplanes.

1.4 SCOPE OF TESTS

The evaluation consisted of a 3.0 hour flight simulation phase in the 2F-111 and F-87 A-7E flight simulators, a flight control evaluation, 20 minute ground taxi familiarization, and four test flights for a total of 5.7 flight hours under day VMC. The author had no flight experience in the A-7E prior to this evaluation. Test events and conditions are outlined in appendix C, table I. Test loading consisted of full internal fuel, and three wing pylons on each wing for a maximum takeoff gross weight of 31,155 pounds and a minimum land weight of 22,600 pounds. Center of gravity (CG) remained within the airplane operating limits and ranged from 27.5 percent MAC at takeoff to 27.3 perccent MAC at landing. Test configurations are presented in table II.

Table II
A-7E TEST CONFIGURATIONS

CONFIGURATION	GEAR	FLAPS	SPEEDBRAKES	POWER
Ground (GR)	Down	Up (1)	In	(2)
Taxi (T)	Down	Takeoff (3)	In	AR (4)
Takeoff (TO)	Down	Takeoff	In	MIL (5)
Climb (CL)	Up	Up	In	MIL
Cruise (CR)	Up	Up	In	TRLF (6)
Power (P)	Up	Up	In	MIL
Glide (G)	Up	Up	In	Idle
Descent (D)	Up	Up	Out 40 degrees	70% RPM
Power Approach (PA)	Down	Down (7)	In	TNA (8)
Waveoff (WO)	Down	Down	In	MIL
Land (L)	Down	Down	In	Idle

Notes:
(1) Flap handle was in ISO Utility position with AMF inoperative and OFF
(2) External electric and hydraulic power or airplane power as required
(3) Flaps TE down 25 degrees, LE down 35 degrees
(4) As required
(5) Double-Datum temperature limiter - OFF
(6) Thrust required for level flight
(7) Flaps TE down 40 degrees, LE down 35 degrees
(8) Thrust for normal approach

The test envelope is presented in table III.

Table III
A-7E TEST ENVELOPE

PARAMETER	ENVELOPE
Altitude	Quantitative testing 5000 to 30,000 ft MSL
	Qualitative testing surface to 30,000 ft MSL
	High AOA/stall testing above 15,000 ft MSL
Airspeed	125 to 480 KOAS
Load Factor	-1.4 to +5.5g

Testing was conducted only in normal flight configurations with no emergency or degraded configurations or modes. Flight tests were conducted with and without Yaw Stabilization, and Control Augmentation engaged. Performance testing was done with AMF OFF due to its inoperability at the time of testing. The A-7E was evaluated as a Class IV-C airplane as defined by "Military Specification, Flying Qualities of Piloted Airplanes", reference (3), hereafter referred to as the Specification.

1.5 METHOD OF TESTS

Test procedures and techniques were in accordance with USNTPS Flight Test Manual 103, "Fixed Wing Stability and Control" (FTM-103), reference (4), and USNTPS Flight Test Manual 104, "Fixed Wing Performance" (FTM-104), reference (5). A series of build-up and flight envelope verification was observed followed by selected mission tasks to determine problem areas requiring further investigation. The evaluation was primarily qualitative in nature with quantitative data taken to substantiate pilot opinion and determine specification compliance. Handling Quality Ratings (HQR's) were assigned by the Cooper-Harper Rating Scale, appendix E. Data were recorded on kneeboard cards and on a portable voice recorder. Special instrumentation consisted of a hand-held force gauge, hand-held stopwatch, and a hand-held tape measure. Formation flight was conducted using an A-7E lead airplane. Low level navigation, ordnance delivery and mining evaluations were conducted in military restricted airspace. Appendix B, Figures 2 and 3 depict mission profiles evaluated. Control forces and displacements were estimated in flight below 5000 ft AGL. Force measurements were taken with the hand-held force gauge centered along the vertical axis of the control stick hand grip. Tape measurements were taken from the right inboard canopy rail for lateral displacement and the HSI gauge face to the designation button on the control stick hand grip for longitudinal displacement. Deficiencies identified with the test airplane were ranked based on their impact on the mission and safety of flight. Deficiencies were ranked by NATC Instruction 5213.3F, reference (6) and are defined in appendix F.

1.6 METHOD OF ANALYSIS

Deficiencies resulting from these tests were analyzed seperately and collectively to determine realistic alternatives or modifications that could update the existing A-7E to meet mission requirements. This evaluation reviewed the current technologies available to correct the deficiencies, the risks associated with the applied technologies, and the critical requirements to be evaluated through follow-on flight testing.

2. RESULTS AND DISCUSSION

2.1 GROUND HANDLING

2.1.1 General

Ground handling was evaluated during taxi tests on dry asphault and concrete surfaces in up to 10 knots of wind during straight line tracking, tight turns of up to 180 degrees and parking using nose gear steering (NGS) and power settings up to 65 percent RPM.

2.1.2 Taxi Directional Control

Nose gear steering was actuated by depressing and releasing an ON/OFF button on the control stick. Nose gear steering was responsive, predictable and easy to employ requiring only small rudder pedal forces and moderate displacements. Without rudder pedal inputs, the airplane tracked in a straight line. Maintaining taxiway certerline within one foot was easy requiring no more than 10 pounds of rudder pedal force and 3/4 of full displacement in turns of up to 135 degrees (HQR-2). The sea strike pilot will be able to accurately taxi and position the aircraft during shipboard and shore-based operations. The taxi directional control is satisfactory for the sea strike mission.

2.1.3 Taxi Turning Performance

Taxi turning performance was evaluated during normal turns of 90 and 135 degrees from a stop and during tight turns of 180 degrees. Turning performance was very good requiring minimal forward movement and power (two feet and

60 percent RPM) required before a turn rate could be established from a stop using NGS without asymmetric braking. A 180 degree turncould be accomplished within the length of the airplane (50 feet). Stopping and starting turns was easily accomplished with NGS and very predictable. Rolling out on a desired heading within two degrees after a sharp 180 degree turn was easy requiring smooth repositioning of the rudder pedals to center as desired heading was approached (HQR-2). The sea strike pilot will be able to effectively maneuver in close quarters during shipboard operations optimizing deck space and providing flexibility in deck spotting. The taxi turning performance is satisfactory.

2.1.4 Taxi Brake Performance

Brake requirements were evaluated during actual on-deck operations and simulated carrier deck operations with idle engine power. Brake operation was predictable and responsive to relatively small rudder pedal tip forces (5 to 10 pounds) providing a smooth and uniform deceleration. Maintaining a normal taxi speed of three to five knots was easy with light brake applications every 10-20 seconds (HQR-2). The pilot will be able to efficiently control on-deck taxi speed improving shipboard safety and reducing the potential for inadvertent collisions with other aircraft or structures. Taxi brake performance is also satisfactory.

2.1.5 Parking Brake Requirement

Ground operations were evaluated for pilot workload and simplicity. Position keeping during final line checks and at the runway hold short required constant rudder pedal tip pressure and was fatiguing during extended holding periods (five minutes or longer). The airplane was not equipped with a parking brake. The sea strike pilot will find it fatiguing to hold airplane position with constant brake pedal pressure while awaiting catapult launch, increasing the potential for inadvertent brake relaxation and collision with other aircraft or deck structures. The absense of a parking brake is a Part II deficiency which should be corrected as soon as practicable.

2.2 AUTOMATIC MANEUVERING FLAP AVAILABILITY

Automatic maneuvering flap operation was documented on two ground and four flight tests in a shore-based environment with airplane engine power on three different A-7 airplanes. All airplanes encountered AMF failures during post-start checks and failed to operate in flight. The sea strike pilot will not be able to rely on AMF for increased turn performance to negate hostile air and surface attacks increasing airplane susceptability to hostile fire. The low AMF system reliability is a Part I deficiency which should be corrected prior to further testing.

2.3 FLYING QUALITIES

2.3.1 Control System Mechanical Characteristics

Mechanical characteristics of the longitudinal, lateral and directional flight control systems were evaluated in configurations PA and CR during a static ground test using airplane power, and were confirmed in flight. Data are presented in table IV.

Table IV
MECHANICAL CHARACTERISTICS

AXIS	BREAKOUT + FRICTION (LB)	FRICTION (LB)	POSITION FREEPLAY (INCHES)	CENTERING BAND (INCHES)	DAMPING
Longitudinal	1	1/2	1/16	1/16	Deadbeat
Lateral	1/2	Zero	1/16	1/16	Deadbeat
Directional	3	Zero	1/8	1/8	Deadbeat

The gradients of control stick and rudder position as a function of control force were moderate and essentially linear throughout the control ranges as illustrated in appendix D, figures 1,2 and 3. Longitudinal control pull forces were slightly higher than push forces (three to five pounds) once stick travel exceeded 50 percent. Breakout plus friction provided good pilot cues at the trim position in all axis allowing constant hand and foot contact with the control stick and rudder pedals without objectionable force requirements to deviate from trim. Control harmony between lateral and longitudinal force and displacement was very good and provided smooth and predictable airplane control during out-of-plane maneuvering. Control position freeplay and control centering bands were essentially unnoticeable. Mechanical characteristics were unaltered by the engagement of yaw stabilization and control augmentation. The mechanical characteristics of the flight control systems are satisfactory for the sea strike mission and met the requirements of the Specification.

2.3.2 Takeoff

2.3.2.1 General. Takeoff flying qualities were evaluated on four takeoffs from brake release to liftoff in configuration TO with gross weight ranging between 31,500 and 31,100 pounds and a CG range between 27.5 and 27.3 percent MAC on dry concrete with crosswinds of up to six knots. Nose gear steering was disengaged at or before 50 KOAS with a 145 KOAS rotation speed. Wings level liftoff attitude of 10 degrees nose up was established on the HUD.

2.3.2.2 Takeoff Directional Control. The rudder became effective for directional control within five seconds after brake release (50 KOAS). Nose gear steering was required only if the nose wheels were not centered prior to brake release. During crosswind takeoffs a small amount of rudder pedal force (5 to 10 pounds) was required opposite to the crosswind to counter a slight weather-cocking tendency which decreased as airspeed increased. The airplane was directionally stable, predictable and responsive to directional inputs. Maintaining runway centerline within five feet was fairly easy requiring small rudder pedal inputs of no more than 10 pounds every five to 10 seconds (HQR-3). The pilot will find precise directional control during field takeoffs fairly easy allowing operations from narrow runways and accurate tracking during section takeoffs. The directional control during takeoff was satisfactory for the sea strike mission.

2.3.2.3 <u>Takeoff Lateral Control.</u> Lateral control was effective at 50 KOAS with relatively small (1/2 inch, two pound) control inputs producing noticable wing movement. In crosswind conditions the up-wind wing tended to rise slightly but was easily controlled with a small lateral control input. This tendency decreasing in magnitude as airspeed increased. The lateral axis was stable and responsive to pilot inputs. Maintaining wings level within two degrees angle of bank during takeoff roll in a six knot crosswind was fairly easy requiring a small and steady lateral control displacement of decreasing magnitude until airborne (HQR-2). The pilot will easily maintain lateral control during takeoff facilitating internal engine crosschecks and allowing increased attention to directional control. The lateral control during takeoff is satisfactory for the sea strike mission.

2.3.2.4 <u>Takeoff Rotation.</u> Five pounds of pull force and

1/2 inch aft stick movement were required at rotation speed to fly the nose wheel off the runway and establish a positive pitch rate. Pitch rate was easily stopped by relaxing the aft stick force setting the pitch attitude following shortly thereafter by liftoff. Establishing and maintaining a takeoff attitude of 10 degrees nose up within two degrees was easy requiring smooth application of five pounds aft stick force to establish the attitude followed by gradual stick force relaxation to hold the attitude (HQR-2). The pilot will be able to set the takeoff attitude easily, avoiding overrotation and the possibility of high angles of attack immediatley after liftoff. The takeoff rotation characteristics are satisfactroy for the sea strike mission and met the requirements of the Specification.

2.3.2.5 Gear and Flap Retraction. Longitudinal control force and displacement required after takeoff were qualitatively evaluated during transition from configuration TO to CL on four takeoffs, and quantitatively evaluated in level flight at 5000 feet MSL. Landing gear were retracted (after a positive rate of climb was established) with no noticable trim change. Flaps were retracted from full down to full up at 180 KOAS with a moderate settling tendency requiring aft stick displacement. Maintaining the takeoff attitude of 10 degrees nose up within two degrees while retracting the flaps was moderately difficult requiring seven pounds aft stick force and one inch travel (HQR-3). The pilot will find transtion to configuration CL moderately difficult requiring careful attention to prevent settling after takeoff and to maintain obstacle clearance. The nose down pitch tendency during flap retraction is a Part III deficiency which should be avoided in future designs. The trim change during flap retraction met the requirements of the Specification.

2.3.3 Static Longitudinal Stability

2.3.3.1 Configuration CR. Static longitudinal stability was qualitatively evaluated during dive bombing runs and level accelerations, and quantitatively evaluated at 15,000 ft MSL and 350 KOAS by observing control stick force and displacement required as a function of airspeed. Data are presented in appendix D, figure 4. Longitudinal control force gradients were positive and essentially linear with a moderate pull force gradient and a shallow push force gradient. During relatively large speed changes away from trim, stick force and displacement required for level flight were light to moderate and easily conducted without retrimming. Good stick position and force cues with light to moderate forces required when off trim airspeed will aid situational awareness when precise airspeed control is necessary. The static longitudinal stability in configuration CR is satisfactory for the mission and met the requirements of the Specification.

2.3.3.2 Configuration PA. Static longitudinal stability was quantitatively evaluated at 5,000 ft MSL at an optimum approach speed of 128 KOAS in calm air, and qualitatively evaluated during six precision approaches in light turbulence. Data are presented in appendix D, figure 5. Longitudinal control force gradients were positive, and essentially linear, with a fairly steep pull force gradient and a moderate push force gradient. While not objectionable, the control forces were strong enough to provide very good pilot cues when off optimum approach speed. The sea strike pilot will have good stick force cues when off trim airspeed on landing approach facilitating timely identification of speed errors. Static longitudinal stability in configuration PA is satisfactory for the sea strike mission and met the Specification.

2.3.3.3 Flight Path Stabilty. Flight path stability, as indicated by variations in flight path angle and vertical velocity with respect to airspeed, was evaluated during FCLP landing approaches, and in level flight in configuration PA at an optimum approach speed of 128 KOAS and 5000 ft MSL. Data are presented in appendix D, figures 6 and 7. A stabilized airspeed within five knots (1/2 unit angle-of-attack indication) from optimum approach speed produced a 0.5 degree deviation in flight path angle and a 50 foot per minute change in vertical velocity. Speeds faster than optimum maintained that moderate positive gradient. Once less than five KOAS from optimum the curve picked up a moderately steep negative gradient. Flight path stability was positive with a moderate gradient around trim speed. The pilot will be able to make small changes in airspeed to correct on glideslope without deviating significantly from optimum AOA improving landing performance. The flight path stability in configuration PA is satisfactory for the mission and met the requirements of the Specification.

2.3.4 Dynamic Longitudinal Stability

2.3.4.1 Phugoid Characteristics. The phugoid response was evaluated longitudinal controls free in configuration CR at 230 and 300 KOAS and 30,000 ft. Configuration PA was evaluated in the GCA pattern in moderate turbulance and at 5,000 ft MSL and 128 KOAS in calm air. In both configurations the phugoid response to small airspeed deviations was slightly convergent, lightly damped and easily excited with a period of 95 seconds in CR and 33 sec in PA. Damping ratio in CR was 0.07 with a ratio of 0.05 in PA. The phugoid response to turbulance in instrument conditions will not adversely effect the pilot when maintaining a desired altitude. The phugoid response is satisfactory for the mission and met the Specification.

2.3.4.2 Short Period.

2.3.4.2.a Configuration CR. The short period response was evaluated quantitatively controls free at 30,000 ft MSL and 300 KOAS, 15,000 ft MSL and 420, 350, and 250 KOAS with control augmentation on, and qualitatively with and without control augmentation engaged during formation and aggressive pitch pointing tasks. Changes in the short period response with altitude and airspeed were not distinguishable. The short period was easy to excite and essentially deadbeat (one small overshoot of three MILS) with control augmentation engaged. Without control augmentation engaged, the short period response was easily excited and lightly damped with large overshoots during pitch pointing making target acquisition and tracking difficult. During aggressive pitch pointing tasks with control augmentation engaged the airplane was very responsive and predictable with no noticable overshoots. Acquiring and tracking a ground or air target within five MILS after aggressive 30 degree dive entries and abrupt 2g pulls was easily done by pulling the center of the gun sight reticle to the target and relaxing aft stick pressure to maintain alignment (HQR-2). The sea strike pilot will find accurate pitch pointing tasks such as air-to-ground and air-to-air ordnance delivery easy, enabling quick and precise target acquisiton, tracking and attack. The short period response in configuration CR is satisfactory for the mission and met the Specification. Control augmentation is considered a mission essential subsystem for the A-7E based on the results of the short period tests.

2.3.4.2.b. Configuration PA. The short period response was quantitatively evaluated controls free at 5000 ft MSL and 128 KOAS in calm air, and qualitatively controls fixed during a section formation approach and in the landing pattern. Gross weight was 25,500 pounds with a CG of 27.3% MAC. Frequency was estimated at three RAD/SEC. The short period was easy to excite, predictable and essentially deadbeat with no noticable overshoots. Setting optimum AOA within one unit after rotation from a touch-and-go landing was fairly easy with one or two small longitudinal inputs of no more than a half inch (HQR-2). The characteristics of the short period will allow the pilot to aggressively and precisely maneuver in the carrier landing pattern. The short period response in configuration PA is satisfactory for the mission and met the requirements of the Specification.

2.3.4.3 Maneuvering Longitudinal Stability.

2.3.4.3.a Configuration P. Maneuvering stability, as indicated by the variation of longitudinal control force gradients with normal acceleration (Nz), was evaluated quantitatively at 15,000 ft MSL and 350 KOAS, and qualitatively during aerobatic maneuvers, sustained pull-ups and wind-up turns. Data are presented in appendix D, figures 10,11,12 nad 13. Gradients were positive and essentially linear with a fairly steep pull gradient (nine lb/g), and a moderate push gradient (four lb/g). Load factors obtained during sudden pulls were lower per control force than steady pulls. Control forces, though predictable, were high during sustained g maneuvers. The sea strike pilot will find predictable but high control forces during sustained positive g maneuvers causing pilot fatigue and restricted body positioning during air combat maneuvering. The high stick force per normal acceleration in maneuvering flight is a part II deficiency which should be corrected as soon as practicable. The maneuvering stabilty characteristics in configuration P met the requirements of the Specification.

2.3.4.3.b Configuration WO. Maneuvering stabilty was evaluated quantitiatively at 145 KOAS and 5000 ft MSL, and qualitatively in the landing pattern. Data are presented in appendix D, figure 14. The control force gradient was positive, linear, and fairly steep (10 lb/g) allowing aggressive landing pattern maneuvering with predictable control feel cues. The pilot will be able to effectively maneuver in the landing pattern while maintaining situational awareness through good feel cues preventing inadvertent accelerated stall conditions. The longitudinal maneuvering stability in configuration WO is satisfactory for the mission and met the Specification.

2.3.5 Miscellaneous Longitudinal Characteristics

2.3.5.1 Trimmability. Longitudinal trimmability was evaluated throughtout testing in configurations CR and PA. Pitch trim inputs produced timely, smooth and steady changes in the pitch axis. Longitudinal trim was irreversible, effectively reducing control forces to zero and facilitated good hands-off pitch attitude holding during cruise flight and on instrument approaches. Establishing a cruise trim speed of 300 KOAS (within two KOAS), or optimum approach angle of attack of 17.5 units (within one half unit) was fairly easy requiring two to three small trim inputs (HQR-2). Good pitch trim characterisitics will reduce pilot workload in instrument conditions allowing hands-off time to complete cockpit tasks such as ACLS equipment configuration. The longitudinal trimmability characteristics are satisfactory for the mission and met the Specification.

2.3.5.2 Pitch Trim Changes.

2.3.5.2.a General. Longitudinal trim changes due to configuration changes were evaluated during section parade formation work and during individual flight tests. A summary of configuration changes throughout the evaluation are presented in appendix C, table II.

2.3.5.2.b Speedbrake Operation. Longitudinal characteristics during speedbrake operation were evalauted at 5000 ft MSL and during formation flight at 3000 KOAS and 10,000 ft MSL in configuration CR. On deployment, the nose pitched down slightly requiring moderate stick force (five pounds maximum) or retrimming to counter. Controls free the airplane reached 10 degrees nose down in five seconds. The response to speedbrake retraction was similar, but in the opposite sense. Maintaining parade formation within two feet during speedbrake deployment was fairly easy with both airplanes simulanenously encountering the slight nose down pitch change requiring one or two small control stick inputs of no more than three pounds to remain in position (HQR-3). The sea strike pilot will be able to maintain a stable position during formation penetrations where speedbrake transitions are required avoiding potential lost sight conditions during IMC. The pitch trim change during speedbrake operations is satisfactory.

2.3.5.2.c <u>Gear and Flap Transition.</u> Longitudinal trim change in transition to configuration PA was evaluated at 5000 ft MSL and 190 KOAS, and during parade formation. Gear and flap extension was done by lowering the gear handle followed immediately by lowering the flap handle causing gear and flaps to extend simultaneously. Seperate gear operations without flaps showed no pitch changes due to gear movement. Flap deployment caused a mild "ballooning" tendency followed immediately by a nose down trim change. Maintaining parade formation within five feet during section transition to configuration PA was fairly easy without attempting to counter the "ballooning" followed by moderate aft stick force of up to eight pounds to counter the nose down movement and then retrimming (HQR-3). The pilot will find maintaining parade position during section configuration changes to PA fairly easy reducing the potential for loss sight or mid-air collisions. The pitch trim changes during gear and flap extension are satisfactory for the mission and met the requirements of the Specification.

2.3.5.2.d Power Changes. Pitch trim changes as a result of power changes were evaluated in configuration PA during GCA approaches and during FCLP approaches using five percent rpm throttle inputs. Power additions caused a moderate nose up pitch. The pitch response to power reductions was nose down with the same magnitude. The engine thrust axis was below the center of gravity producing a pitching moment. Maintaining 17.5 units AOA within one half unit during power additions and retractions was moderately difficult requiring corrections of two pounds stick force opposite to the pitch movement at every power change (HQR-4). During carrier approaches, the sea strike pilot will experience annoying deviations in AOA due to power changes requiring coordinated power and stick inputs to maintain proper landing attitude increasing pilot workload and degrading landing performance. The pitch change due to power in configuration PA is a Part III deficiency which should be avoided in future designs. Pitch trim changes due to power met the requirements of the Specification.

2.3.6 Static Lateral-Directional Stability

2.3.6.1 General. Static lateral-directional characteristics were evaluated during steady heading sideslips in configuration CR at 15,000 ft MSL, 350 KOAS and in configuration PA at 5000 ft MSL and 145 KOAS with symmmetric wing pylons. Rudder-only turns were used to qualitatively evaluate dihedral effect. Ordnance delivery runs of 30 degrees between 200 and 450 KOAS were used to qualitatively evaluate sideslip characteristics. Mild and aggressive aileron-only turns were used to evaluate rudder coordination requirments. Data are presented in appendix D, figures 15 through 17. Pitot static system airspeed error during steady heading sideslips was negligible, reaching a maximum of plus two KOAS in configuration PA at full rudder deflection.

2.3.6.2 Directional Stability. Directional stability, as indicated by the variation of rudder force and pedal position with sideslip angle during steady heading sideslips, was positive in configurations PA and CR. The gradients of rudder pedal force and position versus sideslip angle were positve, linear and steep with a slope of approximately 14 pounds per degree of sideslip angle in both configurations. During aileron-only turns, rudder was not required to maintain balanced flight. Maximum sideslip angles of six degrees in CR and seven degrees in PA were obtained with maximum rudder pedal travel the limiting factor. The airplane demonstrated positve directional stabilty in normal flight conditions with predictable and controlled rudder force and displacement requirements to generate sideslip. The pilot will be able to change speed, bank angle and energy level without the need for coordinated rudder pedal inputs to maintain balanced flight improving air-to-air and air-to-ground tracking and weapons delivery. The directional stabilty is satisfactory for the mission and met the requirements of the Specification.

2.3.6.3 Dihedral Effect. Dihedral effect, as indicated by the variation in lateral stick force and position as a function of sideslip angle during steady heading sideslips, was evaluated in configurations CR and PA. Lateral control force and position gradients were positive, essentially linear and moderate throughout testing. From a 20 degree angle of bank, rudder force opposite the turn was effective in rolling out of the bank angle indicating positive dihedral. The sea strike pilot will be able to use positive dihedral to augment roll rates during combat maneuvering and as an alternate roll control in the event of combat damage to primary roll controls. The dihedral characterisitcs in configurations PA and CR are satisfactory and met the Specification.

2.3.6.4 Sideforce Characteristics. Sideforce characterisitics, as indicated by the change in bank angle versus sideslip angle during steady heading sideslips were positive and fairly strong in configurations CR and PA. Maximum sideslip angles of six degrees in configuration CR and 7 degrees in PA required bank angles of 25 and 12 degrees, respectively. During 30 degree dives, balanced flight was maintained (within 1/4 balance ball deflection) without pilot input. Good proprioceptive sideforce cues existed when sideslip was induced through rudder inputs while the airplane yaw stabilization system effectively prevented significant sideslips from occuring during flight. The positive sideforce characteristics will provide the pilot with adequate cues to detect sideslip if encountered, promoting good weapon aiming and crosswind landing performance. The sideforce characteristics are satisfactory for the mission and meet the Specification.

2.3.7 Dynamic Lateral-Directional Stability

2.3.7.1 Spiral Stability. Spiral stabilty was evaluated in configuration CR at 30,000 ft MSL and 300 KOAS, and in configuration PA at 5000 ft MSL and 128 KOAS using rudder to establish a 20 degree angle of bank turn from level flight and observing the response with lateral-directional controls free. The spiral mode was convergent in both configurations. During rudder only and aileron only turns, control force in the direction of turn was required to maintain the angle of bank confirming a convergent spiral mode. During instrument flight and approaches, the pilot will be able to release the control stick to configure instruments or read publications without having to counter deviations from wings level flight. The spiral mode characteristics in configurations CR and PA are satisfactory for the mission and met the Specification.

2.3.7.2 Dutch Roll Mode.

2.3.7.2.a Configuration CR. Dutch roll characteristics were evaluated in configuration CR at 30,000 ft MSL and 300 KOAS, 15,000 ft MSL, 350 and 425 KOAS and qualitatively during air-to-ground ordnance delivery maneuvers with and without yaw stabilization engaged. The observed responses to rudder doublet inputs without yaw stabilization are presented in table V.

Table V
CRUISE DUTCH ROLL MODE

AIRSPEED/ ALTITUDE (KOAS/FT MSL)	ω_{nd} (RAD/SEC)	T/2 (SEC)	ζ_d	ϕ/β	$\omega_{nd}^2(\phi/\beta)$ $(RAD/SEC)^2$	$\zeta_d\omega_{nd}$ (RAD/SEC)
300/30,000	3.3	1	0.3	3/1	32.7	1.1
425/15,000	3.5	1	0.4	2/1	24.5	1.4
350/15,000	2.5	1.4	0.4	2/1	12.5	1.0

With yaw stabilization engaged the dutch roll response was difficult to excite and well damped. Aggressive aileron inputs during air-to-ground tracking produced minor (three mils) oscillations which damped immediately. Without yaw stabilization, the dutch roll response was easily excited, and lightly damped with noticeable overshoots of 10 mils. Yaw stabilization was required for desirable dutch roll mode characterisitcs. Target acquisition and tracking within five mils after aggressive entry maneuvers was easy with the small dutch roll oscillations damped out within two seconds without pilot input (HQR-2). The sea strike pilot will be able to quickly and aggressively establish target tracking during air-to-ground ordnance delivery without dutch roll contamination increasing delivery accuracy. The dutch roll mode in configuration CR is satisfactory for the mission and met the requirements of the Specification. Yaw stabilization was considered a mission essential subsystem.

2.3.7.2.b <u>Configuration PA.</u> The dutch roll response was evaluated at 5000 ft MSL and 128 KOAS and qualitatively in the GCA pattern with yaw stabilization engaged. Data with yaw stabilization are presented in table VI.

Table VI
POWER APPROACH DUTCH ROLL MODE

ω_{nd} (RAD/SEC)	T/2 (SEC)	ζ_d	ϕ/β	$\omega_{nd}^2(\phi/\beta)$ $(RAD/SEC)^2$	$\zeta_d\omega_{nd}$ (RAD/SEC)
1.6	2	0.28	3/1	7.7	0.45

The dutch roll response was difficult to excite, and well damped with two small overshoots observed controls free with yaw stabilization engaged. During GCA approaches in light turbulance, the dutch roll response was not noticed. The sea strike pilot will not experience heading deviations during instrument approaches from dutch roll excitation. The dutch roll mode in configuration PA is satisfactory for the mission and met the requirements of the Specification.

2.3.8 Miscellaneous Lateral-Directional Characteristics

2.3.8.1 Trimmability.

2.3.8.1.a Lateral. Lateral trimmability was evaluated in configurations CR and PA throughout the flight testing. Trimming lateral forces to zero in wings level flight was easily achieved with one or two small trim inputs and allowed hands-off lateral holding for extended periods at airspeeds at and above optimum approch speed. The pilot will be able to trim out lateral control forces and release lateral controls without changes in roll attitude allowing time for folding charts and other cockpit tasks. The lateral trimmabilty is satisfactory for the mission and met the requirements of the Specification.

2.3.8.1.b <u>Directional.</u> Directional trimmabilty was evaluated in configurations CR and PA with yaw stabilization at constant airspeeds throughout the test envelope and during ordnance dive bombing runs with speed changes of 220 KOAS. The balance ball remained within 1/4 deflection without pilot rudder tirm inputs. Any small deviations could be easily trimmed out with one or two small rudder trim inputs. Yaw stabilization automatically kept the airplane in balanced flight without manual rudder inputs. The pilot will be able to conduct attack runs without having to make directional trim changes to maintain balanced flight improving delivery accuracy. The directional trimmability is satisfactory for the mission and met the requirements of the Specification.

2.3.8.2 <u>Aileron Yaw Characteristics.</u> Aileron yaw characteristics were qualitatively evaluated during aileron-only turns in configuration CR at 350 KOAS, configuration PA at optimum approach speed, and during aggressive ordnance delivery maneuvers with yaw stabilization engaged and disengaged. A small amount (approximately 2 degrees sideslip opposite the roll) of adverse yaw was noticed in configurations CR and PA with yaw stabilization engaged at maximum aileron deflection which reduced rapidly to zero without the need for rudder coordination. Without yaw stabilization, adverse yaw was readily apparent and easily excited the dutch roll mode severely degrading heading control and roll performance. Adverse yaw was apparent but not objectionable with yaw stabilization engaged. Capturing 30 degrees angle of bank within 2 degrees was fairly easy requiring a small lateral input of 1/2 inch to start the roll followed by an opposite aileron input of equal magnitude to stop at the desired bank angle and slight aileron force (1/2 pound) into the turn to maintain bank angle (HQR-2). The pilot will be able to roll into and out of bank angles during instrument turns using aileron controls without the need for rudder coordination. The aileron yaw characteristics in configurations CR and PA are satisfactory for the sea strike mission and met the requirements of the Specification.

2.3.9 Roll Performance

2.3.9.1 Steady State Roll Rate. Steady state roll rates were evaluated in configuration CR at 15,000 ft MSL and 250, 350, and 425 KOAS, and in configuration PA at 128 KOAS (optimum approach speed) using full aileron control deflection rolls of 360 degrees in CR and 60 degrees in PA. Qualitiative evaluation was conducted in the landing pattern, and during aerobatic and ordnance delivery maneuvering. Data are presented in table VII and appendix D, figures 18 and 19.

Table VII
STEADY STATE ROLL RATE

CONFIGURATION	AIRSPEED (KOAS)	MACH (IMN)	STEADY STATE ROLL RATE (DEG/SEC)
CR	420	0.81	144
CR	350	0.69	175
CR	250	0.54	118
PA	128	-	33

The gradient of roll rate versus Mach was fairly shallow indicating relatively constant rates throughout the airspeed range with a peak roll rate at 0.7 IMN. Steady state roll rates in PA were fairly high facilitating timely flight pitch changes in the landing pattern. Roll rates in CR were considered low when compared to current threat aircraft. The sea srike pilot will not be able to rapidly change flight path direction during ACM degrading target acquisition and timely defensive maneuvering increasing the potential for being shotdown. The low steady state roll rate in configuration CR is a Part II deficiency which should be corrected as soon as practicable. The steady state roll rate at 0.54 IMN failed to meet the requirements of the Specification, in that the time to roll 360 degrees was 0.25 seconds more than the maximum value of 2.8 seconds (9 percent).

2.3.9.2 <u>Roll Mode Time Constant.</u> Roll mode time constants were evaluated in configuration CR at 15,000 ft MSL and 350 KOAS, and configuration PA at 5000 ft MSL and 128 KOAS rolling into and out of 30 degrees angle of bank. The roll mode time constant for both configurations was short at 1/3 of a second. The airplane was very responsive to lateral inputs. Capturing zero degrees angle of bank within two degrees from a bank angle of 30 degrees was fairly easy requiring smooth and timely return of the control stick to center followed by one or two small (1/4 inch) lateral stick inputs to stabilize wings level (HQR-2). The pilot will be able to precisely roll out on a desired aim point during air-to-ground ordnance delivery allowing early establishement of straight line aiding delivery accuracy. The roll mode time constants in configurations CR and PA are satisfactory for the mission and met the requirements of the Specification.

2.3.10 Stall and Departure Characteristics

2.3.10.1 General. Stall and departure characteristics were evaluated in the TA-7C during four stalls in configuration CR and two in configuration PA at idle and 85 percent rpm power settings in level and accelerated flight with gross weight ranging from 26,900 to 26,200 lb for a CG of 27.2 percent MAC. Cruise stalls were entered from a trim speed of 140 KOAS with eight degrees of nose up trim. Wings level stalls were entered by slowly increasing aft stick force and reducing airspeed by one KOAS per second. Accelerated stalls were entered from level 60 degree AOB turns at 250 KOAS and 2g's in CR and 30 degrees AOB in PA by steadily increasing aft stick pressure to produce deceleration rates between two and five KOAS per second. Recovery was initiated at stall/departure and considered complete when the VSI indicated zero. Stall data are presented in appendix C, table VI.

2.3.10.2 Configuration CR.

2.3.10.2.a Stall Warning. During wings level unaccelerated stalls, warning was defined by right rudder pedal shaker activation at 20 units AOA and 140 KOAS along with heavy airframe buffet. At 23 units AOA the buffet level increased substantially as a final warning of pending stall. Accelerated stall warning was defined by the same characterisitics only with 20 units AOA being reached at 160 KOAS. Aft stick force at warning ranged from 10 pounds in unaccelerated stalls to 15 pounds in accelerated. Relaxing aft stick force during any phase of stall approach immediately reduced AOA to 17.5 units AOA or less and avoided stall. Stall warnings occured 15 to 20 KOAS above stall speed with an extremely deep and heavy airframe buffet occuring just prior to stall as a final warning. The pilot will have good stall warning signs during accelerated ACM maneuvers allowing timely recognition and avoidance of a stall. Stall warning in configuration CR is satisfactory and met the Specification.

2.3.10.2.b Normal Stall. Wings level unaccelerated stall occured at 24 to 25 units AOA, 130 KOAS and was defined by a noticeable right yaw of 10 to 15 degrees followed immediately by a roll of 45 to 60 degrees in the direction of yaw and the nose dropping 10 degrees below the horizon. One to two yaw oscillations of five degrees were observed immediately prior to stall. After stall the airplane ended up nose down and accelerating with no tendency of entering post-stall gyrations. Normal stall characteristics were fairly benign but indicated an apparent decrease in directional stability at high AOA. The normal stall characteristics in configuration CR are satisfactory for the mission and met the requirements of the Specification.

2.3.10.2.c Accelerated Stall. Accelerated stall occurred at 25 units AOA between 125 and 130 KOAS and was defined by a rapid departure in yaw of 20 to 30 degrees opposite the direction of turn with substantial sideforces, coupled with a rapid 360 degree roll in the direction of yaw ending upright 45 to 50 degrees nose low. Control inputs were not effective during the departure, but returned to neutral when released. The engine oil pressure dropped to 10 psi and the Oil Pressure caution light illuminated during the departure. The airplane departed rather violently, but recovered nose low accelerating if the pilot neutralized or released the controls. The pilot will find the accelerated stall characteristics violent and disorientating with apparent detrimental effects to the engine lubrication system. The violent departure characteristics during accelerated stall in configuration CR is a Part II deficiency which should be corrected as soon as practicable. The accelerated stall characteristics met the requirements of the Specification.

2.3.10.2.d Stall Recovery. Stall recovery was initiated at stall/departure by disengaging the AFCS and neutralizing controls. The airplane recovered quickly in a nose low attitude accelerating at which point the wings were leveled and the airplane pulled up at 17 to 20 units AOA. Altitude loss from stalls/departures was large at 800 to 1500 ft. Maintaining 20 units AOA within one unit during stall recovery was fairly easy requiring 15 to 20 pounds of aft stick force to hold the nose up without trimming (HQR-2). The pilot will find effecting recovery from an inadvertent stall during low altitude maneuvering very difficult significantly increasing the potential for ground impact. The large altitude loss during stall recovery is a Part I deficiency which should be corrected prior to delivery. Stall recovery failed the requirements of the Specification, in that altitude loss was excessive.

2.3.10.3 Configuration PA.

2.3.10.3.a Stall Warning. Stall warning occured at 20.5 units AOA in both normal and accelerated PA stalls and was defined by right rudder pedal shaker activation. As stall approach was continued, control effectiveness in the lateral axis decreased, but was still effective in maintaining the wings level. Stall could be avoided by relaxing aft stick pressure. The margin between warning and actual stall was 10 to 15 KOAS. The pilot will have a timely and clear stall warning in the landing pattern with sufficient airspeed and control effectiveness to avoid the stall. The stall warning characteristics in configuration PA are satisfactory and met the Specification.

2.3.10.3.b <u>Stall.</u> Stall occured at 24 to 25 units AOA, 95 KOAS wings level and 110 KOAS in a level approach turn. Stall was defined by a slow yaw and roll opposite the direction of turn with the nose lowering 10 to 15 degrees below the horizon. Stall characteristics were fairly mild and predictable with no tendency to enter into an aggravated condition. The stall characteristics in configuration PA are satisfactory.

2.3.10.3.c <u>Stall Recovery.</u> Stall recovery was initiated by relaxing aft stick pressure, rolling wings level and pulling up at 20 units AOA with military power. Altitude loss during stall recovery was small at 150 feet. Maintaining 20 units AOA within one unit during recovery was easy with five to seven pounds of aft stick force (HQR-2). The sea strike pilot will find recovery from inadvertent stall in the landing pattern easy with minimal altitude loss. Stall recovery in configuration PA is satisfactory and met the Specification.

2.3.11 Landing Approach Characteristics

2.3.11.1 General. Landing approach characteristics were evaluated in configuration PA during six GCA approaches and 12 FCLP landings using the Fresnel Lens Optical Landing System in light turbulence and up to six knots of crosswind. Gross weight ranged from 26,700 to 23,700 pounds with an average CG of 27.3 percent MAC. Deviations above and below glideslope, as well as angling and overshooting approaches were conducted to determine the magnitude and ease of corrections. One approach was taken to 50 feet AGL where a waveoff was executed. Optimum AOA was maintained throughout approach testing.

2.3.11.2 Engine Response. Engine response was evaluated flying the three degree Fresnel Lens glideslope to touchdown. Coordinated power and pitch inputs were required to make timely corrections for off glideslope conditions. Correcting for a high condition required fairly large (five percent rpm) power reductions and lowering the nose slightly. As gross weight decreased below 27,000 pounds, power requirements dropped to the 80 to 90 percent rpm range and engine response became a problem. The engine was very slow to respond with very long spool-up (six seconds idle to military) and spool-down times making glideslope control difficult. Correcting for a high start during a FCLP landing to place the ball within 1/2 a cell of datum was fairly difficult requiring five to 10 percent reduction in power and a 1/2 inch forward stick movement followed by a timely 10 to 15 percent rpm increase to counter the spool-up delay and arrest the sink rate with a 1/4 to 1/2 inch aft stick input followed by two to three smaller power corrections (HQR-5). Long engine response times will make it difficult for the sea strike pilot to precisely fly the glideslope during carrier approaches increasing the number of hard landings and bolters, and increasing the potential for ramp strikes. The slow engine response to throttle inputs is a Part II deficiency which should be corrected as soon as practicable.

2.3.11.3 <u>Airspeed Control.</u> Optimum approach speed could be maintained using small longitudinal control inputs of 1/2 inch or less. The good longitudinal trimmability presented in paragraph 2.3.5.1 made it easy to hold airspeed in the approach. Maintaining optimum aproach speed within two knots and 1/2 unit AOA was fairly easy requiring small longitudinal control inputs every five seconds (HQR-2). The pilot will find it easy to maintain a precise optimum approach speed reducing pilot workload and providing additional time to devote to glideslope and lineup control.

2.3.11.4 Heading Control. Precise heading control during a GCA was possible due to the good lateral trimmability, convergent spiral mode and the low roll mode time constant. Establishing and maintaining an assigned heading with two degrees during an instrument approach was easy requiring smooth and small (1/2 inch) lateral control inputs with shallow bank angles to roll into and out of turns on a desired heading (HQR-2). The pilot will find heading control during instrument approaches easy, reducing pilot workload.

2.3.11.5 Crosswind Landing. Tracking down the extended centerline of the runway during crosswind approach conditions was easily accomplished by crabbing into the wind. Just prior to landing the crab was taken out with a smooth rudder input. Landing within 10 feet of runway centerline during crosswind landings was fairly easy requiring two or three small lateral control imputs of one to two inches to adjust to centerline and smooth application of 15 to 20 pounds of rudder just prior to touchdown to take out the approach crab angle (HQR-3). The pilot will be able to effectively control lineup during carrier landing approaches in realistic crosswinds preventing off-center cross-deck pendent engagements. The handling qualities during crosswind approaches are satisfactory for the mission.

2.3.11.6 Waveoff. Waveoff characteristics were evaluated during an in-close (50 feet AGL) waveoff with military power from an established 700 foot per minute rate of descent at a gross weight of 24,700 pounds. Angle of attack was maintained at 17.5 units. The delay in engine response was prevalent during the waveoff and allowed the rate of descent to continue to within five feet of touchdown. Maintaining 17.5 units AOA withn one half unit was easy requiring a slight forward stick pressure of two to three pounds once the engine responded to command (HQR-2). The delay in engine response will prevent the pilot from successfully executing an in-close, waveoff during carrier approach resulting in fouled deck landings, hook slaps, and ramp strikes causing damage or loss of personnel and airplane. The delayed engine response during waveoff is a Part I deficiency which should be corrected prior to shipboard operation.

2.4 PERFORMANCE

2.4.1 Takeoff Performance

Takeoff performance was evaluated for compatability with a standard 8000 ft runway in configuration TO on dry concrete at sea level. Data are presented in table VIII.

Table VIII
TAKEOFF PERFORMANCE

GROSS WEIGHT (LB)	FUEL REQUIRED (LB JP5)	ROTATE SPEED (KOAS)	LIFTOFF SPEED (KOAS)	GROUND RUN (FT)	HEADWIND (KNOTS)	OAT (DEG F)
31,500	100	145	150	3300	16	+44
31,100	100	145	150	3500	0	+39

Takeoff run required 42 percent of an 8000 ft runway with liftoff speed corresponding to contractor recommended refusal speed. Takeoff distance was long and the runway remaining was insufficient to effect an abort. The pilot will not have sufficient runway to accelerate to liftoff speed, identify abort criteria and effect a high speed abort without departing the runway. The long takeoff distance is a Part I deficiency which should be corrected prior to delivery.

2.4.2 Climb Performance

Climb performance was evaluated in configuration CL using the contractor's recommended maximum range climb schedule of 360 KIAS to 0.77 IMN between 1000 ft MSL and 30,000 ft MSL with a starting gross weight of 30,700 and a temperature range of six degrees C at 1000 feet to -39 degrees C at 30,000 ft MSL. The climb took seven minutes and 900 pounds of fuel for a down range travel of 41 nautical miles. These agreed with contractor data. The climb was relatively slow, but easy to fly and used only nine percent of the airplane's total internal fuel. The long time to climb will delay an alert launch pilot from reaching intercept altitude reducing the potential for engaging the enemy prior to long range enemy weapons launch. The long time to climb to altitude is a Part II deficiency which should be corrected as soon as practicable.

2.4.3 <u>Level Flight Performance</u>

2.4.3.1 <u>Range and Endurance.</u>

2.4.3.1.a <u>General.</u> Range and endurance characteristics were evaluated at 30,000 feet, 27,900 pounds gross weight, and 7000 ft MSL, 27,300 pounds for test day conditions in configuration CR. Outside air temperature was two degrees C at 7000 feet and - 39 degrees C at 30,000 ft MSL. Wing pylons were carried on all wing stations. Range and endurance test results are presented in appendix D, figures 20 and 21.

2.4.3.1.b <u>Maximum Range.</u> Maximum range performance data are listed in table IX.

Table IX
MAXIMUM RANGE PERFORMANCE

ALTITUDE (FT MSL)	AIRSPEED (KOAS)	MACH (OMN)	FUEL FLOW (LB/HR)	ANGLE OF ATTACK (UNITS)
30,000	240	0.65	2050	11 1/2
7,000	270	(1)	2800	10 1/2

Note: (1) OMN not available on production gage at 7000 ft for that KOAS.

The slopes of fuel flow versus airspeed at maximum range were fairly shallow and deviations of 10 KOAS had little effect on fuel flow required. Maximum range fuel flows were low with fairly high airspeeds providing a no wind ferry range of over 1000 nm on internal fuel. The low fuel and high airspeed characteristics will allow the sea strike pilot to conduct war-at-sea strikes, SSC and choke point mining at extended ranges in advance of the carrier battle group providing timely intelligence collection and neutralization of hostile units before they can threaten the carrier. The maximum range characteristics are satisfactory for the sea strike mission.

2.4.3.1.c Maximum Endurance. Maximum endurance performance data are presented in table X.

Table X
MAXIMUM ENDURANCE PREFORMANCE

ALTITUDE (FT MSL)	AIRSPEED (KOAS)	MACH (OMN)	FUEL FLOW (LB/HR)	ANGLE OF ATTACK (UNITS)
30,000	220	0.61	1950	12
7,000	225	-	2500	11 1/2

The curves of fuel flow versus airspeed at maximum endurance were very flat with deviations of 25 KOAS having very little effect on fuel flow required. Angle of attack correlation was good with a one half unit difference between the altitudes tested. Maximum endurance fuel flow requirements were low and indicated that maximum endurance could be established by flying one AOA (12 units) within the altitude range tested. The sea strike pilot will be able to loiter on station for extended periods of time without refueling, reducing the number of airplanes and carrier launch cycles required to maintain SSC and CAP coverage. The maximum endurance characteristics are satisfactory for the mission.

2.4.4 Specific Excess Power

Specific excess power (Ps) characteristics were evaluated by conducting level acceleration runs in configuration P at 5000, 7000, 15,000 and 30,000 ft MSL with data referred to standard day and a standard gross weight of 30,000 pounds. Data are presented in appendix D, figure 22. Maximum Ps obtained was low at 97 feet/second at 5000 ft MSL with a large reduction in Ps noted between 15,000 and 30,000 feet. Ps dropped rapidly to zero above 0.8 Mach. Acceleration was slow at all altitudes, taking up to five minutes to reach maximum level airspeed. The sea strike pilot will not be able to accelerate rapidly after coastal mining drops or to intercept hostile airplanes increasing exposure time over hostile territory and preventing effective air defense of the carrier. The low specific excess power is a Part I deficiency which should be corrected prior to delivery.

2.4.5 Turn Performance

2.4.5.1 General. Sustained and instantaneous turn performance were quantitatively evaluated in configuration P at 30,000 and 15,000 ft MSL and referred to standard day and a standard gross weight of 30,000 pounds. Turn performance was tested without the benefit of automatic maneuvering flaps. Observed turn performance was compared to predicted turn performance from the Ps data presented in paragraph 2.4.4. Data reduction was conducted using the United States Naval Test Pilot School, Fixed Wing Performance software for the Hewlett Packard personal computer system. Data are presented in appendix D, figures 23 through 26.

2.4.5.2 Sustained Turn Performance. Maximum sustained turn rate and radius obtained at 15,000 ft was eight degrees per second and three quarters of a mile, respectively at 0.65 Mach. The slope of maximum sustained turn rate versus Mach at 15,000 ft was steep with turn rate decreasing rapidly away from 0.65 Mach. Maximum sustained Nz was very low at 3.2 g's at 15,000 ft. Sustained turn rate and radius performance was significantly below that of current threat airplanes due to the low sustainable Nz. The sea strike pilot will not be able to match or exceed the turning performance of potential threats forcing him into a defensive posture and increasing the potential of being shot down. The low sustained load factor performance in configuration P is a Part I deficiency which should be corrected prior to delivery.

2.4.5.3 Instantaneous Turn Perforamnce. Instantaneous turn performance was evaluated at 15,000 feet with a maximum load factor of 5 1/2 g's at 0.75 OMN. Maximum instantaneous turn rate was low at 11 1/2 degrees per second and decreased rapidly below 0.75 OMN. Minimum turn radius was large at over one half mile. The instantaneous turn performance was below that of current threat airplanes sustained performance. Low instantaneous turn performance will not allow the sea strike pilot to effectively break a weapons tracking solution or evade a surface to air missile increasing the potential of being shot down. The low instantaneous turn performance is a Part I deficiency which should be corrected prior to delivery.

2.4.6 Descent Performance

Descent performance was evaluated using contractor recommended maximum range and penetration descent profiles at test day conditions in configurations G and D. Data are presented in table XI.

Table XI
DESCENT PERFORMANCE

PROFILE	CONFIGURATION	ALTITUDE (FT MSL)	AIRSPEED (KOAS)	FUEL (LB)	TIME (MIN)	DISTANCE (NM)
Maximum Range	G	30,000 to 5,000	220	300	13	41
Penetration	D	20,000 to 6,000	250	100	2	14

Maximum range descent had an average rate of 1.6 nautical miles per 1000 ft MSL, an average fuel flow of 850 pounds per hour, with AOA stable at 12.5 units throughout the descent. The penetration descent had a rate of one nautical mile per 1000 feet and was compatable with standard CV instrument penetrations. The sea strike pilot will find maximum range descent easy to fly with low fuel consumption, and will be able to comply with standard CV instrument procedures using the penetration descent. The descent performance is satisfactory for the mission.

2.4.7 Landing Performance

Landing performance was evaluated for compatability with a standard 8000 foot runway during three landings on dry concrete with an RCR of 23 in configuration L. Data are presented in table XII.

Table XII
LANDING PERFORMANCE

GROSS WEIGHT (LB)	LAND SPEED (KOAS)	DISTANCE (1) (FEET)	HEADWIND (KNOTS)	OAT (DEG F)
24,700	130	5,700	+16	+44
23,700	125	6,500	0	+39
25,200	132	6,500	+8	+52

Note: (1) Touchdown at optimum approach speed, aerodynamic braking to 100 KOAS than moderate anti-skid braking to a safe taxi speed.

Landing required 82 percent of an 8000 foot runway leaving only a 1500 foot safety margin. Under optimum conditions and low gross weight the landing distance was long with the airplane slow to decelerate after touchdown. The sea strike pilot will find it difficult to stop the airplane on a dry runway increasing the potential for hot brakes, blown tires, and departing the runway under wet runway, high gross weight and/or tailwind landing conditions. The long landing distance is a Part II deficiency which should be corrected as soon as practicable.

2.4.8 Mission Profile

The airplane's fuel capacity and fuel flow requirements were evaluated for utility in completing mission Profiles A and B detailed in appendix B, figures 2 and 3. Total fuel available at engine start was 10,100 pounds of JP-5 (full internal). The airplane had a maximum combat radius of 460 nautical miles (no wind) in accordance with Profile A, and a 28,800 square mile sector search capability according to Profile B. Large fuel capacity coupled with low fuel flow requirements made mission profiles easy to meet and still have a fuel reserve. The sea strike pilot will be able to operate at extended ranges without tanker support providing timely threat localization, engagement and intelligence collection far in advance of the carrier. The combat radius and sector search coverage capabilities are satisfactory for the mission.

2.5 POTENTIAL SOLUTIONS TO OBSERVED DEFICIENCIES

2.5.1 General

The following presents potential solutions for the identified deficiencies. Several of the deficiencies have a common solution or combination of contributing solutions to be evaluated.

2.5.2 Delayed Engine Response During Waveoff

Delayed engine response (paragraph 2.3.11.6) is a characteristic often encountered with the fuel efficient turbofan powerplant and becomes dramatic with the reduced power requirements at lower gross weights associated with a carrier based mission. Precise glideslope control for carrier approaches dictates frequent and timely power corrections. At low rpm ranges, a turbofan engine with high fan and compressor mass requires long spool-up times. Delays in power response equate to deviations below glideslope or failure to arrest a sink rate already established. The simplest potential solution is to maintain high turbofan engine core RPM providing rapid response to throttle inputs. A higher thrust required at a given approach speed can be achieved by increasing parasidic or zero lift drag in configuration PA. This has been accomplished on carrier airplanes such as the A-4, A-6, and T-2 by deploying speedbrakes or spoilers for landing with the capability to rapidly retract them in the event of a waveoff. The resultant increase in drag should be governed by the worst case recovery weight and external configuration which would still provide satisfactory wave-off and glideslope control without requiring the maximum thrust available or AB. The current A-7E speedbrake is not capable of being deployed during landing because it extends below the landing gear. A fuselage mounted speedbrake system, or incorporating a wing spoiler system like that of the A-6, would have to added. Using the existing spoiler system is not a suitable solution. The goal is to increase drag, not to reduce lift or reduce the roll performance in configuration PA. An additional spoiler system is also not economical because the installation, aerodynamic loads and resultant buffet would require modification of the existing airfoil and flap systems. It is recommended that the manufacturer investigate the installation of a fuselage speedbrake system, installed in such a manner as to allow deployment in configuration PA. This system should be designed as a modification or replacement for the current under-belly speedbrake. Modification should be completed prior to further testing. Risks associated with this modification are considered low. The potential adverse pitch changes with speedbrake operation and the effects of airflow over the speedbrake system and the airplane tail surfaces at high angles of attack, high dynamic pressures and high Mach numbers would require wind tunnel and flight test evaluation.

2.5.3 Low Specific Excess Power

The solution to increase Ps involves decreasing airplane weight, increasing airplane thrust, or reducing total drag. In dealing with an existing airframe, decreasing weight and drag would be potential high cost areas. Reengining the existing airplane to increase thrust is a more realistic approach,particularly since the current TF41 engine has been in service for over 20 years. However, the existing A-7E powerplant provided satisfactory level flight performance, as discussed in paragraphs 2.4.3.1.b and 2.4.3.1.c, which supports the continued use of a turbofan engine. Increasing thrust while maintaining good range and endurance chracteristics dictate the use of a turbofan engine with afterburner (AB). Selection of a similar basic engine thrust level should minimize intake modifications for the new engine. Efficiency improvements over the last 20 years could potentially improve range and endurance while the use of an AB could increase the thrust of a basic turbofan engine by approximately 60 percent without the need for increased airflow. These conclusions are based on F-14, F-15 and F-16 engine specifications found in reference (7). Based on the maximum Ps obtained from 5,000 ft MSL (97 ft/sec) with a desired Ps level of 250 ft/sec under the same conditions, a thrust increase of approximately 10,431 pounds (70 percent) is predicted (references 8 and 9).

$$Ps = dhe/dt = \frac{V\left[Ta \cos(\alpha + i_T) - D\right]}{W}$$

Assuming level, unaccelerated flight and zero thrust angle;

$$Ps = \frac{V(Ta-D)}{W}$$

From 5,000 ft test data (appendix D, figure 22);
D = 8386 lb

With a desired Ps of 250 ft/sec; T = 25431 lb

For a T/W = 25431/30,000 = 0.85 versus 0.50 for current A-7E.

It is recommended that the manufacturer investigate the reengining of the basic A-7E airframe with a current technology turbofan engine with AB. This modification should be incorporated prior to further testing. Risks associated with reengining the A-7E are considered fairly high and affect the structure, flying qualities and performance of the airplane. Engine form, fit and function must be achieved as well as providing for AB installation and any differences in airflow for the new engine. Afterburner ducts and nozzles increase engine length. Such an increase can not decrease the hook-to-ramp clearance, limit optimum approach AOA or otherwise cause inadvertent contact of the lower aft engine/fuselage area with the landing surface. Increased Ps leads to increased maximum level flight airspeeds for a subsonic airplane design. Transonic flying qualities, as well as structural flutter analysis will require wind tunnel and flight testing for an un-ruled airplane with a current Vmax of 663 KIAS, 0.89 IMN. The characteristics of shock wave formation along the UHT and engine intake will be critical areas for investigation. If AB is used to make up the difference in required Ps, the penalty will be increased fuel consumption and decreased combat radius unless fuel capacity is increased.

2.5.4 Low Automatic Maneuvering Flap Availability

Turn performance with AMF was not tested due to the inavailability of the system during the performance phase of this evaluation. As a result, the Part I turn performance deficiencies to be discussed in paragraphs 2.5.5 and 2.5.6 are based on flaps up turn performance. AMF, or AMF combined with leading edge extensions and increased thrust, may provide sufficient lift improvements without additional structural modifications for satisfactory turn performance. Reliability and maintainability of the system is the first problem to correct followed by reevaluation of the airplane prior to modification. It is recommend the contractor investigate and provide reliable AMF operation with a mean time between between failure (MTBF) of at least 400 hours. This correction should be completed prior to modification of the A-7E, or further testing to determine the maximum turn performance capability of the airplane without modification.

2.5.5 Low Sustained Load Factor

Improving the sustained load factor involves increasing the thrust-to-weight ratio, decreasing wing loading or improving the lift-to-drag ratio and maximum lift coefficient as illustrated (references 5 and 10).

$$nz \text{ (sustained)} = (Ta/W)(Cl/Cd)$$

From test turn performance data (appendix D, figure 23);

$$3.4g = (15{,}000/30{,}000)(Cl/Cd)$$

$$Cl/Cd = 6.8$$

For a desired sustained nz of 6, with a 0.85 T/W ratio from paragraph 2.5.3, the increase in the lift-to-drag ratio would be;

$$6g = (0.85)(Cl/Cd)$$

$Cl/Cd = 7.1$ for an increase of 0.3 with AB.

Paragraph 2.5.3 addresses a thrust increase which should significantly improve the trust-to-weight ratio, but at the cost of increased fuel consumption and reduced range. Decreasing wing loading would require decreasing airplane weight or increasing wing area. Using an existing airframe limits the weight reduction capabilities, but increasing wing area (chord length, and lifting area) can be accomplished using existing or improved leading and trailing edge high lift devices. Increasing the wing span is seen as a major and expensive alternative. Reducing induced drag of the existing airfoil would be a costly undertaking with limited gain potential. Increasing the maximum lift (increasing the maximum angle-of-attack before stall) is however, an area where current technology can be applied. The goal is to delay seperation of the boundary layer over the wing. Active boundary layer controls have worked but are costly and come with their own maintenance problems. Application of leading edge extensions or strakes, as in the F-16 and F-18 airplanes, has been effective in generating favorable vortex flow over the wing to reenergize the boundary layer. Based on these considerations, it is recommended that the contractor investigate artificial increases to the chord/camber through mechanical leading and trailing edge lift devices as well as employing a leading edge extension to the wing root. These modifications should be incorporated prior to further testing. Risks associated with these modifications are considered fairly high and center on directional stability and stall/departure characteristics. Documented stall and departure characterisitcs of the existing airplane in paragraphs 2.3.10.2 and 2.3.10.3 indicate reduced or negligable directional stability at high angles-of-attack. Delaying boundary layer seperation to a higher AOA may further degrade directional stability and impede airflow over the vertical tail. High Mach number and AOA wind tunnel testing followed by cautious stall/departure flight test investigation will be required. Based on current stall and accelerated departure characteristics, the recommended additions required to increase turn performance would probably produce unacceptable direction stability characteristics.

2.5.6 Low Instantaneous Turn Performance

Instantaneous turn rate is influenced by the same lift-to-drag ratio as discussed in paragraph 2.5.5 for sustained load factor, as well as wing loading (reference 5).

$$nz(\text{instantaneous}) = \frac{Cl\ \rho\ V^2}{2(W/S)}$$

Increasing thrust-to-weight produces significant improvements in sustained turn performance and Ps, but has little effect on instantaneous turn preformance. Instantaneous performance is greatly influenced by the lift and drag characterisitcs of the wing. Recommendations for the use of mechanical high lift devices such as leading and trailing edge flaps in paragraphs 2.5.4 and 2.5.5 are also seen as the potential solutions for improving instantaneous turn performance.

2.5.7 Long Takeoff Distance

Takeoff distance can be improved by increasing the trust-to-weight ratio, or improving the lift-to-drag characteristics of the airplane to enable rotation and liftoff at a slower airspeed. The use of an AB engine recommended in paragraph 2.5.3 along with the lift improvements recommended in paragraphs 2.5.4 and 2.5.5 are also seen as potential solutions to the long takeoff distance deficiency. Increasing T/W by 0.35 (paragraph 2.5.3) alone indicates a potentiaol takeoff distance reduction of 1500 ft at sea level (reference 8).

2.5.8 Large Altitude Loss During Stall Recovery

The large altitude loss during stalls/departures in configuration CR is attributed to the reduced directional stability at high angles-of-attack which causes the nose to slice and the airplane to roll off nose low as documented in paragraphs 2.3.10.2.b and 2.3.10.2.c. Increased directional stabilty, particularily on a high, swept wing airplane should resist yaw/roll motions at stall aiding stall recovery. Directional stability is normally addressed as the summation of the stability contributions of the fuselage, wing and tail. Fuselage contributions are the prominent negative contribution while the tail provides the dominent positive contribution (references 4, 8 and 10). A swept wing such as the A-7E's normally provides a small positive contribution caused primarily by the asymmetric induced drag as a result of sideslip. Improving directional stability using the existing fuselage and wing with mechanically increased chord length would require increasing the vertical tail surface area, sideforce or the moment arm of the tail in relation to the CG (references 4 and 10). Increasing the size of the vertical tail should do a combination of all of the above. It is recommended that the contractor investigate increasing the vertical tail sizing to improve directional stability. This modification should be incorporated prior to further testing. The risks associated with increasing the vertical tail size are considered fairly low. Modification should be based on structural and flutter analysis followed by wind tunnel and flight tests building up to maximum dynamic pressure. Decreased directional stability as a result of transonic flight will also require investigation. Increased directional stability, coupled with a large thrust capability as with an AB engine should significantly reduce altitude loss during stall recoveries.

2.5.9 Long Landing Distance

Decreasing landing distance involves reducing gross weight, approach speed or rapidly reducing wing lift and increasing total drag after touchdown. Deployed speedbrakes will increase parasite drag after touchdown, while the recommended mechanical lift improvements should allow slower approach speeds. The use of deployable speedbrakes for landing (paragraph 2.5.2) along with high lift devices (paragraphs 2.5.4 and 2.5.5) are also seen as potential solutions for the long landing distance deficiency. Additional improvements could be gained, if required, by triggering the existing wing spoilers to fully deploy symmetrically as a function of weight-on-wheels to further reduce lift on the wing during landing rollout.

2.5.10 Slow Engine Response to Throttle Inputs

This deficiency will be corrected by the addition of deployable speedbrakes in configuration PA as presented in paragraph 2.5.2.

2.5.11 Low Steady State Roll Rate

Increasing roll rates in configuration CR would require decreasing roll damping, or increasing lateral control authority. As stated in paragraph 2.3.9.2, the roll mode time constant was satisfactory, that is the maximum steady state roll rate was rapidly reached, but that rate value was low. Roll damping comes primarily from the aspect and taper ratios of the wing (reference 4), in this case a high mounted wing with relativly high aspect ratio, and would be a costly modification which also changes the roll mode time constant. The logical area for improvement would be to increase the lateral control authority. This can be accomplished aerodynamically by changing the lift values of the roll controls through increased surface area or deflection angle. There are a number of combinations to produce the desired result, the simplest starting point being to increase the deflection angle of the upper wing spoilers with 30 degrees of unused movement at the present time. This would also avoid any adverse yaw effects if increased lifting surface area or control deflection were used, and aid in reducing lift if used as a means of reducing landing distance (paragraph 2.5.9). It is recommend the contractor investigate increasing the lateral control surface deflection per unit of control stick deflection using the existing aileron and spoiler control surfaces. This modificaiton should be incorporated as soon as practicable. The risks associated with such an improvement are considered low and focus on the existing stability augmentation systems ability to compensate for any increased dutch roll excitation due to increased yawing moments during abrupt control inputs. Proper selection of the increased vertical tail sizing (paragraph 2.5.8) should aid in avoiding those problems.

2.5.12 Long Time to Climb

The long time to climb deficiency is associated with alert launches and intercepts, not maximum range climb fuel and down range travel performance. In this regard, the addition of an AB engine (paragraph 2.5.3) will increase airplane Ps values significantly and is also seen as the potential solution to the long time to climb to altitude deficiency.

2.5.13 Violent Departure Characteristics

The violent departure characteristics during accelerated stalls in configuration CR are the rapid departure in yaw of 20 to 30 degrees opposite the direction of turn with substantial sideforces, coupled with a rapid 360 degree roll in the direction of yaw. Abrupt loss of directional stability is considered the cause in this case based on repeated inflight observation by the author. The yaw rates produce an advancing and retreating wing condition which accents the loss of the rising wing lift producing roll in the direction of yaw. As discussed in paragraph 2.5.8, increased vertical tail sizing to improve directional stability is also seen as the potential solution to the violent departure characterisitics.

2.5.14 High Stick Force Per Normal Acceleration

Stick force per normal acceleration (Fs/g) is a result of the artificial feel system in an irreversible, hydraulic powered flight control system. In the case of the A-7 a set of forward and aft bobweights provide pilot longitudinal stick forces. It is recommend the contractor investigate reducing Fs/g in configuration CR by rebalancing the forward and aft bobweights. This modification should be incorporated as soon as practicable. The risks associated with this modification are considered small and focus on the resultant maximum obtainable g during a sudden pull at the airplanes natural short period frequency throughout the operational airspeed and CG ranges. Fs/g can not be relaxed to the point where inadvertent overstresses will occur during maneuvering.

2.5.15 Absense of a Parking Brake

The addition of a parking brake is considered an oversight in the original design and an easy and inexpensive modification. The S-3 operates a similar landing gear and brake system with a parking brake system operating off a common brake accumulator which is continuously recharged off the utility hydraulic system and contains a nitrogen precharge for extended parking brake application (reference 11). It is recommended that the contractor install a parking brake system with cockpit control as soon as practicable.

2.5.16 Pitch Change with Power in Configuration PA

Correction of this deficiency would require an automatic thrust-pitch control system like the S-3 (reference 11) matching engine power levels with coordinated automatic UHT inputs to negate pitch changes due to power caused by the moment arm between the thrust line and the CG.

2.5.17 Nose Down Pitch Tendency During Flap Retraction

This characteristic is a common occurance for most airplanes as the center of lift moves forward with flap retraction. Pilot compensation by increased aft stick or nose up trim to set the climb attitude are successful techniques.

3. CONCLUSIONS

3.1 GENERAL

Within the scope of these tests, the A-7E demonstrated limited potential for the sea strike mission and will be satisfactory upon correction of the Part I deficiencies. The performance characteristics of the A-7E require significant improvements to meet mission requirements.

3.2 DEFICIENCIES

3.2.1 Part I Deficiencies

3.2.1.1 General. A total of seven Part I deficiencies were identified which were either severe safety hazards threatening the airplane/pilot, or increased the vunerability of the A-7E to hostile fire.

3.2.1.2 The delayed engine response during waveoff (paragraph 2.3.11.6).

3.2.1.3 The low specific excess power (paragraph 2.4.4).

3.2.1.4 The low automatic maneuvering flap availability (paragraph 2.2).

3.2.1.5 The low sustained load factor (paragraph 2.4.5.2).

3.2.1.6 The low instantaneous turn performance (paragraph 2.4.5.3).

3.2.1.7 The long takeoff distance (paragraph 2.4.1).

3.2.1.8 The large altitude loss during stall recovery (paragraph 2.3.10.2.d).

3.2.2 Part II Deficiencies

3.2.2.1 General. A total of seven Part II deficiencies were identified which significantly degraded the mission effectiveness, survivability, or safety of the airplane.

3.2.2.2 The long landing distance (paragraph 2.4.7).

3.2.2.3 The slow engine response to throttle inputs (paragraph 2.3.11.2).

3.2.2.4 The low steady state roll rate (paragraph 2.3.9.1).

3.2.2.5 The long time to climb (paragraph 2.4.2).

3.2.2.6 The violent departure characteristics (paragraph 2.3.10.2.c).

3.2.2.7 The high stick force per normal acceleration (paragraph 2.3.4.3.a).

3.2.2.8 The absense of a parking brake (paragraph 2.1.5).

3.2.3 Part III Deficiencies

3.2.3.1 General. A total of two Part III deficiencies were identified which were considered too costly or impractical to correct on the existing airplane.

3.2.3.2 Pitch changes with power in configuration PA (paragraph 2.3.5.2.d).

3.2.3.3 The nose down pitch tendency during flap retraction (paragraph 2.3.2.5).

3.2.4 Specification Conformance

The A-7E airplane met all specifications requirements against which it was tested, except those listed below:

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(1) Paragraph 3.3.4.1.1, in that the time to roll 360 degrees at 0.54 IMN was 0.25 seconds more than the maximum value of 2.8 seconds (9 percent).

(2) Paragraph 3.4.2.2.1, in that the airplane was not resistant to departure from controlled flight and the yaw roll motions were not arrested promptly by simple application of pilot controls.

(3) Paragraph 3.4.2.1.3, in that altitude loss during stall recovery was excessive.

4. RECOMMENDATIONS

4.1 GENERAL

The following paragraphs present the recommended timing for the correction or disposition of the identified deficiencies along with the recommended corrective actions necessary to achieve a satisfactory A-7 configuration for the sea strike mission.

4.1.1 Correct the deficiency listed in paragraph 3.2.1.4 (low AMF availability) and reevaluate turn performance prior to redesign or modification of the A-7E.

4.1.2 Correct the deficiencies listed in paragraphs 3.2.1.2, 3.2.1.3, and paragraphs 3.2.1.5 through 3.2.1.8 during redesign and modification before further testing.

4.1.3 Correct the deficiencies listed in paragraphs 3.2.2.2 through 3.2.2.8 as soon as practicable.

4.1.4 Avoid the deficiencies listed in paragraphs 3.2.3.2 and 3.2.3.3 in future designs.

4.2 SPECIFIC

4.2.1 Provide reliable AMF operation with a MTBF of at least 400 hours followed by reevaluation of the maximum turn performance of the A-7E (paragraphs 2.2 and 2.5.4).

4.2.2 Install a fuselage mounted speedbrake allowing deployment in configuration PA to avoid delayed engine response during waveoff (paragraphs 2.3.11.6 and 2.5.5), reduce landing distance (paragraphs 2.4.7 and 2.5.9), and avoid slow engine response to throttle inputs (paragraphs 2.3.11.2 and 2.5.10).

4.2.3 Reengine the airplane with a current technology turbofan engine with AB to increase Ps (paragraphs 2.4.4 and 2.5.3), improve the sustained load factor (paragraphs 2.4.5.2 and 2.5.5), reduce takeoff distance (paragraphs 2.4.1 and 2.5.7), reduce altitude loss during stall/departure recovery (paragraphs 2.3.10.2.d and 2.5.8), and reduce the time to climb (paragraphs 2.4.2 and 2.5.12).

4.2.4 Increase the chord length and camber of the wing through mechanical leading and trailing edge lift devices (including AMF reevaluation), as well as a leading edge extension to the wing root. These recommendations are to improve sustained and instantaneous turn performance (paragraphs 2.4.5.2, 2.4.5.3, 2.5.5 and 2.5.6), and to reduce takeoff and landing distances (paragraphs 2.5.7 and 2.5.9).

4.2.5 Increase the vertical tail size to improve directional stability, reduce altitude loss during stall/departure recovery, and increase departure resistance (paragraphs 2.3.10.2.c, 2.5.8 and 2.5.13).

4.2.6 Increase the lateral control surface deflection available to increase the steady state roll rate (paragraphs 2.3.9.1 and 2.5.11).

4.2.7 Reduce Fs/g in configuration CR by rebalancing the forward and aft bobweights (paragraphs 2.3.4.3a and 2.5.14).

4.2.8 Install a parking brake (paragraphs 2.1.5 and 2.5.15).

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APPENDIXES

APPENDIX A

A-7E AIRPLANE FLIGHT CONTROL DESCRIPTION

A-7E AIRPLANE FLIGHT CONTROL DESCRIPTION

1. GENERAL

The primary flight controls of the A-7E consist of a irreversible, hydraulically powered unit horizontal tail (UHT),ailerons, rudder and spoiler/deflectors operated from the flight station by a conventional control sitck and rudder pedals. The primary flight control surfaces are powered by tandem hydraulic cylinders; each cylinder is connected to two independent power control (PC) hydraulic systems for redundancy and reliability. Pilot inputs are transmitted to the cylinders and then directly to the UHT and lateral control surfaces through pushrods and bellcranks; rudder inputs are transmitted through a closed loop cable system and pushrods. Artificial feel is introduced into theflight control system to offset no airload feedback through feel springs, bobweights and viscous dampers. Trim is provided in all three axis by direct repositioning of the UHT, ailerons and rudder through electromechanical actuators and cockpit controls. A three-axis, dual channel automatic flight control system (AFCS) is provided with yaw stabilization, control augmentation (control stick steering), attitude , heading, and altitude hold, along with a automatic carrier landing system (ACLS) mode. Secondary flight controls consist of hydraulically operated leading and trailing edge flaps with an automatic maneuvering flap feature (AMF), and a hydraulically operated speedbrake mounted under the fuselage. Flight controls and surfaces are illustrated in appendix B, figures 1 and 4.

2. HYDRAULIC POWER CONTROL SYSTEM

Hydraulic power is supplied by three independent power control systems, PC1, PC2, and PC3. Each system is powered by an engine-driven pump operating at 3,100 psi. The UHT, rudder, ailerons, and spoiler-deflectors are controlled by tandem actuators. Each half of the tandem actuators are powered by two of the three power control systems. If one PC system fails, the other two systems will continue to supply hydraulic power for flight. In the event engine driven hydraulic pump pressure is lost, the emergency power package (EPP) hydraulic pump can be deployed to restore pressure to the PC3 system for continued flight. PC1 and PC3 systems provide flight control system power. PC2 system provides flight control and utility hydraulic power. The airplane is designed to sustain controlled flight and return for a shore based landing with any one of the PC systems operating. During flight the flap handle can be positioned to an Isolation Utility position to provide PC2 hydraulic system isolation from sub-systems not required in flight such as the launch bar, landing gear and nose gear steering. A flight control hydraulic schematic diagram is presented in appendix B, figure 5.

3. LONGITUDINAL CONTROL SYSTEM

The longitudinal control system, illustrated in appendix B, figure 4, consists of a center control stick, longitudinal stick stops, control linkages, feel spring strut, forward and aft bobweights, linkage preload springs and viscous damper cylinders, relaying pilot inputs to the UHT power control packages to position the UHT surfaces. Control stick travel is limited by two stops that engage a fixed arm attached to the control stick torque tube designed to allow control stick overtravel after the control linkage bottoms. Forward and aft bobweights counteract pitch oscillations and transmit forces to the control stick in proportion to the rate of pitch. The resultant force exerted between the forward and aft bobweights is designed to be approximately 2.75 pounds per g measured at the center of the control stick grip. Forward and aft linkage preload springs prevent the bobweights form providing a control stick force in level flight. Forward and aft viscous dampers are designed to provide a snubbing action to resist rapid or abrupt control stick movement and damper oscillations caused by the bobweights. A negative rate spring mechanism is connected to the control linkage inertia loads to maintain proper stick feel forces, reduce control stick overshoots, and cancel stick forces that originate at the preload spring. A variable gain linkage is incorporated to reduce control stick sensitivity at or near the neutral position. Moving the stick a given amount from neutral produces a small amount of UHT deflection, moving the stick the same amount away from neutral results in a considerably larger amount of UHT deflection. A dual rate feel spring strut simulates feel forces at the control stick and works in two stages. The first stage spring presents a relatively large opposing force to a small control deflection form neutral. The second stage action occurs as the control stick is moved further from neutral to the point where the second stage breakout force is reached where relatively large stick deflections are possible with only small increase in stick force. Each side of the UHT is operated independently by a hydraulic cylinder installed in a power control package. The two power control packages are hydraulically synchronized so that both move as one. A mechanical backup is connected to both UHT surfaces to insure continued syncronized operation in the event one PC package becomes inoperative. If PC system pressure is lost, check valves trap fluid in the cylinders to prevent the airplane form pitching into a sharp nosedown attitude.

4. PITCH TRIM SYSTEM

The pitch trim system consists of a linear electromechanical pitch trim actuator acting as a fixed length link in the UHT control system. Pilot inputs through the pitch trim switch on the control stick, or AFCS inputs cause the fixed-length to change repositioning the UHT control surfaces while the control stick assumed a new neutral position. A maximum trim of 14 degrees trailing edge up and two degrees trailing edge down can be obtained.

5. AILERON CONTROL SYSTEM

The aileron control system consists of the center control stick, control linkages, feel springs, viscous dampers, and a bobweight transferring pilot control stick inputs to a conventional trailing edge ailerons through tandem hydraulic cylinders located in each wing. A viscous damper is incorporated to resist rapid or abrupt control stick movement and prevent overcontrol of the aileron control system. A bobweight is installed to counteract stick grip and stick force sensor mass effect during sideslips and roll accelerations. Lateral control stick movement displaces a mechanical feel spring assembly, providing simulated airload resistance fell forces at the control stick and control stick centering. A tandem hydraulic cylinder roll feel isolation actuator, powered by PC 2 or PC 3, installed downstream of the feel spring assembly relays control system inputs to roll control linkage and isolates the control stick from high breakout forces of spoiler/deflector load limiting links and AFCS feedback. The ailerons are interconnected and move in advance of spoiler/deflector control surfaces through a mixing linkage allowing two and one half degrees of aileron movement before spoiler//deflector movement occurs. THe ailerons are positioned by tandem power control (PC) cylinders receiving power from two of the three PC systems. PC1 and PC3 power the left aileron, and PC1 and PC2 power the right aileorn. This provided redundancy in the aileron system unless PC1 is the only powered system in which case the ailerons will not respond since the roll feel isolation actuator in line with the aileron control linkages will not be powered.

6. SPOILER/DEFLECTOR CONTROL SYSTEM

The spoiler/deflector control system is a primary flight control system linked to the aileron control system to provide increased roll rate. Spoiler location is on top of the wing with a corresponding deflector below the wing moving in conjunction with the upward moving aileron through the mixing linkage and the spoiler/deflector control linkage during roll inputs from the pilot. The spoilers are positioned by tandem PC cylinders and will continue normal operations in the event of one PC system failure. Maximum spoiler deflection is 60 degrees. The deflector is mechanically slaved to the spoiler and will reach a maximum deflection of 30 degrees.

7. ROLL TRIM SYSTEM

The roll trim system positions the aileron control surfaces through linear electromechanical trim actuators without deflecting the control stick. Pilot inputs are through the aileron trim switch on the control stick.

8. RUDDER CONTROL SYSTEM

The rudder control system is a conventional hydromechancial flight control system using to control movement about the yaw axis. Forward and aft movement of the rudder pedals is mechanically transmitted to the rudder control cables which in turn relay the input to the rudder PC package with tandem hydraulic cylinders to position the rudder surface. Rudder pedal movement is limited by stopbolts and a jumper cable attachment. Rudder position is controlled as a function of right main landing gear door position. Rudder deflection is limited to six degrees with the gear door closed and 24 degrees with the door open (gear down). Rudder pedal artificial feel forces are provided by a mechanical spring arrangement which produces a different feel force gradient for the flaps up and flaps down configurations. The right rudder pedal incorporates a rudder shaker which becomes active when angle of attack reached 20 and one half units AOA. Rudder trim is obtained through the yaw stabilization mode of the AFCS. Lateral accelerometers provide a yaw computer with yaw signals used for automatic trim in the yaw axis. Manual yaw trim is accomplished through a rudder trim control knob on the left cockpit console. Both means of rudder trim are through the tandem hydraulic AFCS yaw actuator directly positioning the rudder surface for a maximum of 12.5 degrees of deflection.

9. COCKPIT CONTROL STICK

The cockpit control stick pivots forward and aft at the floor plate for pitch control and left and right at mid-lenght for lateral control. The control grip incorporates the pitch and roll trim switch, trigger, armament release, nose wheel steering and designate buttons.

10. AUTOMATIC FLIGHT CONTROL SYSTEM

The automatic flight control system (AFCS) is a three-axis, dual channel autopilot with control augmentation (control stick steering). The features of this system include automatic pitch and yaw trim, system self-test, fail passive monitoring and warning, yaw stabilization, attitude, heading, and altitude hold, as well as automatic carrier landing system (ACLS) provisions. Electrical and hydraulic power are required for AFCS operation. Yaw stabilization is designed to remain engaged regardless of airplane attitude. Yaw stabilization provides lateral-directional damping, aileron-rudder interconnect for automatic turn coordination, and rudder trim. Control augmentation is designed to improve lateral and longitudinal stability. Control stick steering is designed to provide a constant roll rate per pound of stick force and a normal acceleration rate per second of stick force, regardless of airspeed.

11. FLAP CONTROL SYSTEM

Two full-span, two-position flaps are installed at the leading edge of each wing and a single-slotted, variable-position flap, is installed at the trailing edge of each wing center section. Leading edge flaps extend full down when trailing edge flpas are extended to any position. Trailing edge flaps can be extended to a maximum of 40 degrees. Flaps are mechanically actuated through the cockpit flap lever, and hydraulically operated through the PC2 system and twelve hydraulic actuators in the wings. An automatic maneuvering flap (AMF) mode of operation is pilot selectable to provide increased stall resistance and improved turning performance. AMF extension occurs at 14.75 units AOA with airspeed below 325 KIAS. Leading edge flaps extend full down while trailing edge flaps extend 15 degrees. Retraction is initiated automatically with AOA 10.5 units or airspeed at 325 KIAS.

12. SPEEDBRAKE SYSTEM

The speedbrake system is an electrically controlled and hydraulically operated system which provides rapid deceleration in flight by deploying a relatively large speedbrake mounted under the airplane fuselage. Speedbrake position can be adjusted by pilot inputs and extended to a maximum deflection of 60 degrees to the fuselage. Speedbrake retraction is automatic with landing gear extension or electrical power loss. As the speedbrake extends, additional surface area in the form of hinged chines deploy on each side of the speedbrake. If airloads become excessive, a relief valve will allow the speedbrake to partially close preventing structural damage. Speedbrake control is through a switch located on the right side of the engine throttle.

APPENDIX B

FIGURES

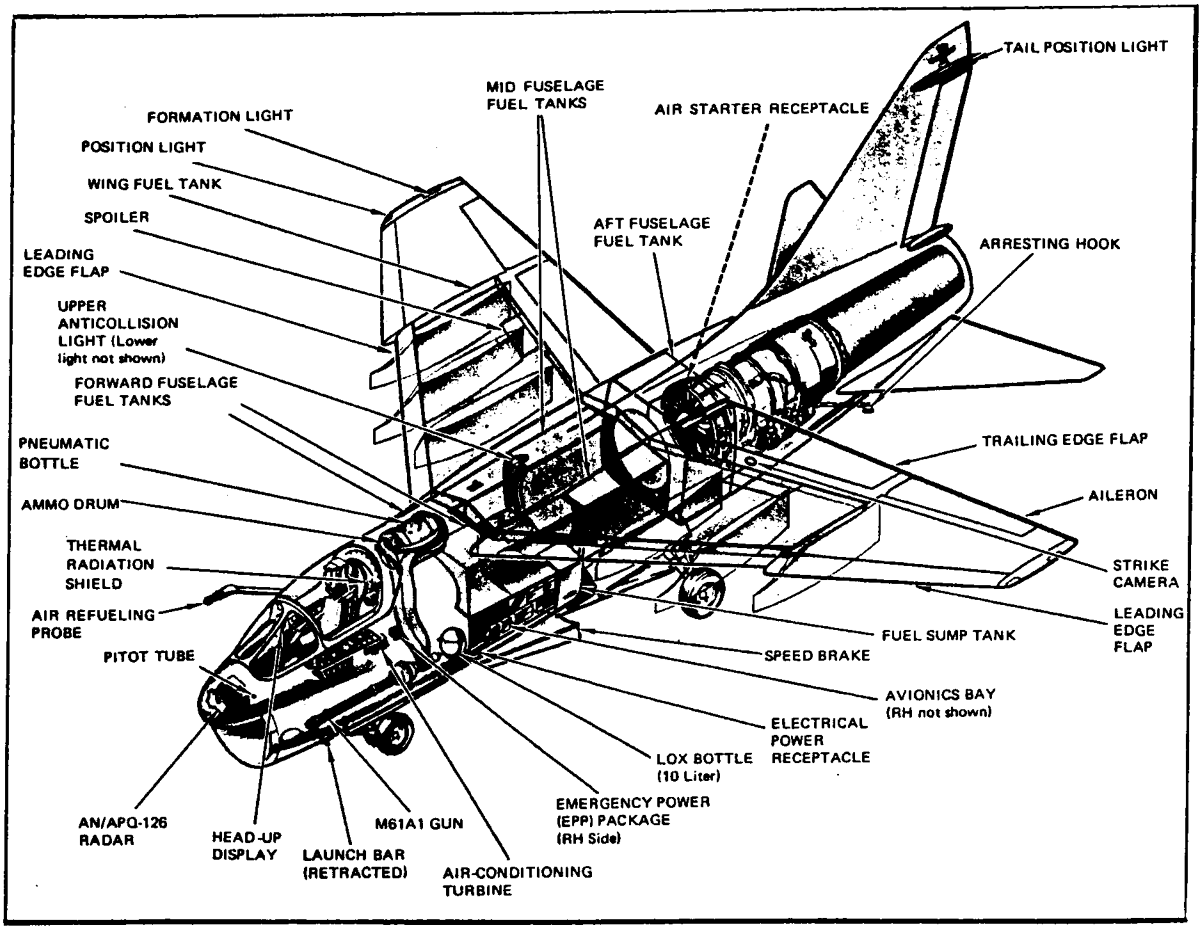


Figure 1

A-7E AIRPLANE

EVENT	FUEL REQUIRED (POUNDS)	TIME (HOURS + MINUTES)	DISTANCE (NM)
Start/Taxi	200	0+15	-
Takeoff	100	0+02	3
Climb to 30,000 ft MSL	900	0+07	41
Cruise (.65M/2050 lb/hr)	1,875	0+55	367
Maximum Range Descent	300	0+13	41
High Speed Ingress-Egress/ Mining Run	2,300	0+15	15
Climb to 30,000 ft MSL	900	0+07	41
Cruise	1,875	0+55	367
Maximum Range Descent	100	0+04	14
Instrument Penetration	100	0+02	14
Instrument Approach	200	0+05	20
Reserve (1/2 Hour at 7,000 MSL)	1,250	-	-
TOTAL	10,100	3+00	923

Maximum Combat Radius (1): 460 nautical miles

Note: (1) No wind, full internal fuel, drag count 50

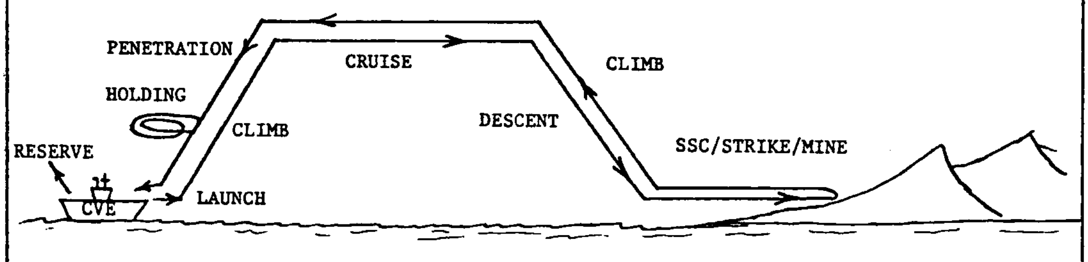


Figure 2

PROFILE A, LONG RANGE SEA STRIKE

EVENT	FUEL REQUIRED (POUNDS	TIME (HOURS + MINUTES)	DISTANCE (NM)
Start/Taxi	200	0+15	-
Takeoff	100	0+02	3
Maximum Range Cruise at 7,000 ft MSL (2,800 lb/ hr)	6,575	2+35	697
Loiter On Station	1,250	30	-
Holding	625	15	-
VFR Landing	100	0+05	-
Reserve (1/2 Hour at 7,000 ft MSL)	1,250	-	-
TOTAL	10,100	3+42	700
Area Coverage (1): 28,800 square miles			
Note: (1) No wind, full internal fuel, drag count 50, 40 nautical mile radar track width.			

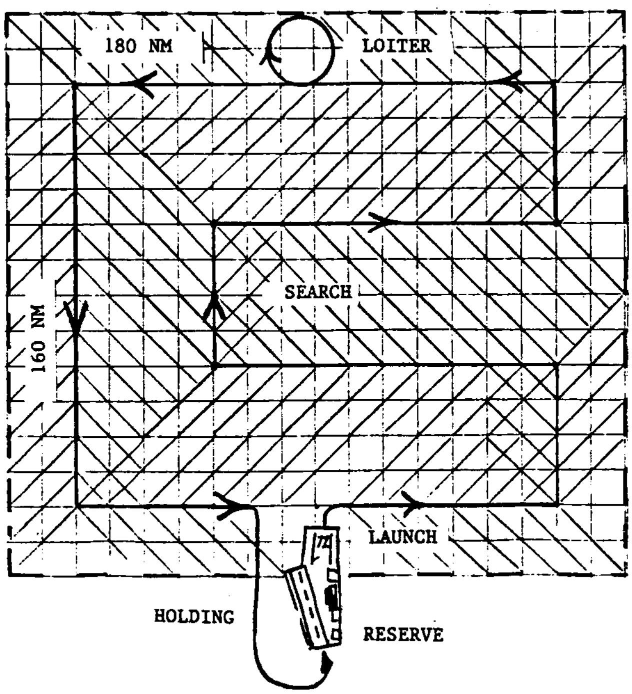


Figure 3

PROFILE B, SECTOR SSC

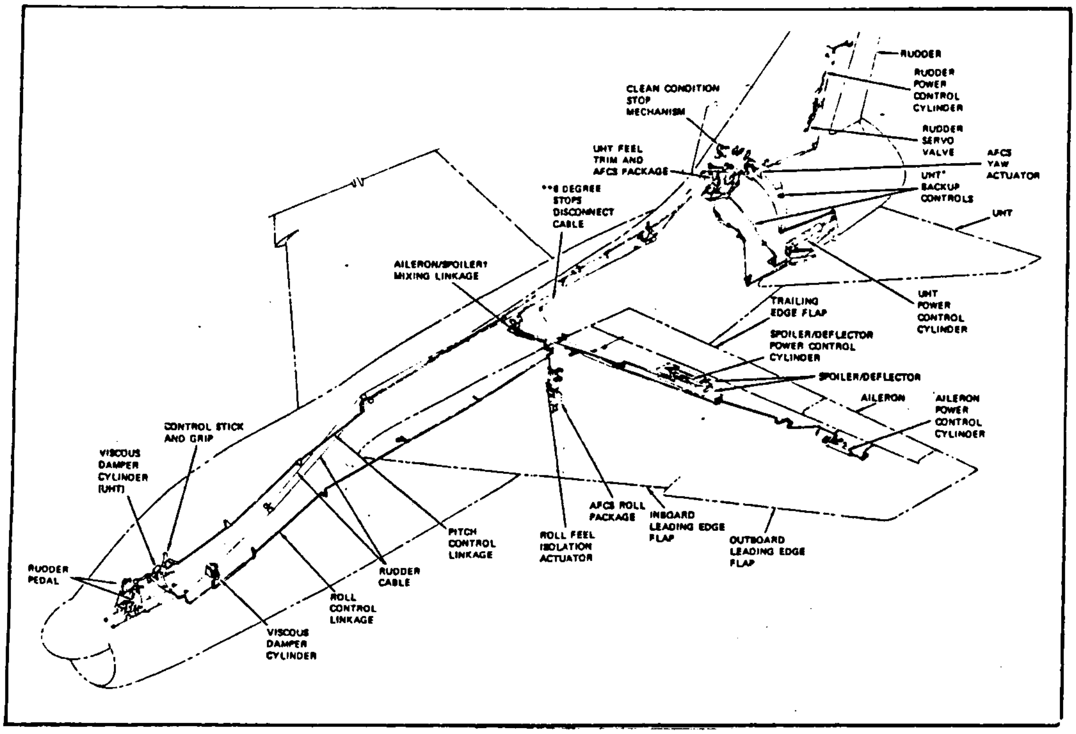


Figure 4

A-7E FLIGHT CONTROLS

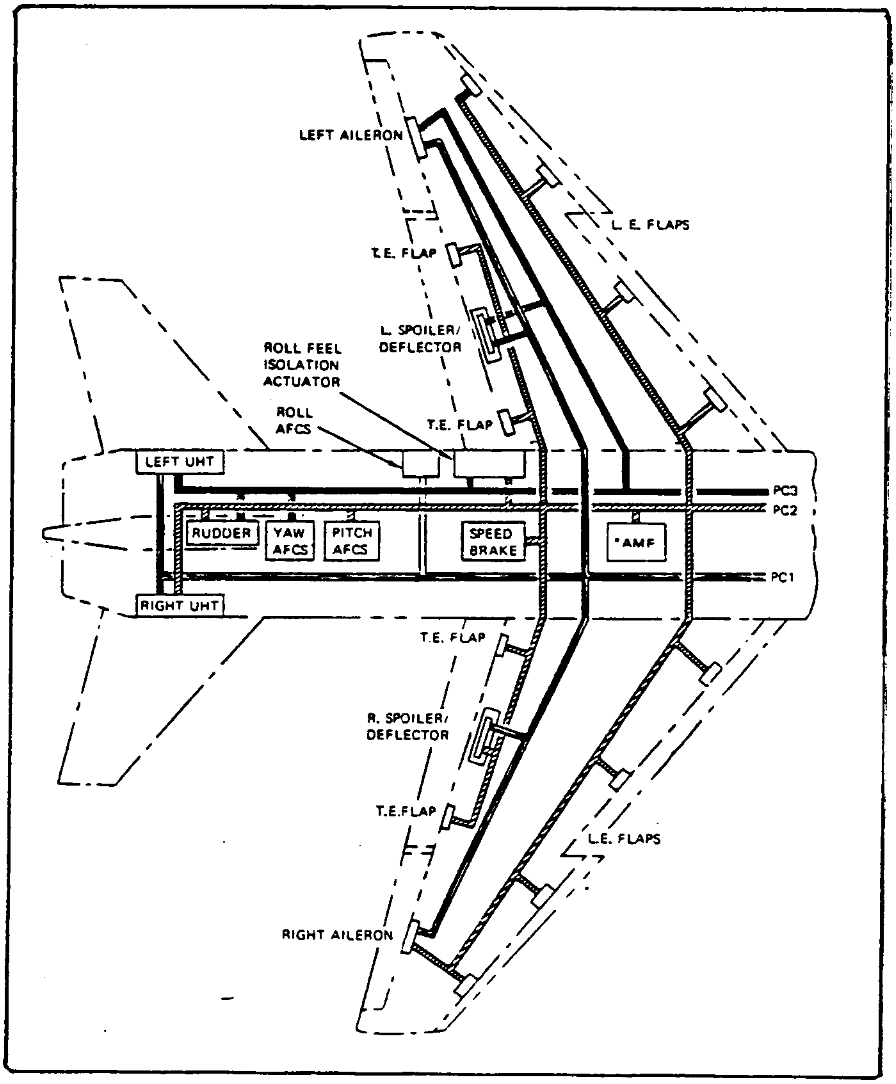


Figure 5

FLIGHT CONTROL SYSTEM HYDRAULIC POWER

APPENDIX C

TABLES

Table I

A-7E TEST EVENTS AND CONDITIONS

TEST	CONFIGURATION	ALTITUDE/AIRSPEED ENVELOPE (FT MSL/KOAS)
Flight Simulation Build up to flight testing Procedures Familiarization Weapon system	A-7E flight and weapon system trainers	-
Cockpit Evaluation Human factors Field of view Procedures Ingress/egress Systems testing INS static drift test	GR (1)	On deck/zero
Taxi Testing Line procedures Start and post-start procedures Ground handling Build up	GR and T	On deck/10
Flight Control Mechanical Characteristics With airplane power	GR and T	On deck/zero
Takeoff Flying qualities Performance Trim changes	TO	30-1,000/0-350
Climb Performance	CL	1,000-30,000/ 360-0.77 MN
Mechanical Characteristics	CL/CR	1,000-30,000 250-300
Trimmability Characteristics Long term holding Configuration changes	CL/CR/P/D/PA	500-30,000/ 125-420

Table I Continued

A-7E TEST EVENTS AND CONDITIONS

TEST	CONFIGURATION	ALTITUDE/AIRSPEED ENVELOPE (FT MSL/KOAS)
Flying Qualities Longitudinal Lateral Directional Static Dynamic Maneuvering Flight path stability	CR/P/PA	128-425/30,000, 15,000, and 5,000
Stall Characteristics Normal Accelerated Departure Power effects Stall warning Stall Post stall Recovery	CR/P/PA	105-250/20,000
Specific Excess Power (P_s)	P	170-.88 OMN/ 5,000, 7,000, 15,000 and 30,000
Range and Endurance	CR	180-.88 OMN/ 30,000 and 7,000
Descent Performance	D/G	220-250/ 30,000-6,000
Turn Performance	P	160-.88 OMN/ 30,000 and 15,000
Approach/Landing Characteristics Instrument approach FCLP Waveoff Landing pattern	PA/WO	125-145/ 5,000 to surface

Table I Continued

A-7E TEST EVENTS AND CONDITIONS

TEST	CONFIGURATION	ALTITUDE/AIRSPEED ENVELOPE (FT MSL/KOAS)
Landing Performance Braking Distance	L	135-10/surface
Maneuvering Aerobatics Pitch pointing Air-to-ground Air-to-air	CR/P	200-500/2,500-25,000
Formation Section parade Cruise Configuration changes Section approach Tanking simulation	CR/P/PA	140-400/15,000-2,500
Mission Tasks Navigation Simulated mining Simulated air-to-ground ordnance delivery SSC Simulated air-to-air tracking	CR/P	250-500/15,000-1,500

Table II

TRIM CHANGES

CONFIGURATION CHANGE	GROSS WEIGHT (LB)	ALTITUDE (FT MSL)	TRIM AIRSPEED (KOAS)	CONTROL FORCE REQUIRED AT 5 SECONDS (LB)	NOSE PITCH TENDENCY	SPECIFICATION COMPLIANCE
Takeoff Rotation	31,500	30	145 (1)	5 Pull	Down	Yes
TO to CL	31,500	500	180 (1)	7 Pull	Down	Yes
Speedbrake	26,100	5000	300	5 Pull	Down	Yes
Gear	26,100	5000	200	None	None	Yes
Flaps (2)	26,100	5000	190	5 Push 8 Pull (3)	(4)	No
Power Changes(CR) (6)	26,100	5000	300	None	None	Yes
Power Changes(PA) (6)	24,700	1500	130	2 Push 2 Pull (5)	Up Down	Yes

Notes: (1) Takeoff trim set at 5 degrees nose up, rotation to 10 degrees nose up
(2) Flaps from full up to full down
(3) 5 pounds push at 5 seconds, followed by 8 pounds pull after 5 seconds
(4) Initial nose up followed by nose down pitch after 5 seconds
(5) Power addition caused a nose pitch up, power reduction caused nose down pitch
(6) +/- 5% RPM

Table III

STALL DATA

CONFIGURATION	STALL (POWER/TYPE)	GROSS WEIGHT (LB)	STALL WARNING SPEED (KOAS)	STALL WARNING AOA (UNITS)	STALL SPEED (KOAS)	STALL AOA (UNITS)	ALTITUDE LOSS (FEET MSL)
CR	Idle/Wings Level	26,900	150	17 (1)	135	24	800
CR	85% Wings Level	26,800	145	17.5 (1)	125	25	1500
CR	85%/Accel-erated	26,600	160	20 (3)	130	25	1500
CR	85%/Accel-erated	26,500	160	20 (3)	125	25	1500
PA	Idle/Wings Level	26,350	105	20.5 (2)	95	25	- (4)
PA	85%/Accel-erated	26,200	125	20.5 (2)	110	24	150

Notes:
(1) Moderate buffet
(2) Rudder pedal shaker
(3) Heavy airframe buffet
(4) Recovery delayed due to OIL pressure caution light illumination

APPENDIX D

CURVES

Model: TA-7C Airplane
Configuration: Ground
Power: Airplane

Number: 154379
UHT Trim: 5 degree nose up
Method: Control Sweep

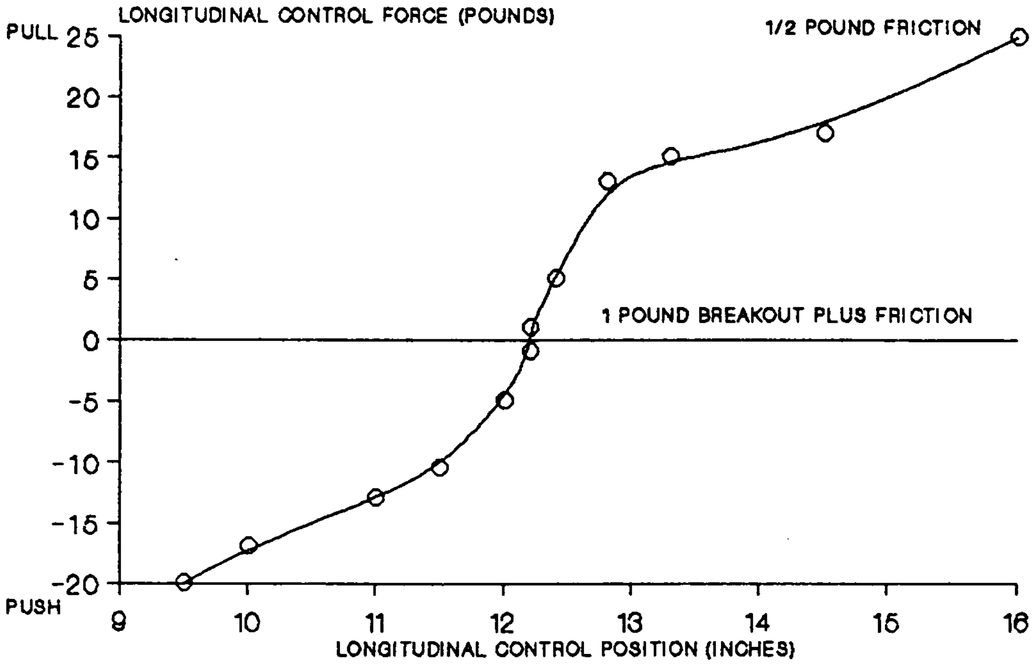


Figure 1

LONGITUDINAL CONTROL FORCE VERSUS DISPLACEMENT

Model: TA-7C Airplane
Configuration: Ground
Power: Airplane

Number: 154379
Aileron/Rudder Trim: Zero
Method: Control Sweep

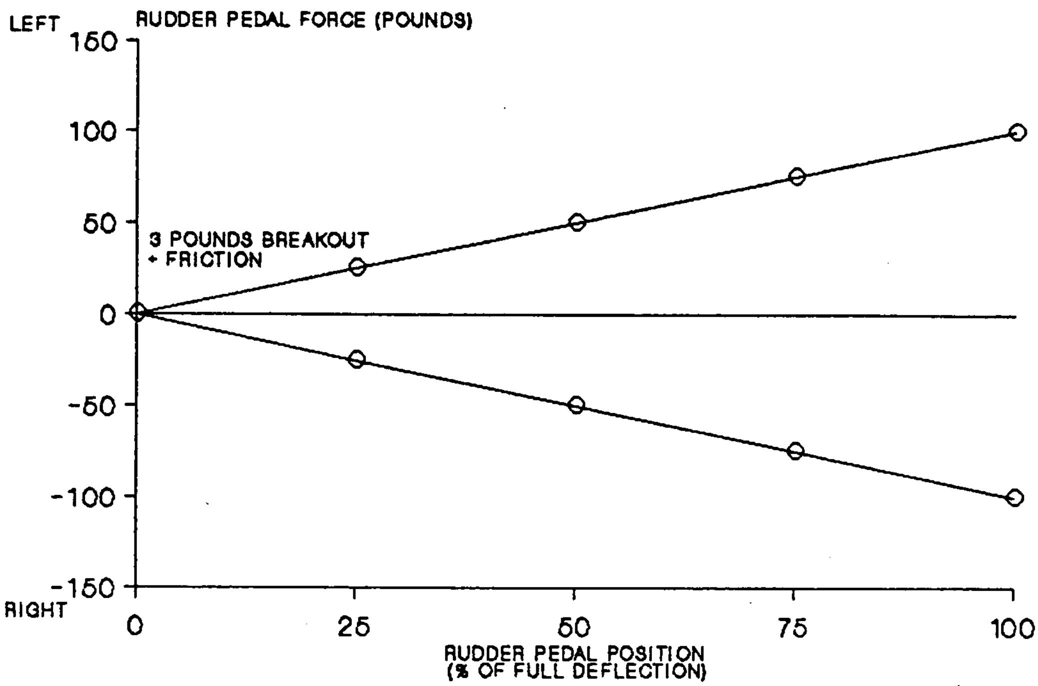


Figure 2

RUDDER PEDAL FORCE VERSUS DISPLACEMENT

Model: TA-7C
Configuration: Ground
Power: Airplane

Number: 154379
Aileron/Rudder Trim: Zero
Method: Control Sweep

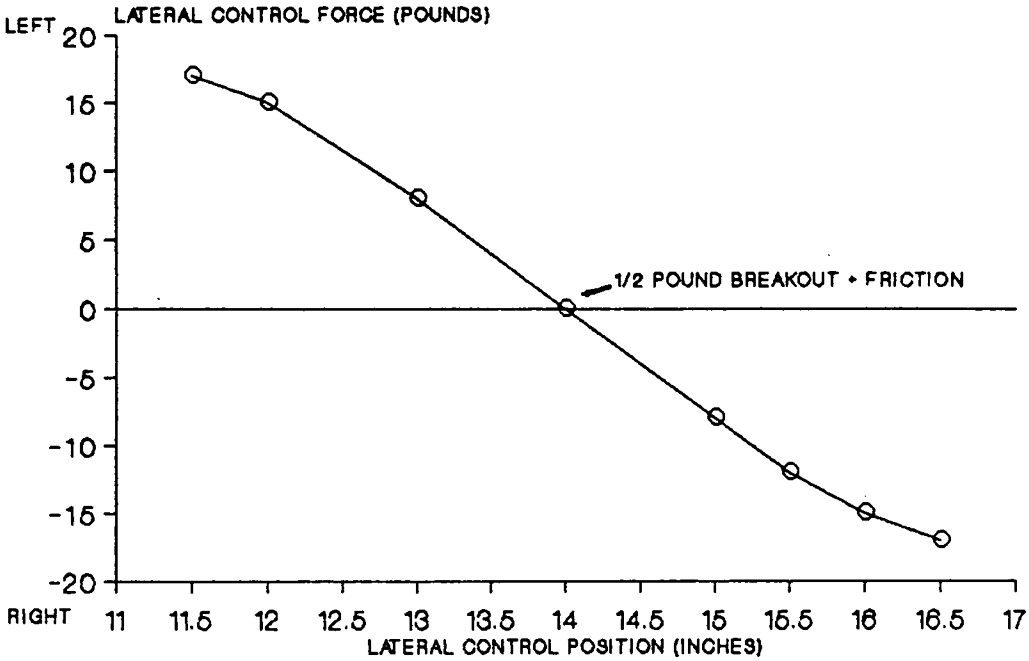


Figure 3

LATERAL CONTROL FORCE VERSUS DISPLACEMENT

Model: TA-7C Airplane	Number: 154379
Configuration: Cruise	UHT Trim: 5 degrees nose up
Altitude: 15,000 ft MSL	Gross Weight: 27,300 lb
Trim Speed: 350 KOAS	Method: Stable Point

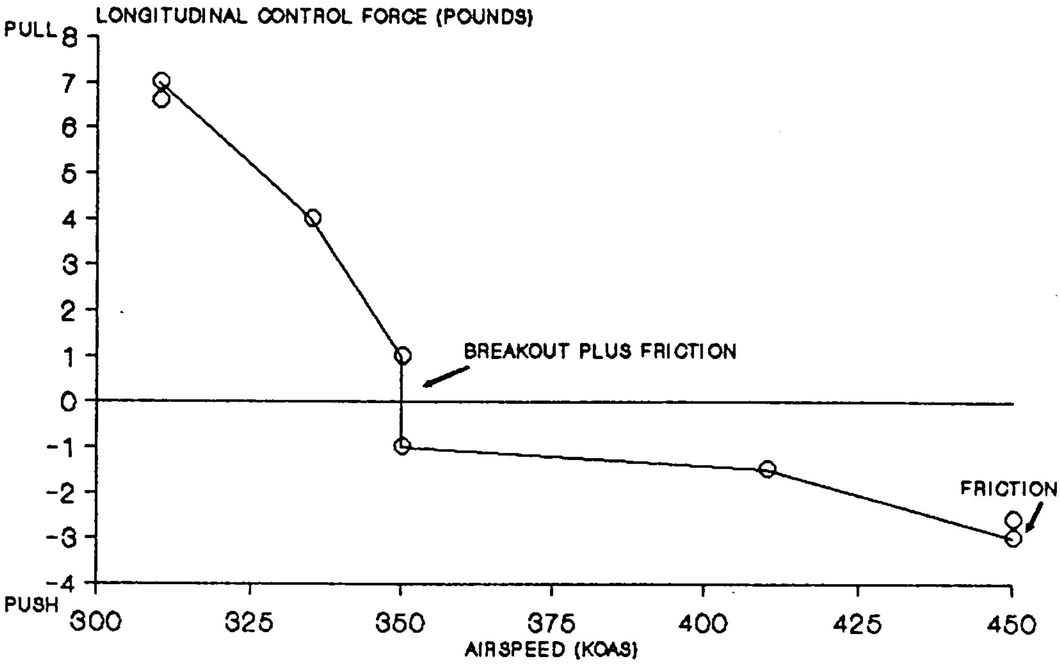


Figure 4

CRUISE STATIC LONGITUDINAL STABILITY

Model: TA-7C Airplane
Configuration: PA
Altitude: 5000 ft MSL
Trim Speed: 17.5 Units AOA, 128 KOAS

Number: 154379
UHT Trim: 8 degrees nose up
Gross Weight: 25,700 lb
Method: Stable Point

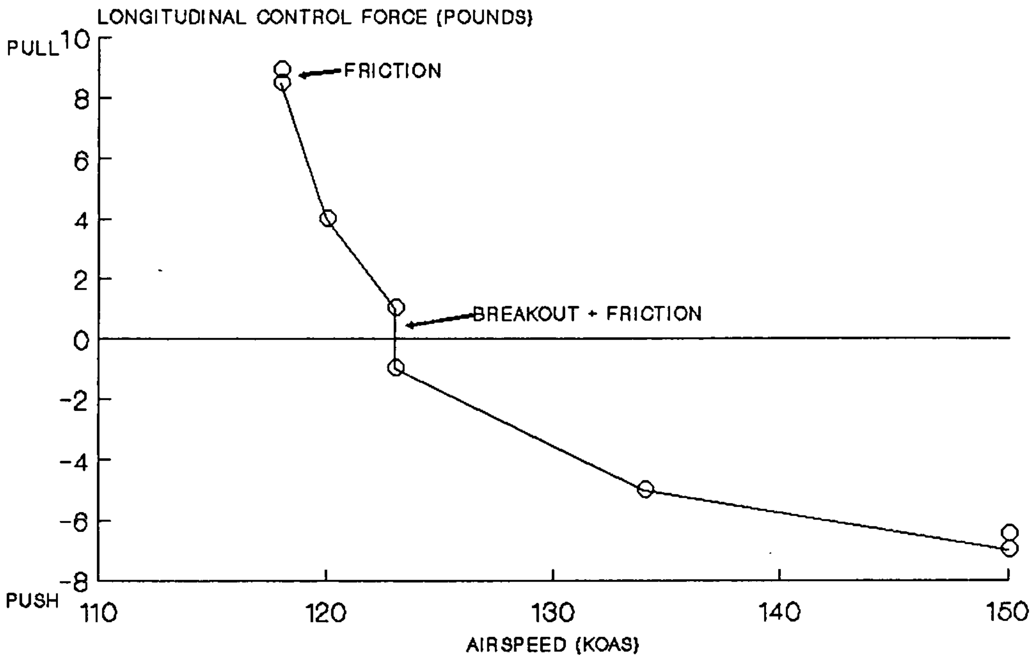


Figure 5

POWER APPROACH STATIC LONGITUDINAL STABILITY

Model: TA-7C Airplane
Configuration: PA
Altitude: 5000 ft MSL
Trim Speed: 17.5 Units AOA, 128 KOAS

Number: 154379
UHT Trim: 8 degrees nose up
Gross Weight: 25,700 lb
Method: Stable Point

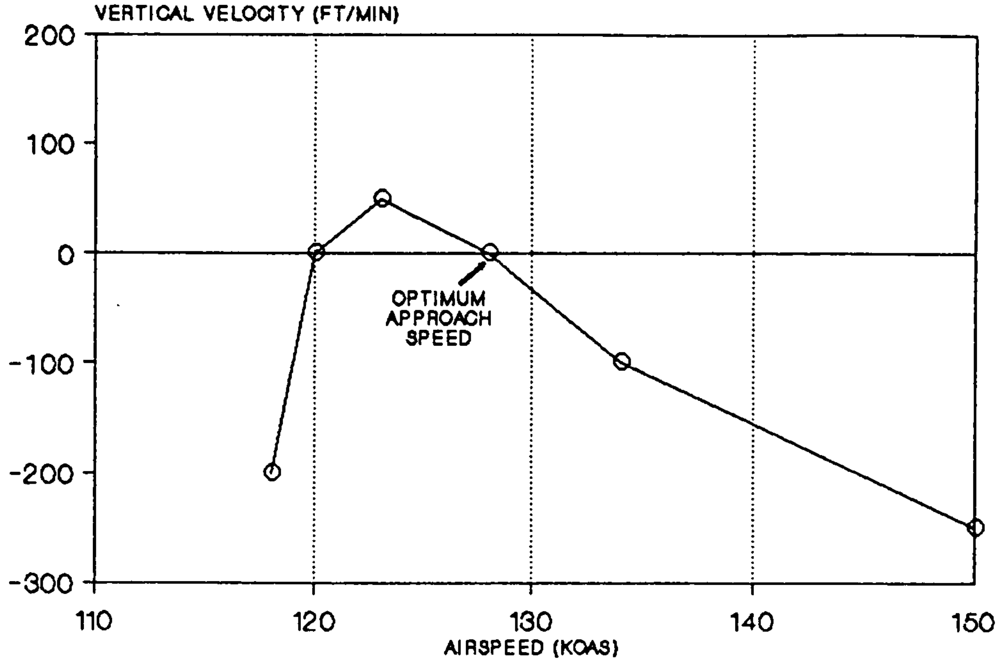


Figure 6

VERTICAL VELOCITY VERSUS AIRSPEED
FLIGHT PATH STABILITY

Model: TA-7C Airplane
Configuration: PA
Altitude: 5000 ft MSL
Trim Speed: 17.5 Units AOA, 118 KOAS

Number: 154379
UHT Trim: 8 degrees nose up
Gross Weight: 25,700 lb
Method: Stable Point

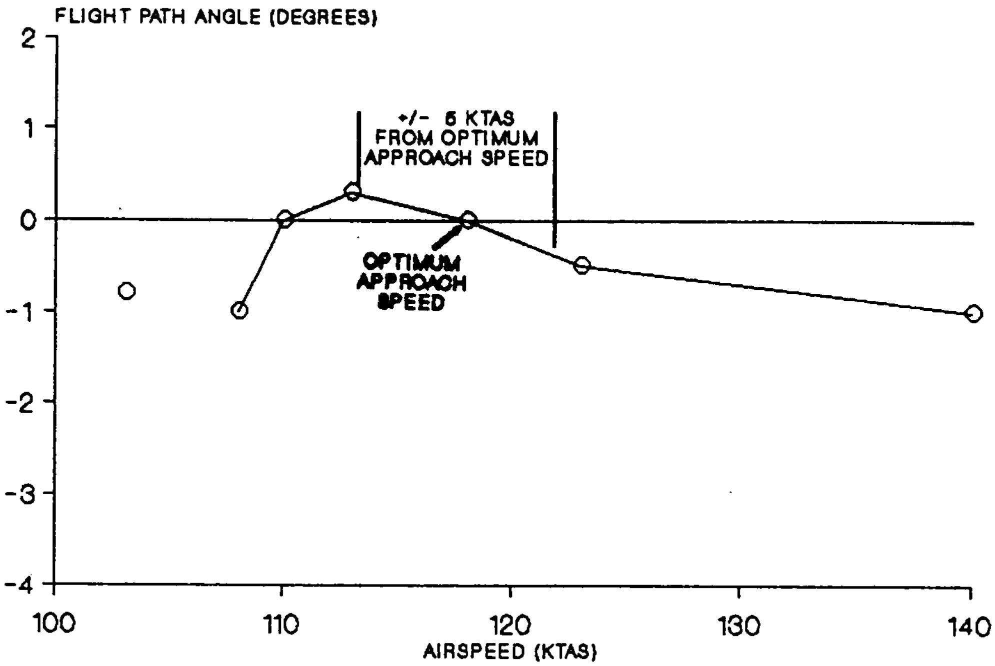


Figure 7

FLIGHT PATH ANGLE VERSUS AIRSPEED

Model: TA-7C
Configuration: CR
Altitude: 30,000 ft MSL
Trim Speed: 230 KOAS

Number: 154379
UHT Trim: 6 degrees nose up
Gross Weight: 26,500 lb
Method: 15 KOAS slow entry, controls free

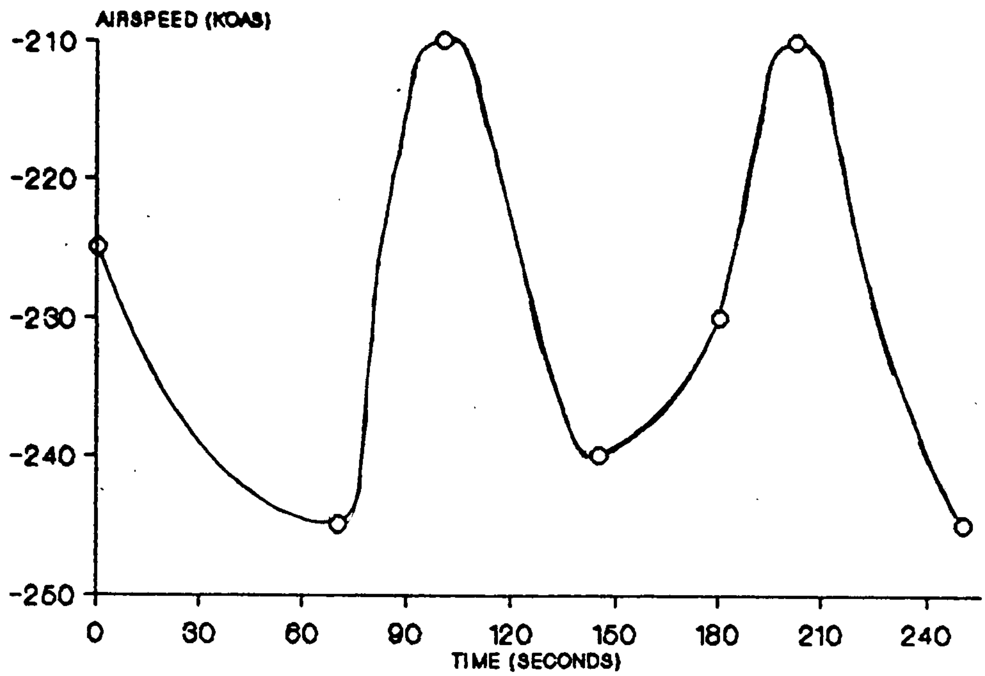


Figure 8

CRUISE PHUGOID

Model: TA-7C Airplane Number: 154379
Configuration: PA UHT Trim: 8 degrees nose up
Trim Speed: 17.5 Units AOA, 128 KOAS Method: 5 KOAS slow entry, controls free

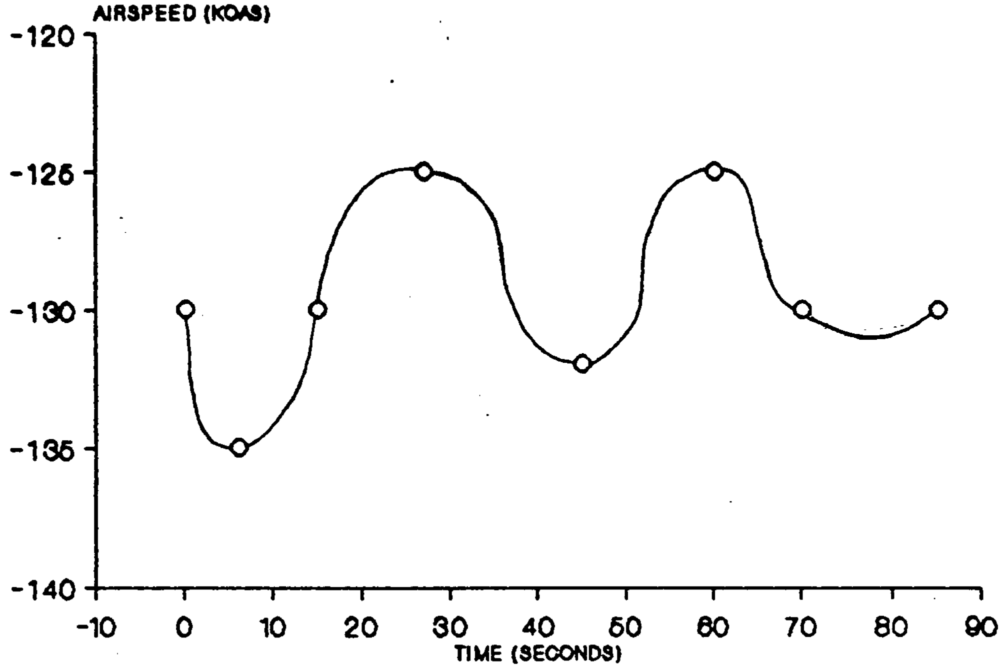


Figure 9

POWER APPROACH PHUGOID

Model: TA-7C
Configuration: Power
Altitude: 15,000 ft MSL
Trim Speed: 350 KOAS

Number: 154379
UHT Trim: 5 degrees nose up
Gross Weight: 27,900 lb

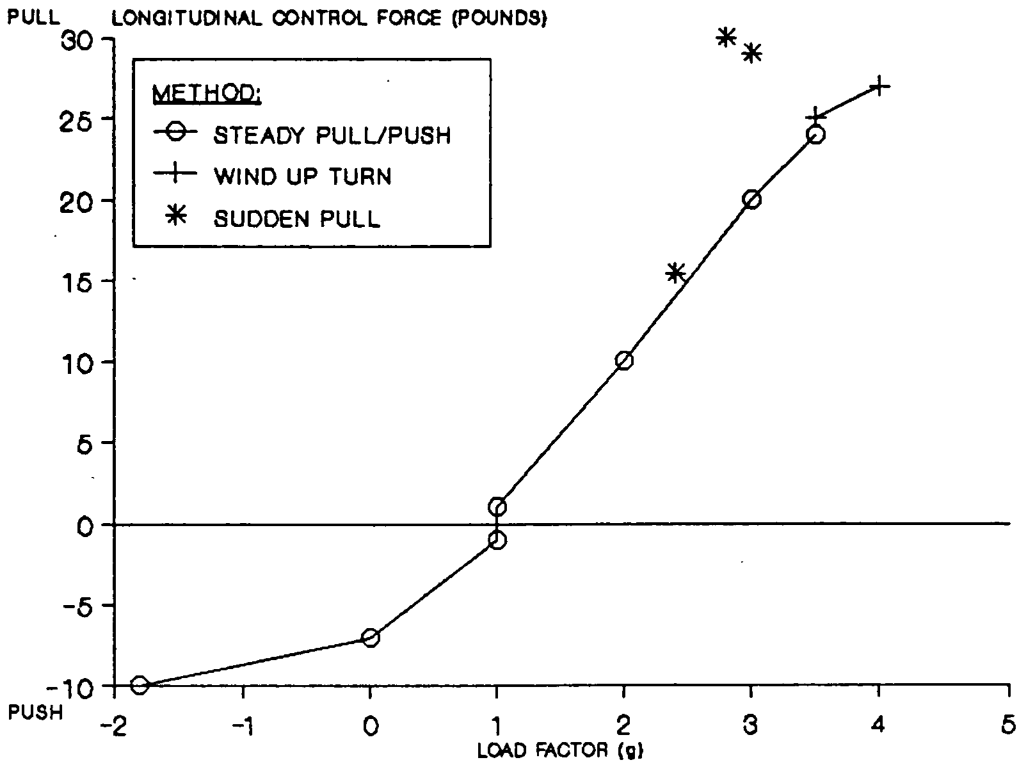


Figure 10

LONGITUDINAL MANEUVERING STABILITY

Model: TA-7C
Configuration: Power
Altitude: 15,000 ft MSL
Trim Speed: 350 KOAS

Number: 154379
UHT Trim: 5 degrees nose up
Gross Weight: 27,900 lb

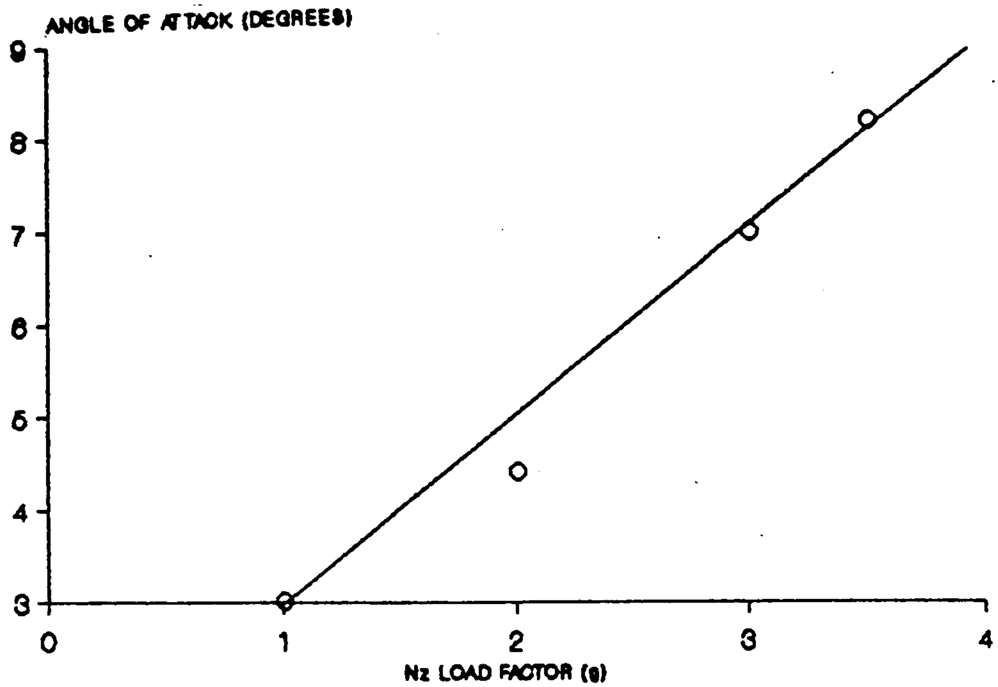


Figure 11

Nz VERSUS ALPHA

Model: TA-7C
Configuration: Power
Altitude: 15,000 ft MSL
Trim Speed: 350 KOAS

Number: 154379
UHT Trim: 5 degrees nose down
Gross Weight: 27,900 lb

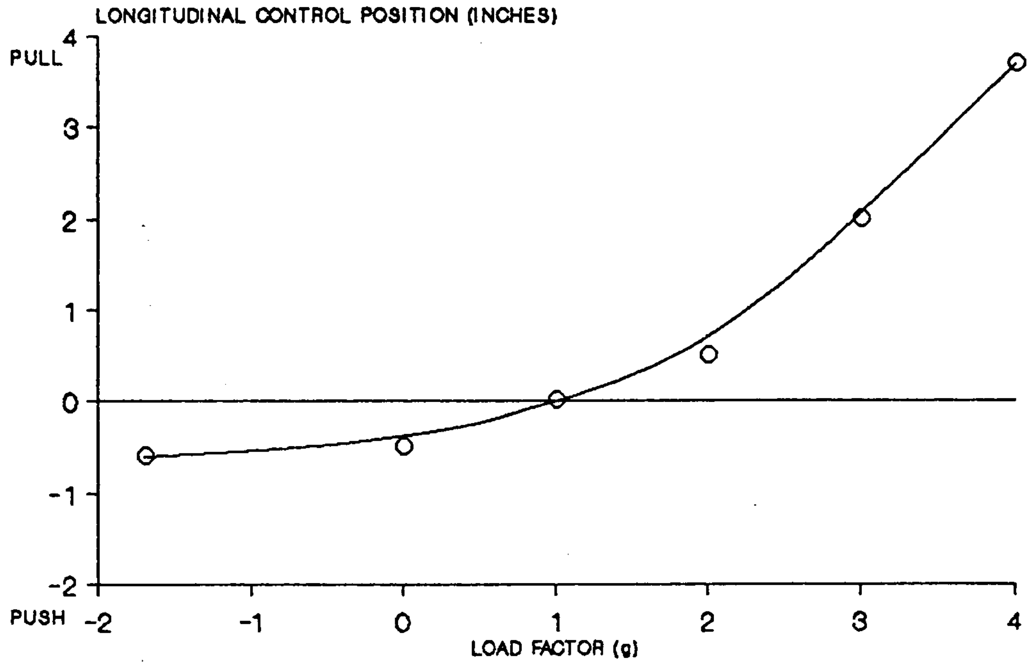


Figure 12

Nz VERSUS LONGITUDINAL CONTROL DISPLACEMENT

Model: TA-7C Airplane
Configuration: Power
Altitude: 15,000 ft MSL
Trim Speed: 350 KOAS

Number: 154379
UHT Trim: 5 degrees nose up
Gross Weight: 27,900 lb

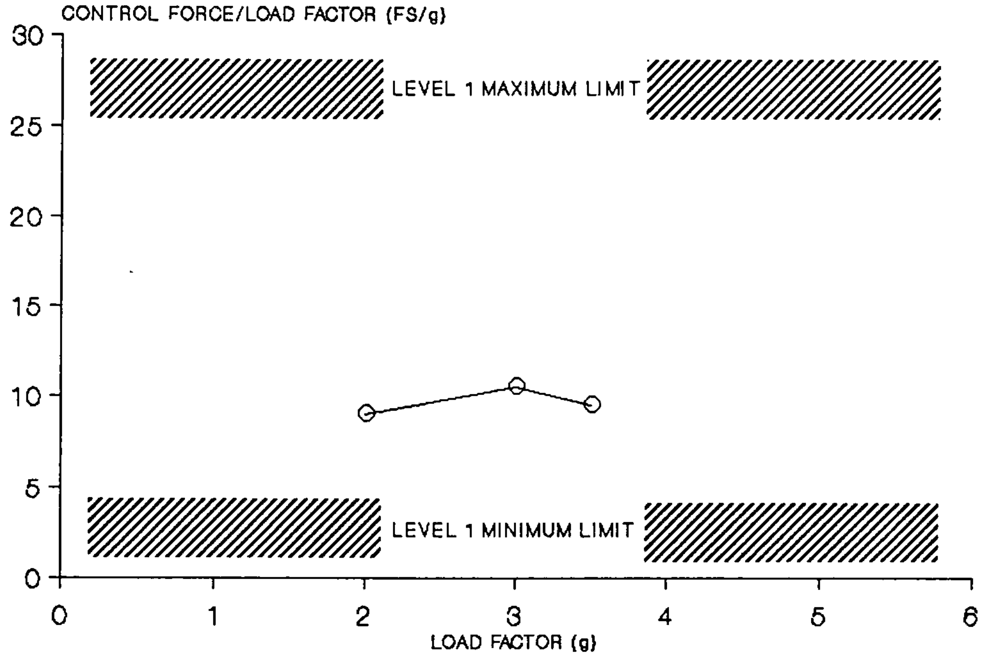


Figure 13

CONTROL FORCES IN MANEUVERING FLIGHT

Model: TA-7C Airplane
Configuration: PA
Altitude: 5000 ft MSL
Trim Speed: 145 KOAS

Number: 154379
UHT Trim: 7 degrees nose up
Gross Weight: 24,200 lb
Method: Steady and Sudden Pull

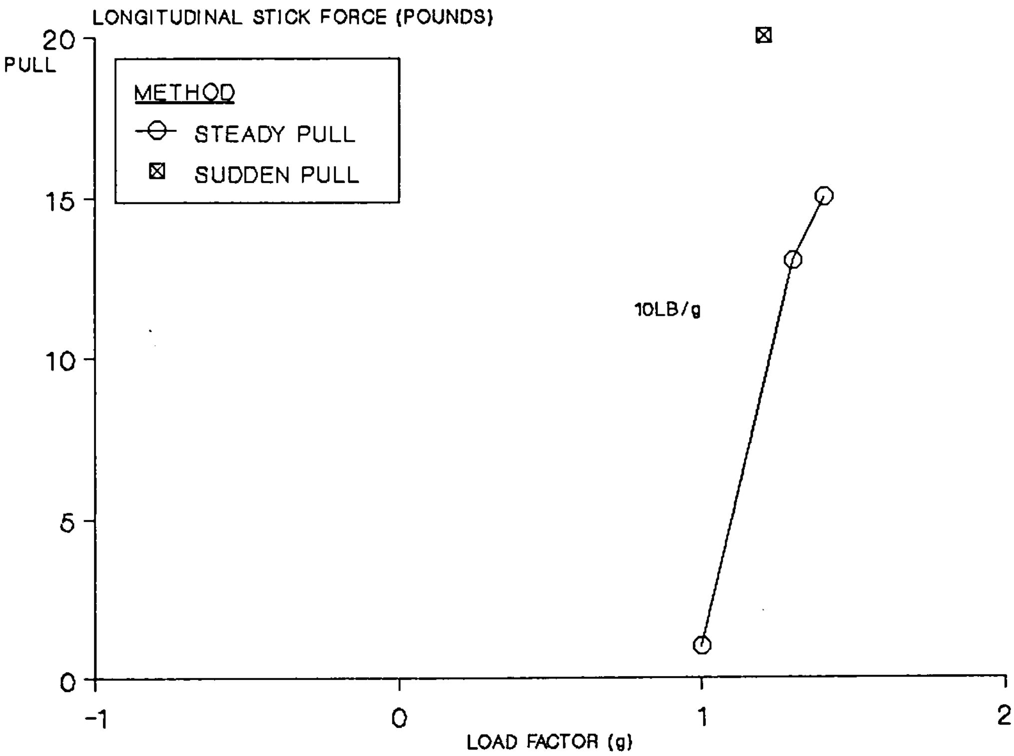


Figure 14

POWER APPROACH LONGITUDINAL
MANEUVERING STABILITY

Model: TA-7C
Configuration: Cruise
Altitude: 15,000 ft MSL
Trim Speed: 350 KOAS

Number: 154379
UHT Trim: 5 degrees nose up
Rudder/Aileron Trim: Zero
Gross Weight: 26,900 lb

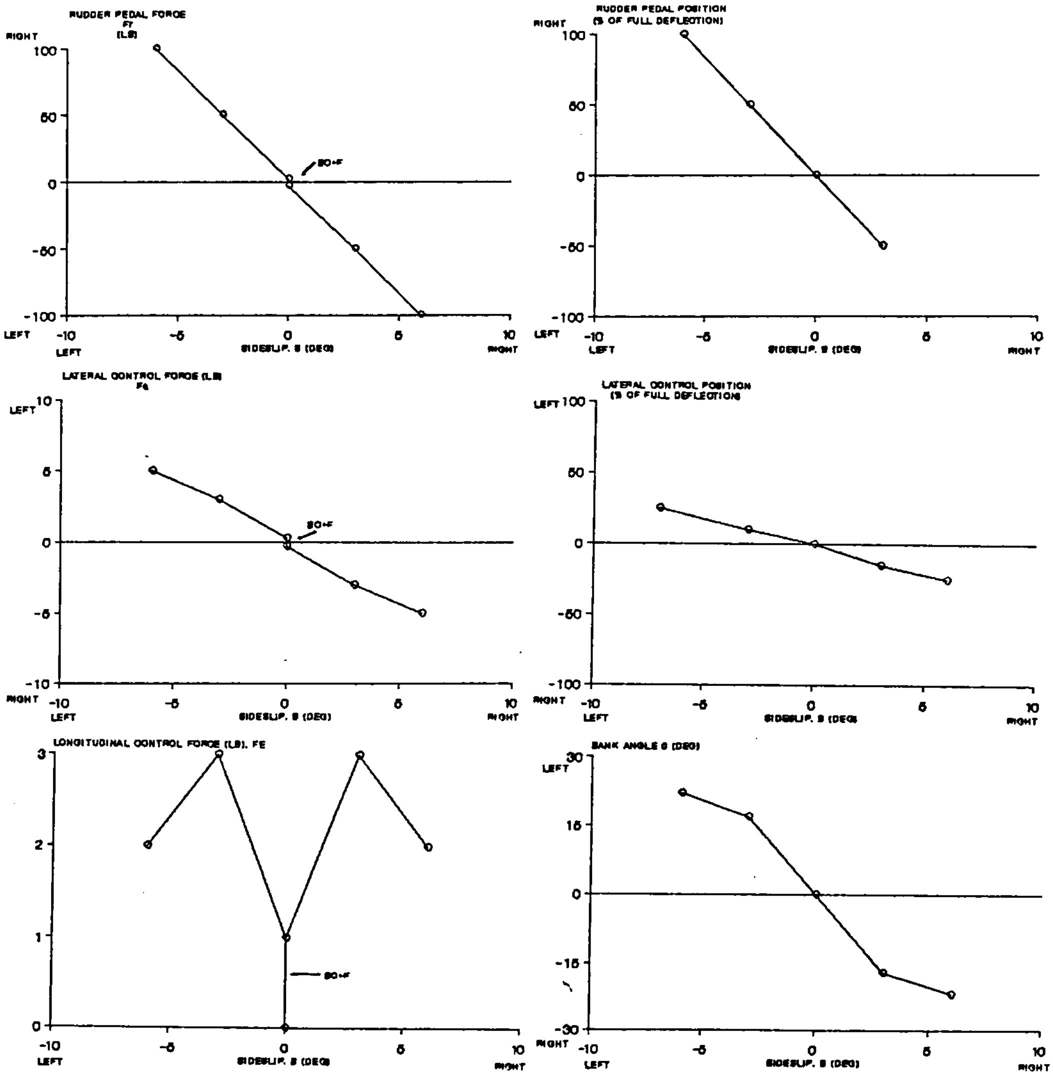


Figure 15

CRUISE LATERAL-DIRECTIONAL STABILITY

Model: TA-7C
Configuration: PA
Altitude: 5000 ft MSL
Trim Speed: 145 KOAS

Number: 154379
UHT Trim: 8 degrees nose up
Aileron/Rudder Trim: Zero
Gross Weight: 25,700 lb

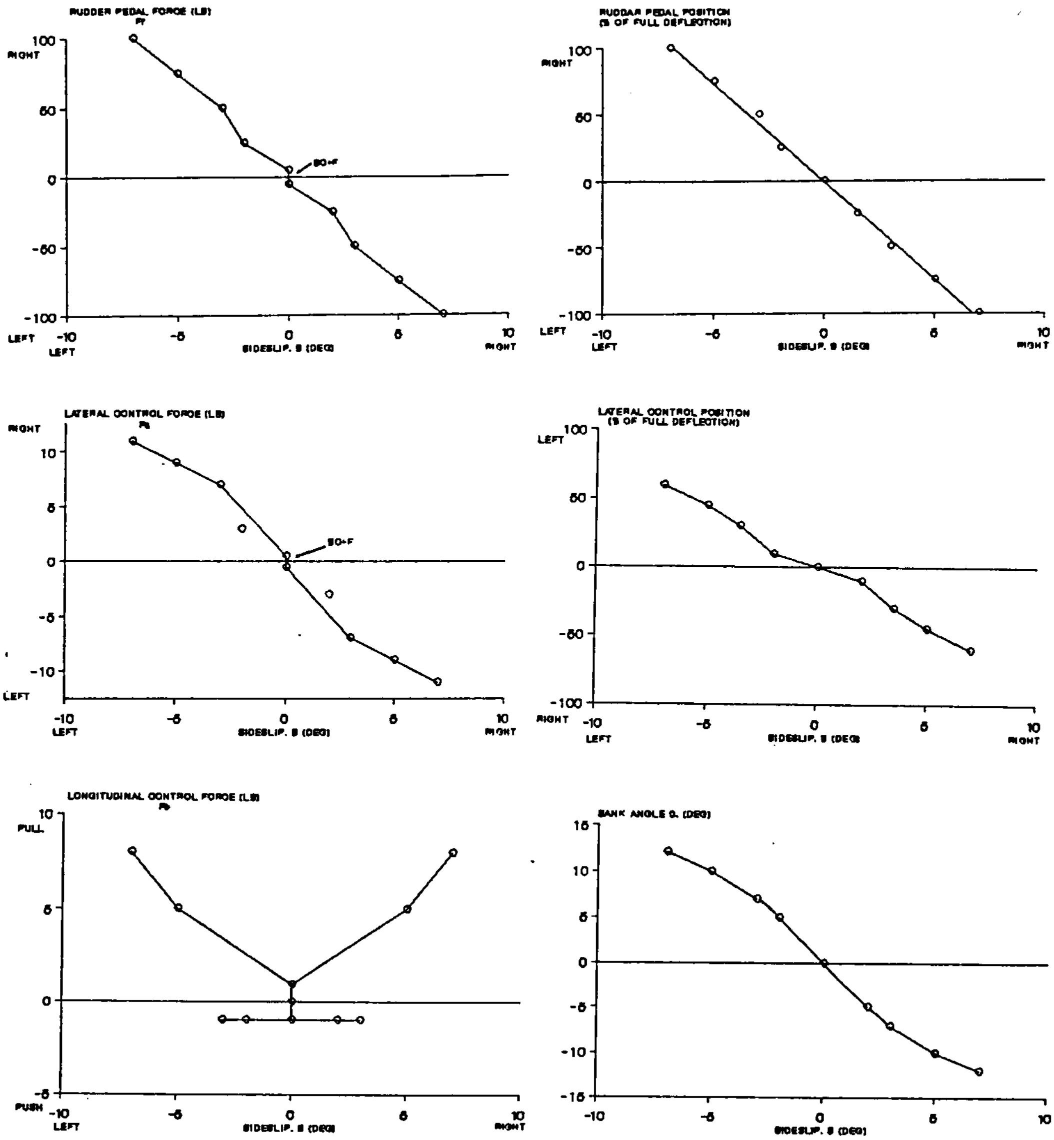


Figure 16

POWER APPROACH LATERAL-DIRECTIONAL STABILITY

Model: TA-7C	Number: 154379
Configuration: PA	UHT Trim: 8 degrees nose up
Altitude: 5000 ft MSL	Aileron/Rudder Trim: Zero
Trim Speed: 145 KOAS	Gross Weight: 25,700 lb

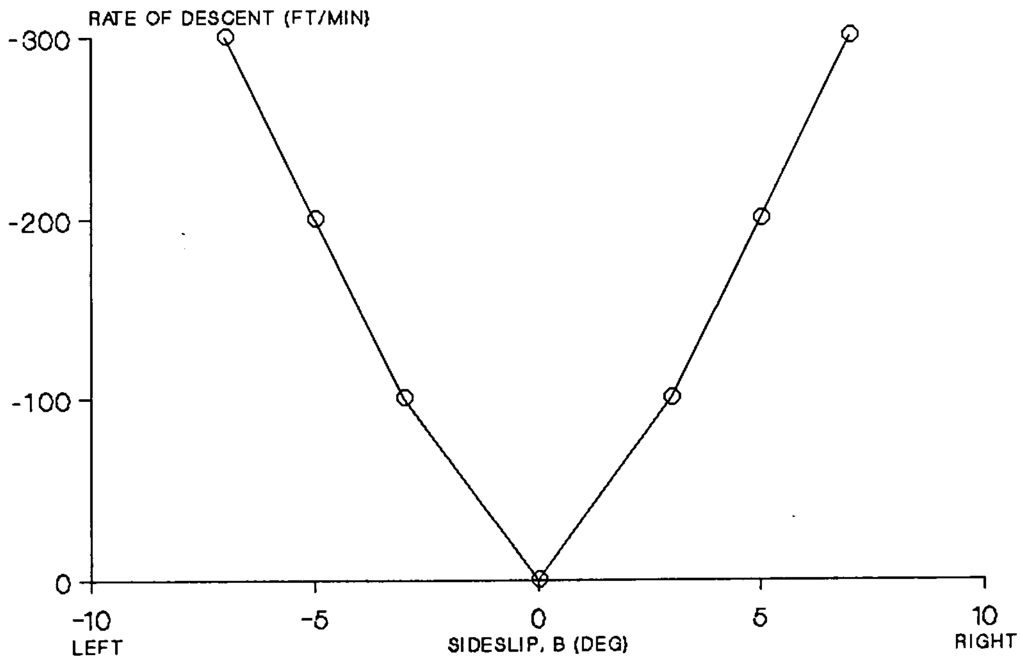


Figure 17

DESCENT RATE VERSUS SIDESLIP

Model: TA-7C
Configuration: Cruise
Trim Speeds: 420, 350, 250 KOAS

Number: 154379
Gross Weight: 28,800-25,900 lb
Method: Full Deflection Aileron Rolls, Step Input

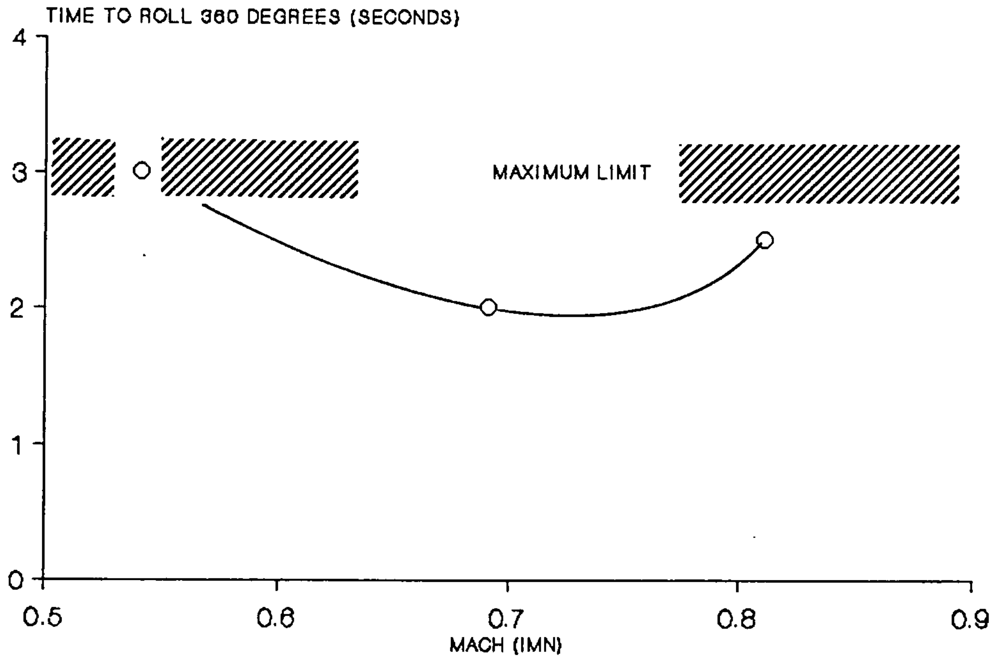


Figure 18

TIME TO ROLL 360 DEGREES VERSUS IMN

Model: TA-7C
Configuration: CR
Altitude: 15,000 ft MSL
Trim Speeds: 420, 350, 250 KOAS

Number: 154379
Gross Weight: 28,800-25,900 lb
Method: Full Deflection Aileron Rolls Step Input

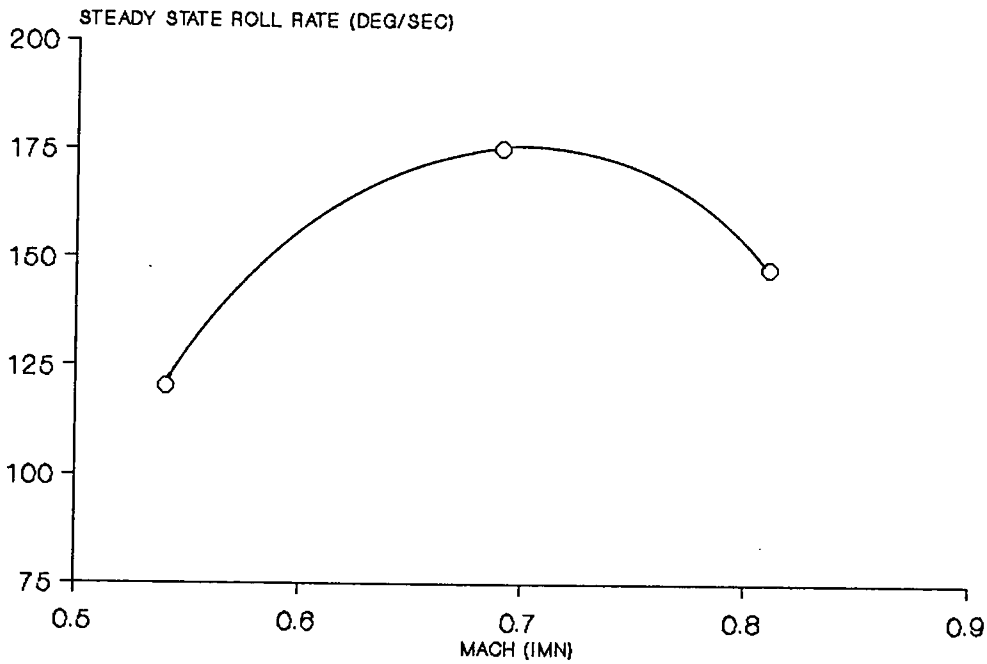


Figure 19

STEADY STATE ROLL RATE VERSUS IMN

Model: TA-7C
Configuration: Cruise
Altitude: 30,000 ft MSL
OAT: - 39 degrees C

Number: 154379
Gross Weight: 27,900 lb
Method: Stable Point

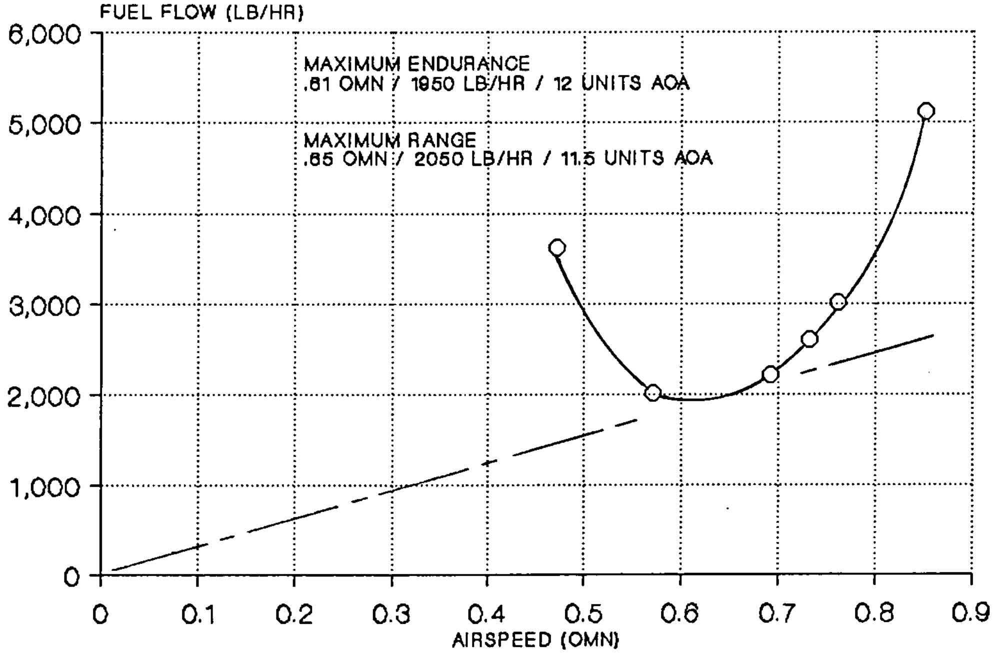


Figure 20

30,000 FT MSL RANGE AND ENDURANCE

Model: TA-7C
Configuration: Cruise
Altitude: 7000 ft MSL
OAT: + 2 degrees C

Number: 154379
Gross Weight: 27,300 lb
Method: Stable Point

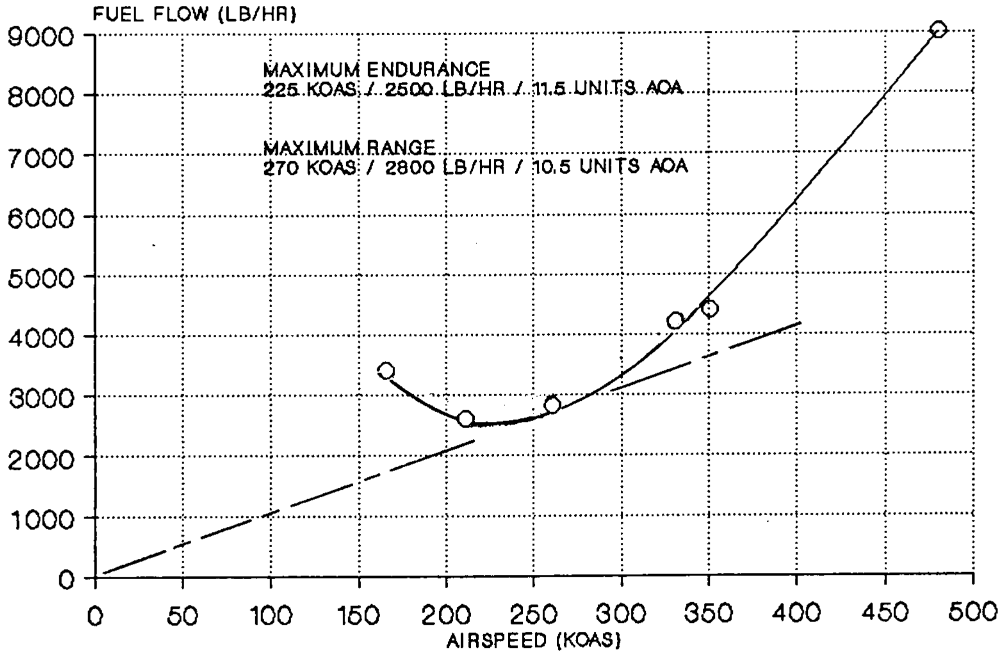


Figure 21

7000 FT MSL RANGE AND ENDURANCE

Model: TA-7C
Configuration: Power
Gross Weight: 30,000 lb
Engine: TF-41

Number: 154379
Standard Day Reference
Method: Level Acceleration
Fuel: JP-5

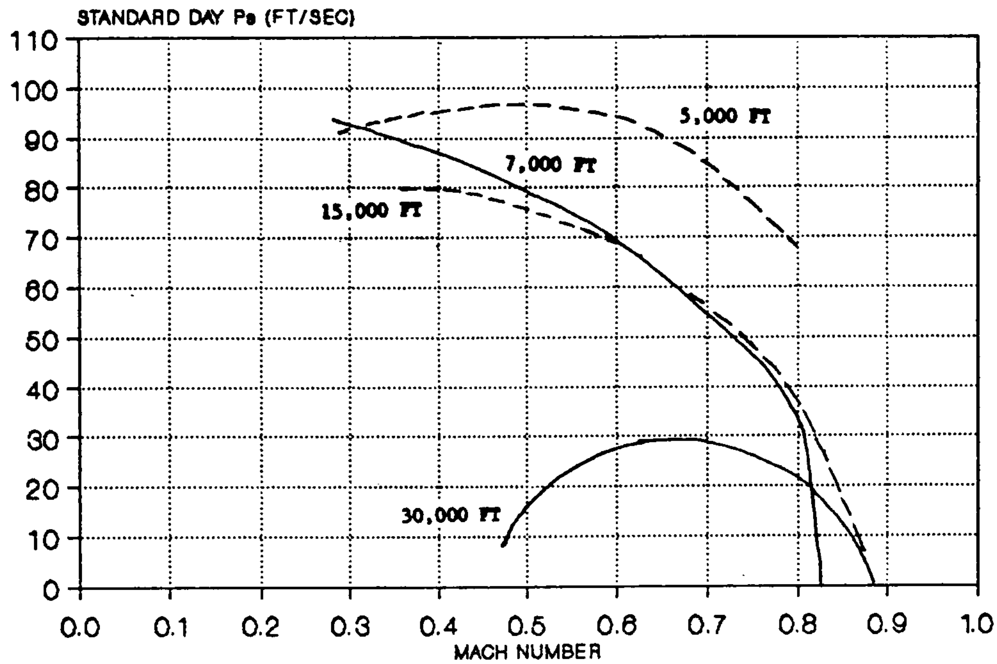


Figure 22

STANDARD DAY Ps VERSUS MACH
SPECIFIC EXCESS POWER

Model: TA-7C
Configuration: Power
Altitude: 15,000 ft MSL
AMF: Inoperative
Gross Weight: 30,000 lb

Number: 154379
Standard Day
▬ = Limit Buffet/Lift Limit
ıııııı = Structural/Airspeed Limit
—— = Sustained Turn Performance

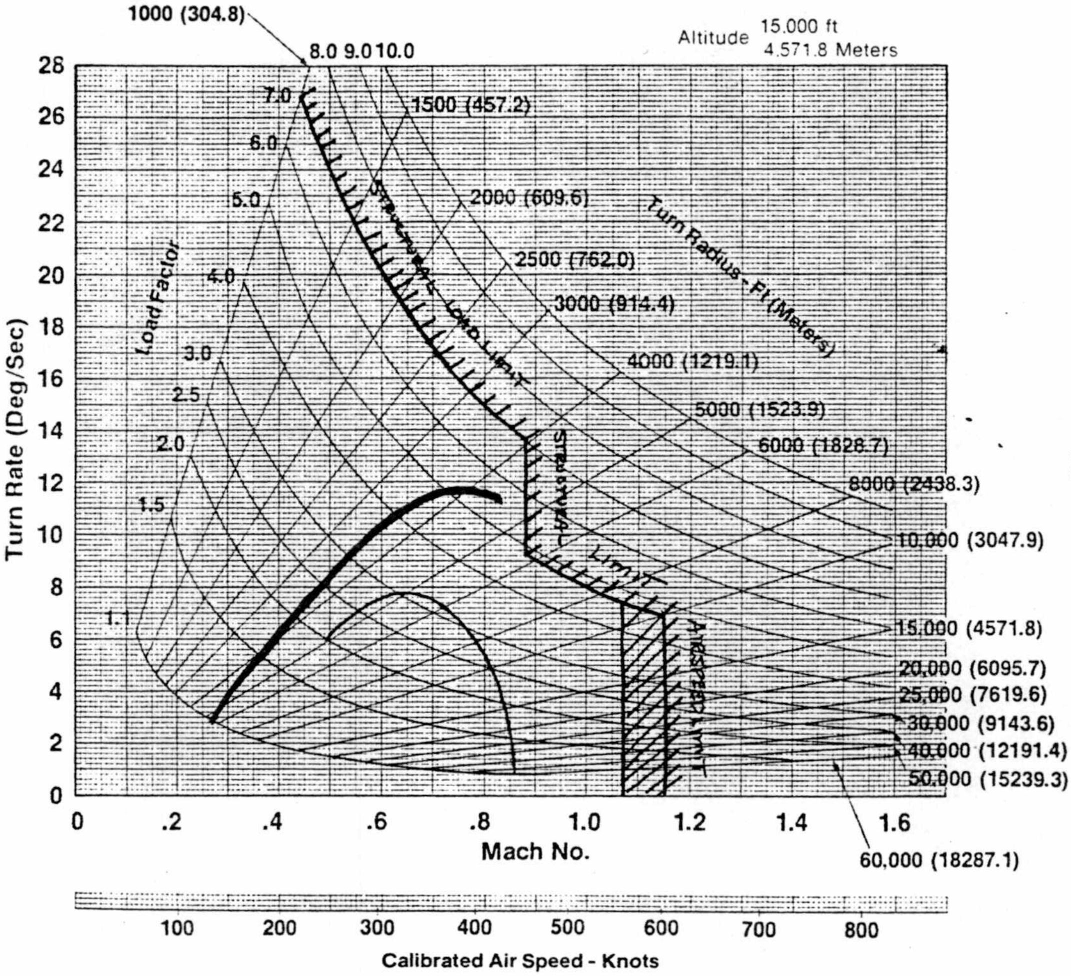


Figure 23

TURN PERFORMANCE

Model: TA-7C
Configuration: Power
Standard Day
Wing Area: 375 SQ FT
Aspect Ratio: 4
Altitude: ft MSL

Number: 154379
Gross Weight: 30,000 lb
Engine: TF-41-A2
Method: Predicted Nz from Ps
Program: USNTPS Fixed Wing
------ = Predicted
▬▬▬ = Test Data

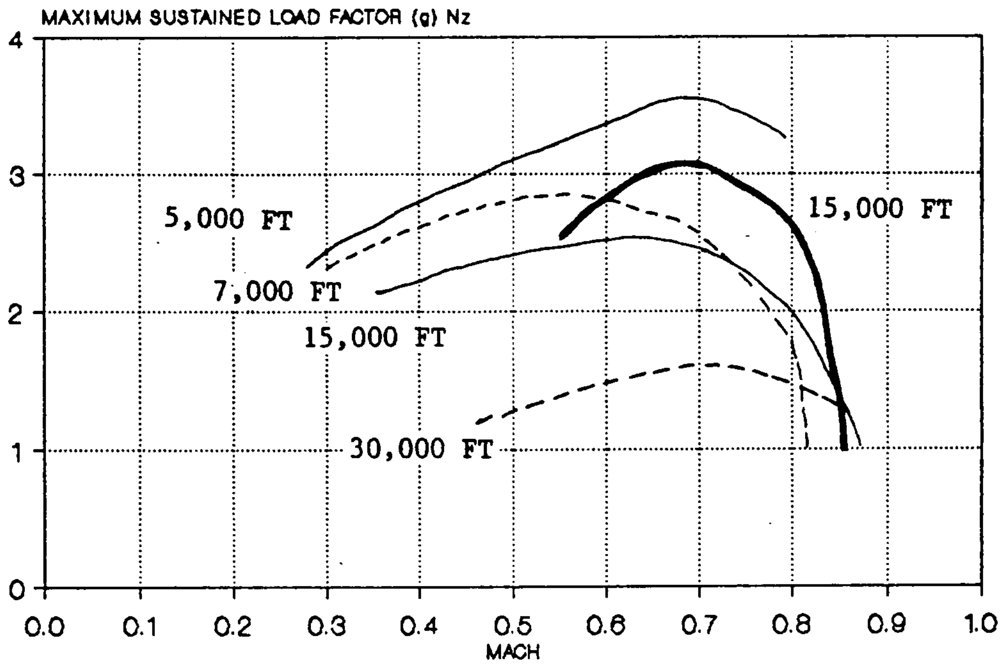


Figure 24

SUSTAINED LOAD FACTORS

Model: TA-7C
Configuration: Power
Gross Weight: 30,000 lb
Standard Day

Number: 154379
Altitude: 15,000 ft MSL
Method: Stable Point

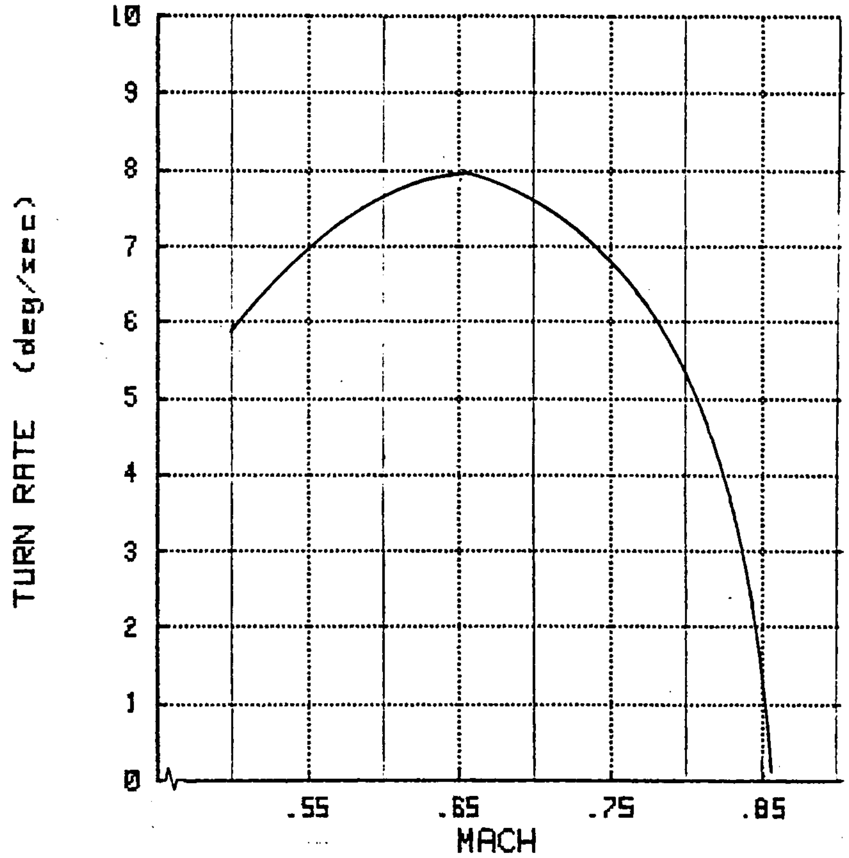


Figure 25

MAXIMUM SUSTAINED TURN RATE

Model: TA-7C
Configuration: Power
Gross Weight: 30,000 lb
Standard Day

Number: 154379
Altitude: 15,000 ft MSL
Method: Stable Point

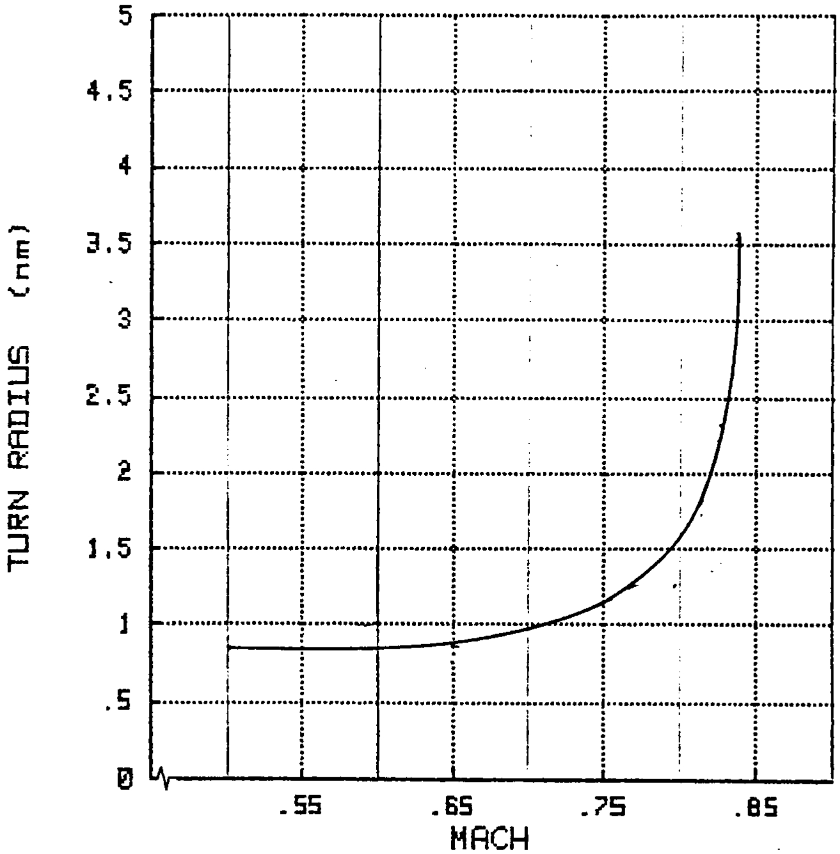


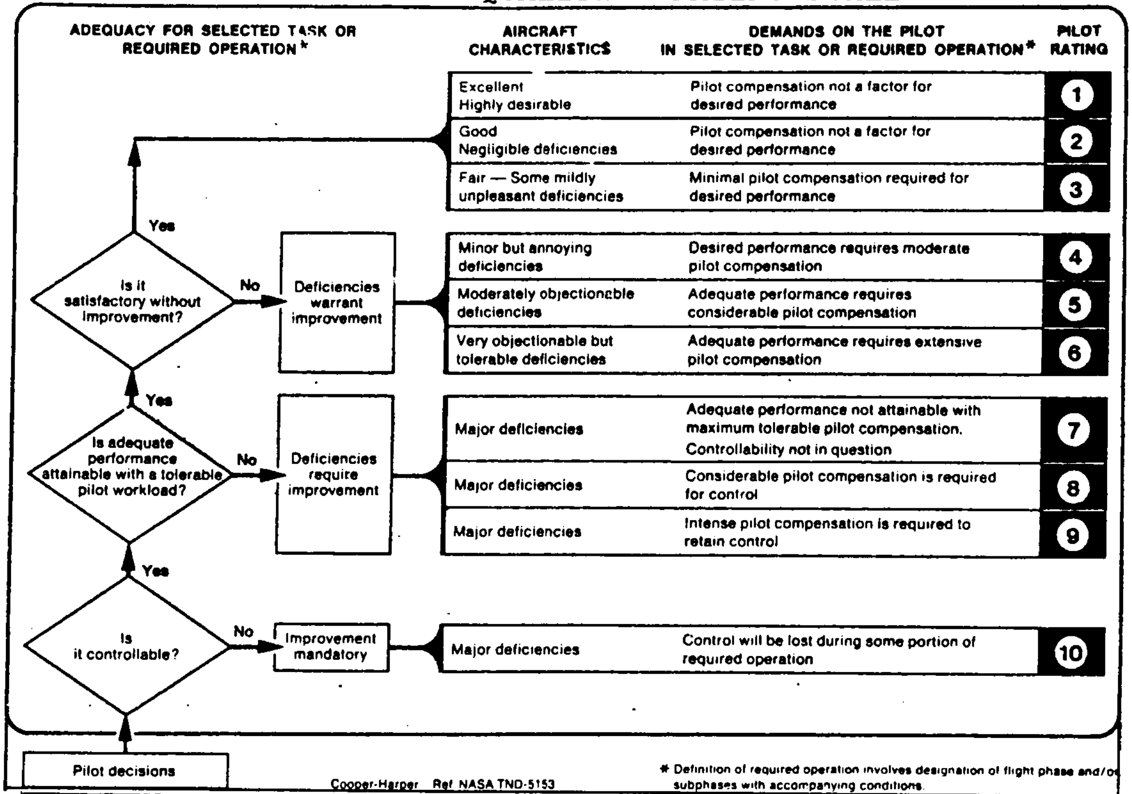
Figure 26

MAXIMUM SUSTAINED TURN RADIUS

APPENDIX E

HANDLING QUALITIES RATING SCALE

HANDLING QUALITIES RATING SCALE



DEFINITIONS FROM TN-D-5153

COMPENSATION

The measure of additional pilot effort and attention required to maintain a given level of performance in the face of deficient vehicle characteristics.

HANDLING QUALITIES

Those qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to perform the tasks required in support of an aircraft role.

MISSION

The composite of pilot-vehicle functions that must be performed to fulfill operational requirements. May be specified for a role, complete flight, flight phase, or flight subphase.

PERFORMANCE

The precision of control with respect to aircraft movement that a pilot is able to achieve in performing a task. (Pilot-vehicle performance is a measure of handling performance. Pilot performance is a measure of the manner or efficiency with which a pilot moves the principal controls in performing a task.)

ROLE

The function or purpose that defines the primary use of an aircraft.

TASK

The actual work assigned a pilot to be performed in completion of or as representative of a designated flight segment.

WORKLOAD

The integrated physical and mental effort required to perform a specified piloting task.

COOPER-HARPER RATING SCALE

APPENDIX F

DEFINITION OF DEFICIENCIES

DEFINITION OF DEFICIENCIES

Part I indicates 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 missions.

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.

Part II indicates a deficiency of lesser severity than a Part I 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 effectivenss, maintainability, or safety of the aircraft.

Part III indicates a deficiency that appears too impractical or costly to correct in this model but which should be avoided in future designs. Included are violations of specifications for use by the contract negotiator in final settlement of the contract.

VITA

VITA

Lieutenant Charles E. Smith was born in Newark, New Jersey on July 25, 1957. He attended Piscataway High School in Piscataway, New Jersey, where he graduated in 1975. He received a Bachelor of Science Degree in Civil Engineering from the Virginia Military Institute in May 1979.

Upon graduation he was commissioned an Ensign in the United States Navy with orders to report for flight training where he was subsequently selected for jet training. On March 6, 1981 he received his pilots wings and designation as a Naval Aviator. Following four years of sea duty deployed aboard the USS Forrestal and USS Saratoga, he was selected to attend the United States Naval Test Pilot School where he graduated in December of 1986. Assigned to the Naval Air Test Center as a project officer and test pilot, he completed thirty months of flight test work in the areas of flying qualities and performance, carrier suitability, ordnance seperation and delivery, aerial refueling, mission systems/avionics integration, and survivability/vunerability analysis. He enrolled in The Graduate School of the University of Tennessee, Knoxville, in September of 1987.

The author has accumulated over 2,500 hours and 200 carrier landings with first pilot experence in 31 different aircraft. He will return to operational duty with a fleet squadron and continue in his naval career.