AIR FORCE FLIGHT TEST CENTER
EDWARDS AIR FORCE BASE CALIFORNIA
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE

REVISED FLIGHT TEST PROGRAM FOR EVALUATION OF THE ROCKET AUGMENTED NF-104A AEROSPACE TRAINER

FLIGHT TEST ENGINEERING DIVISION
PERFORMANCE ENGINEERING BRANCH
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INTRODUCTION

A limited flight test program is to be conducted on NF-104A, S/N 560-760 at the Air Force Flight Test Center (AFFTC), Edwards Air Force Base, California. In the event this aircraft is not available, one of the two airplanes that will be delivered to the Aerospace Research Pilot School (FTT) serial numbers 560-756 and 560-762, will be used by the Directorate of Flight Test (FTF) for flight testing. The Lockheed-California Company's testing, consisting primarily of high speed directional stability parameter determination along with system development, will be closely monitored. Tests preceding high altitude testing will be limited to the minimum necessary to supplement and confirm contractor data. Insofar as is possible, data will be collected during energy management flights to insure maximum data for operational safety and planning in the high altitude region.

TEST OBJECTIVES

The objectives to be gained through the FTF flight testing are as follows:

1. Compilation of safe operating procedures, including normal and emergency methods for operation of all systems peculiar to the NF-104A.

2. Determination of the safe flight regime to include:

a. Directional stability parameter (C_{n_B}) vs Mach number (angle of attack or load factor as a parameter).

b. Maximum safe angle of attack at the apogee.

c. Aerodynamic and Reaction Control System (RCS) damping requirements throughout the flight envelope.

d. Maximum safe re-entry angle of attack.

3. Determination of the optimum flight envelope parameters (entry load factor, climb angle, angle of attack, etc) within safe limits.

4. Determination of operational data for flight planning purposes will be presented as shown in Appendix I, along with other standard presentations. Included are acceleration fuel and distances, altitude versus climb angle, zoom and landing fuel requirements, etc.

CONDITION OF THE AIRCRAFT RELATIVE TO TESTS

The test aircraft is one of three production F-104A's to be modified to Aerospace Trainer configuration. The modified aircraft will be utilized by the USAF Aerospace Research Pilot School to provide the following training functions:

1. Operation of a throttleable rocket engine.

2. Operation of reaction controls.

3. Experience in shifting from reaction to aerodynamic controls.

4. Experience in zero "g" conditions.

5. Experience in re-entry effects.

6. Experience in power-off low lift to drag ratio landings.

Conversion of the production F-104A's to Aerospace Trainers have included the following installations:

1. An AR2-3 rocket engine faired between the fuselage and vertical fin.

2. An F-104G tail and canopy.

3. X-15 type reaction controls. (Yaw, pitch and roll)

4. Two foot wing tip extensions to accommodate the roll motors.

5. Modified engine air inlets.

6. Hydrogen peroxide oxidizer tanks located in the armament and electronic bays replacing auxiliary fuel tanks.

7. APW-11-S band beacon.

8. Auxiliary cockpit pressurization.

9. Auxiliary battery.

10. All metal nose cone with yaps head boom.

11. Adequate canopy defrosting for all conditions of flight.

12. A J79-3B engine.

13. Two Collins 718-B-8 radios.

14. All-attitude indicator (AAI) with angle of attack and sideslip indicators superimposed in front of the AAI ball.

15. Rudder limiter cut-out.

16. Radar beacon transponder (APX-46).

The following equipment and systems were removed from the production airplane to make room for the new installations:

1. M-61 gun.
2. ARC-66 UHF radio.
3. Fire control system.
4. Data link provisions.
5. VOR radio.
6. ILS.
7. Missile auxiliaries.
8. Auxiliary fuel tank.
9. Standard radar beacon transponder.

TEST INSTRUMENTATION

The following instrumentation has been installed and calibrated by the Lockheed-California Company (LCC):

1. Airspeed (nose boom).
2. Altitude (nose boom).
3. Free air temperature.
4. Normal acceleration.
5. Longitudinal acceleration (cg).
6. J79 engine rotor speed.
7. J79 engine fuel used.
8. J79 afterburner fuel used.
9. J79 engine nozzle position.
10. J79 engine exhaust gas temperature.
11. Rocket engine chamber pressure.
12. Rocket engine exit ambient pressure (aircraft S/N 560-760 only).

13. Rocket propellant pump discharge pressure.

14. Rocket propellant used.

15. Pitch angle.

16. Bank angle.

17. Angle of sideslip.

18. Angle of attack.

19. Roll rate.

20. Pitch rate.

21. Yaw rate.

22. Rudder position.

23. Left aileron position.

24. Right aileron position.

25. Stabilizer position.

26. Longitudinal stick force.

27. Lateral stick force.

28. Rudder force.

The following additional instrumentation will be installed and calibrated by the AFFTC in NF-104A S/N 560-760.

1. J79 engine fuel flow rate.

2. J79 afterburner fuel flow rate.

3. J79 engine fuel temperature.

4. J79 afterburner fuel temperature.

5. High-low speed switch on the oscillograph control panel.

6. 1000 cycle oscillator side tone.

7. Reaction control monitor.

The instrumentation requirements for this test will remain flexible. Any special instrumentation requirements or modifications required by the AFFTC will be specified as the need arises. The AFFTC will maintain all instrumentation and check the contractor's instrument calibrations before and after the test program.

GROUND TESTS

A. Weight and Balance

The gross weight, center of gravity, and center of gravity variations of the aircraft were determined by LCC prior to the contractor's first flight. The aircraft will be weighed before and after several flights of the AFFTC test program to check the fuel used instrumentation.

B. Static Thrust Calibration

The ground static thrust of the J79 and rocket engines will be determined through use of the AFFTC thrust stand. Calibrations will be made before the program has been initiated, after any engine change, and after flight tests are terminated. Sufficient data will be obtained to determine the thrust and fuel flow characteristics of the engines as installed.

C. Airspeed System Lag Check

A lag check will be accomplished prior to the first flight to determine the time lag of the airspeed system.

FLIGHT TESTS

A. Airspeed Calibrations

The position error of the airspeed system will be calibrated by the pacer formation and smoke trail acceleration methods. Sufficient data will be obtained to define changes in position error resulting from Mach number and weight/altitude effects.

B. Takeoffs

An evaluation of elevator power will be made during takeoff to determine the ability to rotate to the takeoff attitude. Takeoff data will be measured on as many flights as necessary to determine takeoff performance if elevator power becomes a limiting factor.

C. Climbs

Climb performance of the aircraft will be determined during the energy management (zoom) flights by continuous military power climbs to altitudes near the combat ceiling.

D. Level Accelerations

Accelerations with maximum afterburning thrust will be accomplished at approximately 35,000 feet during all energy management flights.

E. Cruise Performance

Cruise performance will be determined at 35,000 feet at low gross weight. The results of these tests will be presented in a usable form for determination of an alternate landing site in the event of an "overshoot" in a zoom maneuver. (See Appendix I) Insofar as possible, these data will be obtained during the post mission return to base.

F. Static Longitudinal Stability

Static longitudinal stability data will be obtained from all level accelerations performed during the test.

G. Dynamic Stability

Dynamic longitudinal and lateral-directional stability data will be obtained throughout the speed and altitude range insofar as possible at the critical angles of attack corresponding to the profile mission. Data will be obtained with yaw dampers on and off. Lateral-directional oscillations will be initiated by rudder pulses and data will be recorded until the oscillations have damped or at least five cycles of oscillation have been completed. Maneuvering flight data in the form of "wind-up turns" may be necessary to investigate all of the critical angles of attack.

H. Energy Management Flights

The energy management flights (zooms) which will comprise the major portion of the flight program, will be simulated and optimized on a digital computer. These high altitude flights will be conducted with and without aerodynamic and reaction control stability augmentation systems operating in approximately 5000 foot increments starting at approximately 100,000 feet and increasing to the maximum altitude. Data on re-entry stability parameters will be obtained and analyzed as the peak altitude is increased.

Approximately 15 energy management flights will be conducted at an initial altitude of 35,000 feet and a rocket engine light Mach number of 1.7. At pull up the maximum normal acceleration will be 3 to 3.5 "g" and the maximum angle of attack will be 7 to 8 degrees. The pull up Mach number will vary from 1.8 to 2.0 and the flight path from 30 to 70 degrees. Data from these tests will form the basis for the information presented as shown in Appendix I. The following is a tentative schedule for these flights:

ENERGY MANAGEMENT SCHEDULE

Initial altitude - 35,000 ft
Rocket engine light Mach number - 1.7
Entry normal acceleration - 3.5g

Flight Number	Pull up Mach Number	Climb Angle (degrees)
1	1.8	30
2	1.8	40
3	1.8	50
4	1.8	60
5	1.8	70
6	1.9	30
7	1.9	40
8	1.9	50
9	1.9	60
10	1.9	70
11	2.0	30
12	2.0	40
13	2.0	50
14	2.0	60
15	2.0	70

There will be approximately 12 flights to determine the effects of wind gradients and rocket engine light Mach number at a constant pull up Mach number. In addition there will be approximately 12 to 15 flights to optimize the "zoom" maneuver. These tests will be conducted with varying initial altitude, normal acceleration, climb angle and Mach number to verify the results of the digital simulation.

AIRCRAFT FLIGHT TEST SUPPORT RESPONSIBILITIES

The aircraft flight test support responsibilities will be as follows:

1. Flight Test Engineering/FTFEE/37761.

The Performance Engineering Branch of the Flight Test Engineering Division will be responsible for initiating the flight test plan, collecting, reducing and analyzing data, and producing the final report.

2. Flight Test Instrumentation/FTFSI/27421.

The Instrumentation Branch of the Technical Support Division will maintain all flight test instrumentation and install any additional instrumentation necessary to complete the flight test evaluation.

3. Systems Engineering/FTFED/24751.

The Systems Engineering Branch of the Flight Test Engineering Division will evaluate the various systems peculiar to the NF-104A.

4. Flight Test Operations/FTFOF/39191.

The Manned Spacecraft Operations Branch of the Flight Test Operations Division will furnish the pilot and chase aircraft as necessary to evaluate the NF-104A. Pilot duties will include inputs for operating instructions and procedures.

5. Aircraft Maintenance/FTEM/34091.

Maintenance of the aircraft as a unit and all components common to the standard F-104A will be the responsibility of the 6515th Organizational Maintenance Squadron.

6. Rocket Engine Maintenance and Overhaul/FTEMP-1/24091/42091.

The Rocket Unit of the 6515th Field Maintenance Squadron will perform maintenance, overhaul and functional testing of the AR2-3 rocket engine and reaction control motors.

7. Aircraft Servicing/FTMSF-5/45141/21341.

The Propellants Branch of the Fuel Supply Division will be responsible for all propellant servicing operations including nitrogen (GN_2) servicing.

8. Aerospace Research Pilot School/FTTR/27081/36911.

The Aerospace Research Pilot School will assist in coordinating activities between the above organizations.

CONCLUSIONS

It is estimated that approximately 25 hours of flying time will be required to complete the above test program.

PREPARED BY: Clendon L. Hendrickson
CLENDON L. HENDRICKSON
Project Officer

APPROVED BY: C E Anderson Col
FOR CLAYTON L. PETERSON
Colonel, USAF
Director, Flight Test

APPENDIX I (DATA DISPLAY)

Data presentation resulting from the NF-104A testing will be in standard format with the exception of the following attached charts. These will be displayed as indicated because of the peculiar mission of the NF-104A and to facilitate student pilot pre-mission planning.

The energy management data will be presented as shown in Figure 2. If it is determined that rocket engine light Mach number is a significant parameter, the presentation will vary accordingly.

FIGURE NO 1

LEVEL ACCELERATION WITH FULL AFTERBURNER POWER
35,000 Ft

NOTE: THIS CHART DOES NOT DISPLAY TRUE DATA
AND IS INTENDED AS A SAMPLE ONLY.

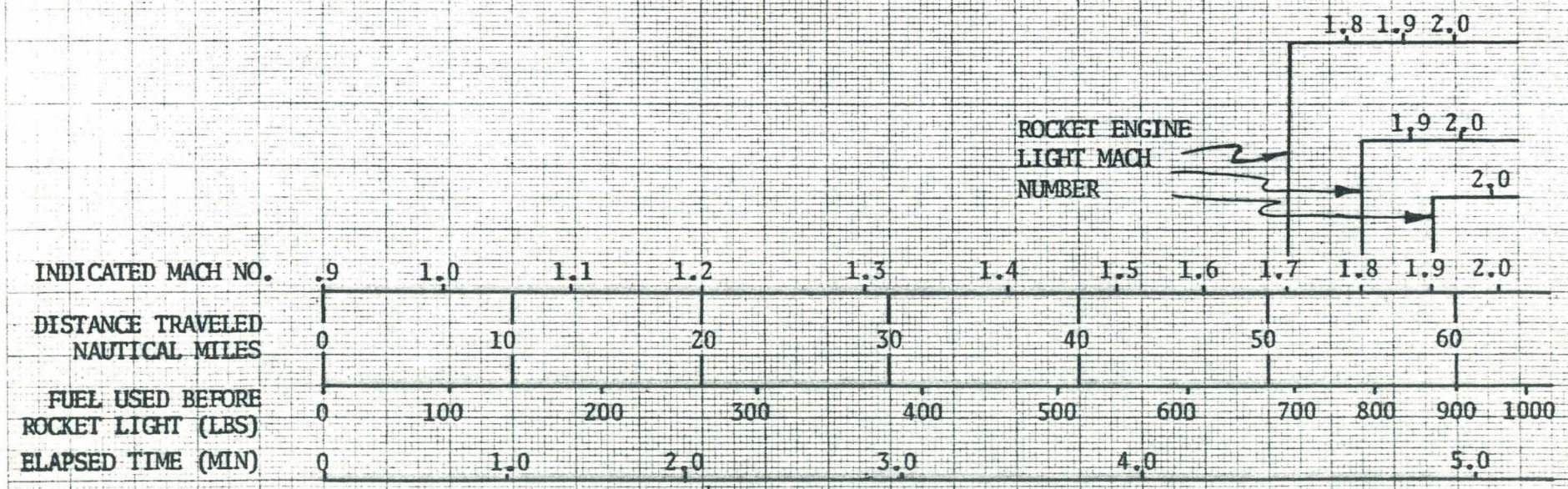


FIGURE NO 2

ENERGY MANAGEMENT FLIGHTS

ROCKET ENGINE LIGHT @ 1.7 MACH NO.

INITIAL ALTITUDE = 35,000 FT

NORMAL ACCELERATION @ PULL UP = 3.5 "g"

MAXIMUM ANGLE OF ATTACK = 8 DEGREES

NOTE: THIS CHART DOES NOT DISPLAY TRUE DATA AND IS INTENDED AS A SAMPLE ONLY.

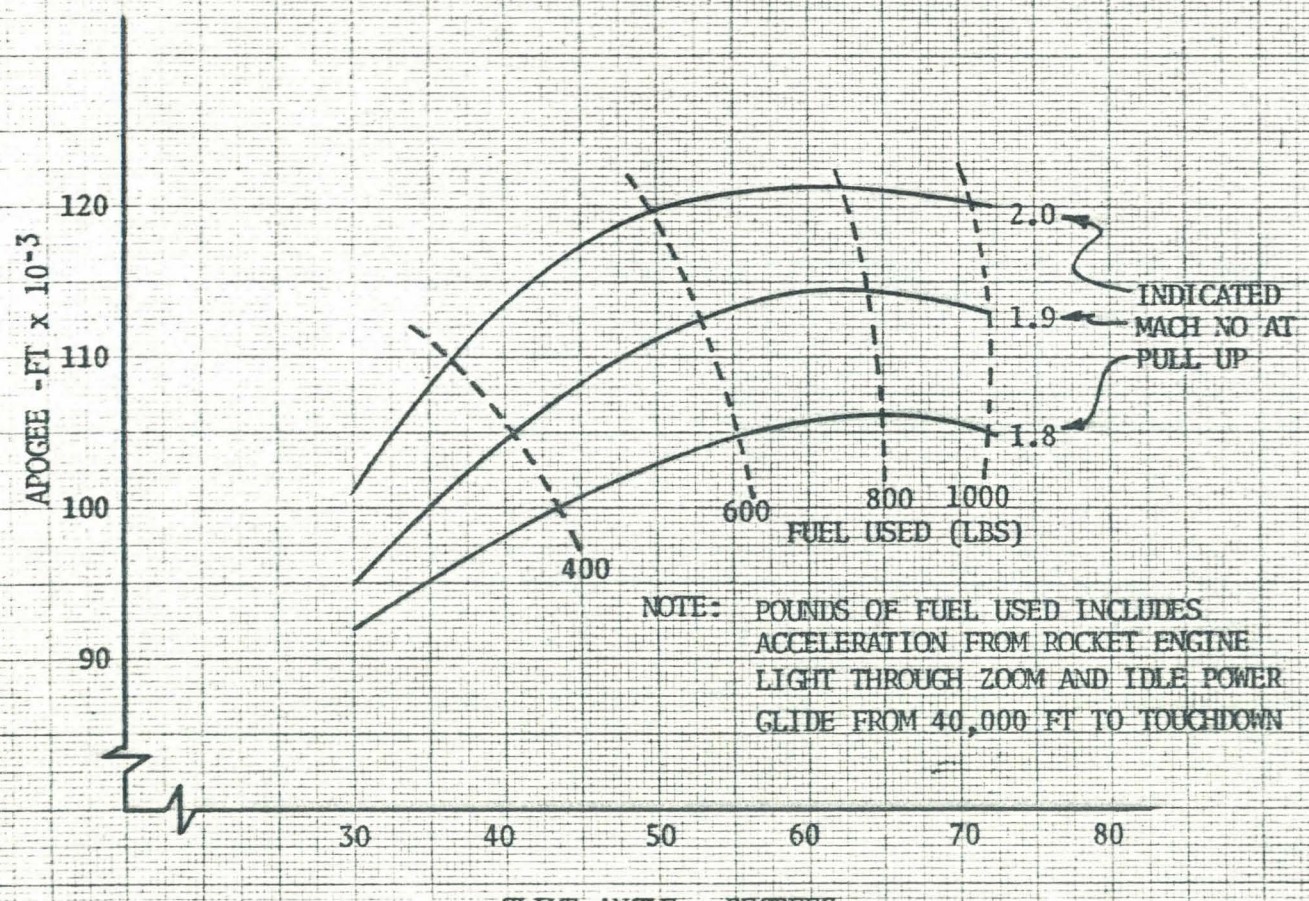
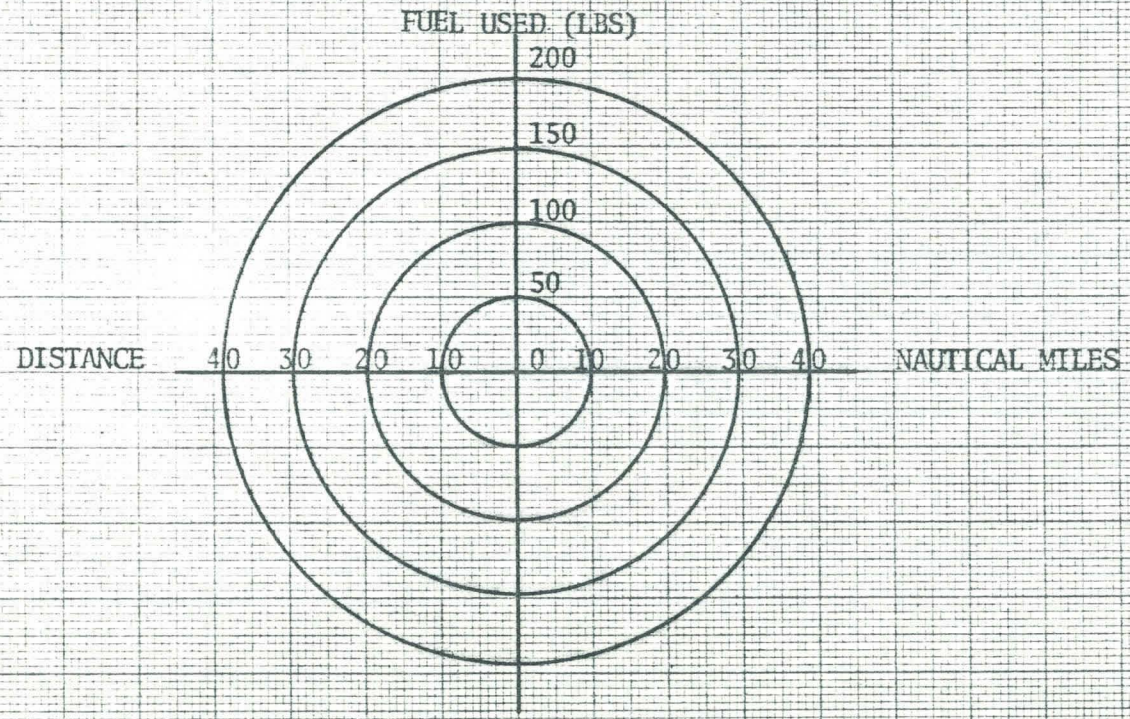


FIGURE NO 3
CRUISE AT 35,000 FT
CONSTANT ALTITUDE TO BASE
NO WIND CONDITIONS

NOTE: THIS CHART WILL BE DISPLAYED AS A LOCAL AREA MAP OVER-LAY.
THIS CHART DOES NOT DISPLAY TRUE DATA AND IS INTENDED AS A SAMPLE ONLY.



ANNEX I

SYSTEMS EVALUATION

I INTRODUCTION

The systems evaluation team will concentrate their investigation on features of the modified F-104A that enable it to operate at extreme altitudes. In addition to functional tests, system reliability and fail safe criteria will be evaluated.

II TEST OBJECTIVES

The objectives of the system evaluation are to:

A. Demonstrate that the complete system functions satisfactorily.

B. Determine that systems meet design objectives.

C. Survey serviceability, maintainability, and reliability.

These objectives will be met by utilizing data obtained from aircraft instrumentation and pilot observations and reports.

III AREAS OF INVESTIGATION

The systems and components which will be more closely monitored are:

A. AR2-3 liquid fuel rocket engine.

B. X-15 type reaction controls.

C. Auxilliary cockpit pressurization.

D. Collins 718-B-8 radios.

E. Complete nitrogen system.

F. Complete H_2O_2 oxidizer system.

Any additional systems that demonstrate a requirement for investigation will be added to the above systems. In the event that separate flight time is required to investigate thoroughly and correct any problem that may develop in a given system, Systems Engineering Branch (FTFED) will request the necessary flight time.

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