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(AFATL-TR-75-114)

QF/PQM-102 TARGET SYSTEM, PROJECT PAVE DEUCE

PQM-102 SYSTEM PROGRAM OFFICE

MAY 1975

FINAL REPORT: MARCH 1973 - APRIL 1975

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DEPUTY FOR ARMAMENT SYSTEMS
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The PQM-102 Target System consists of a de-manrated QF-102, Mobile Ground Station, Fixed Ground Station, and peculiar aerospace ground equipment. It was designed to provide a full-scale, supersonic target with afterburning capable of: (1) performing 8g maneuvers, (2) performing in an altitude envelope from 200 feet to 55,000 feet, and (3) maintaining Mach 1.19 at 35,000 feet straight and level.

The engineering development was conducted at Crestview, Florida, and Holloman Air Force Base, New Mexico. The DT&E/IOT&E Flight Test Program was conducted at Holloman Air Force Base

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between 20 January 1974 and 7 November 1974. The Flight Test Program consisted of engineering evaluation flights, reliability flights, QF/PQM record flights, and an evaluation of the complete target system. The tests demonstrated that the PQM-102 de-manrated concept is reliable, the system can be utilized to provide presentations up to and including 8g, and is maintainable and operable by the contractor in an operational environment.

The system description, development engineering, test objectives, evaluation, record flight data, and findings are presented in this report.

PREFACE

This technical report covers work performed in support of the PQM-102 Target System by the PQM-102 System Program Office [redesignated Aerial Targets System Program Office (SD102)], Deputy for Armament Systems, Armament Development and Test Center, Eglin Air Force Base, Florida, during the period 31 March 1973 through 1 April 1975.

The prime contractor during this effort was Sperry Flight Systems, Phoenix, Arizona, Contract No. F08635-73-C-0100. Subcontractors were Fairchild Industries, Crestview, Florida; Vega Precision Laboratories, Inc., Vienna, Virginia; Hydro-Aire Division of the Crane Company, Burbank, California; and Hi-Shear Corporation, Torrence, California.

The program monitor for this technical report was Elmer Mittwoch (ADTC/SD102).

Personnel responsible for management, testing, and acceptance were as follows:

Robert L. Loukota, Colonel, USAF, Director, Aerial Targets System Program Office

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Frank C. Halstead, Lt Col, USAF, Test Director, Air Force Special Weapons Center

The Aerial Targets System Program Office gratefully acknowledges the Air Force Special Weapons Center for its professionalism, planning, interface with the White Sands Missile Range and the contractor, and in-depth evaluation of test data.

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

ALTO F. SMITH, Deputy Director
Aerial Targets System Program Office
Deputy for Armament Systems

JAMES R. LINDSAY, Colonel, USAF
Deputy for Armament Systems

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SECTION I

INTRODUCTION

The Development, Test and Evaluation (DT&E) and Initial Operational Test and Evaluation (IOT&E) were conducted in response to Program Management Directive (PMD), dated 23 July 1973 and Master Test Plan, dated 15 December 1973.

This report is based upon the results of: (1) ground and flight tests associated with engineering development at Crestview, Florida (27 September to 20 December 1973), (2) the engineering and flight test program at Holloman Air Force Base, New Mexico (10 January to 7 November 1974), and (3) the NULLO flights in support of IOT&E missile firings (8 November 1974 to 31 January 1975).

The government conducted all tests associated with the QF/PQM-102 Destruct System, antenna pattern measurements, and determination of gyro behavior at various tilt angles and g loading up to 8g. The contractor conducted all other ground and flight tests during the DT&E/IOT&E program. The Armament Development and Test Center (ADTC) PQM-102 System Program Office (SPO) was assigned responsibility to provide the overall executive management, funding, acceptance pilot, and final test report.

The Air Force Special Weapons Center (AFSWC) was the responsible test organization and provided the test director for the tests conducted at Holloman Air Force Base. AFSWC, representing the implementing command (AFSC), headed the PAVE DEUCE Joint Test Force (JTF). The JTF consisted of representation from AFSC, ADC, TAC, and AFLC. The Air Force Contract Management Office administered the contract at Holloman Air Force Base under a secondary delegation from Defense Contract Administration Services (DCAS), Phoenix, Arizona.

SECTION II

BACKGROUND

1. INTRODUCTION

The purpose of this technical report is to provide a description of the PQM-102 Target System; data on engineering development conducted at Crestview, Florida, and Holloman Air Force Base, New Mexico; an evaluation of the target system; and flight test data on QF/PQM-102 record flights at Holloman Air Force Base.

The target system was developed for the Armament Development and Test Center (ADTC), Eglin Air Force Base, Florida, by Sperry Flight Systems, Phoenix, Arizona. Subcontractors were Vega Precision Laboratories, Fairchild Industries, Hydro-Aire Division of the Crane Company, and Hi-Shear Corporation. The DT&E/IOT&E program consisted of three phases.

Phase I, initial engineering development, was conducted under PQM-102 SPO management at Crestview, Florida. This phase primarily involved the modification of three basic F-102 aircraft into QF-102 test beds for evaluation of: (1) flight worthiness of electronics in the Flight Control Stabilization System (FCSS); (2) aircraft/FCSS interface; (3) premission test stand procedures and aircraft interface; (4) ground flight test procedures; (5) anti-skid brake system; and (6) visual augmentation (Smoke). During this phase 23 engineering test flights were conducted.

Phase II, engineering development, was conducted at Holloman Air Force Base during the period 10 January to 7 November 1974. This phase was continued simultaneously with the Flight Test Program (Phase III). The Holloman Air Force Base engineering effort required 73 additional flights for further refinement and evaluation of the stub antenna configuration; backup FCSS; high and low altitude maneuver programmers; scoring (DIGIDOPS); visual augmentation (Smoke); and upgraded transponders. A total of 96 engineering flights were required. The flight test program included the conduct of 13 QF-102 hands-off reliability flights (7 before the first QF-102 record flight), 16 QF-102 record flights, and 6 PQM-102 record flights.

Due to deficiencies within the FCSS portion of the target system, three additional record flights (two QF/one PQM) were needed to successfully demonstrate that all of the Statement of Work (SOW) objectives had been met. Additionally, other flights were flown to verify the existence of a reliable full-up target system, practice pattern/profiles prior to record flights, and satisfy pilot proficiency and functional check flight requirements. Excluding pilot proficiency, 182 flights were flown at Holloman Air Force Base in support of the DT&E/IOT&E program which concluded with the conduct of QF Record Flight No. 16 on 7 November 1974. Between 8 November 1974 and 31 January 1975 an additional 32 flights were flown to support the follow-on IOT&E program. A total of 214 flights were flown in support of DT&E/IOT&E.

2. SIGNIFICANT PROGRAM EVENTS

Contract Awarded	31 March 1973
First Engineering Flight, Crestview, Florida	27 September 1973
First QF Flight, Holloman Air Force Base, New Mexico	10 January 1974
Design Review II, Holloman Air Force Base	29 March 1974
Reliability Flights Started	2 July 1974
First QF Record Flight	29 July 1974
White Sands Missile Range Demonstration Flights Started	30 July 1974
Reliability Flights Completed	6 August 1974
First PQM Record Flight (NULLO)	13 August 1974
Last PQM Record NULLO/First AIM 9-J Firing	26 September 1974
Last QF Record Flight (DT&E Completed)	7 November 1974
Last NULLO	31 January 1975
ADC Acceptance of QF/PQM-102 Target System	1 April 1975

3. SYSTEM DESCRIPTION

The QF/PQM-102 Target System was developed to fulfill the need for a full-scale, afterburning, maneuverable, supersonic aerial target. It is composed of three basic components: (1) the drone system consisting of a droned version of the F-102 aircraft; (2) the Mobile Ground Station (MGS) which launches and recovers the drone, and (3) the Fixed Ground Station (FGS) which controls the target (Figures 1 and 2). Additionally, the system includes six items of peculiar Aerospace Ground Equipment (AGE).

a. The Target System

This system consists of two types of flight vehicles: The PQM-102 and the QF-102. The PQM-102 is the unmanned version. Once an F-102 is converted to a PQM-102, it becomes de-manrated and is no longer used with a pilot unless it is re-manrated for ferrying purposes. The QF-102 is a manned version of the PQM-102 and is used for captive presentations, crew training, and system checkout. Both vehicles were modified to carry the following subsystems:

Flight Control Stabilization System (FCSS)
Airborne Command/Control and Telemetry System
DIGIDOPS Scoring System
Anti-Skid Brakes
Smoke Visual Augmentation System
Destruct System (PQM-102 only)
Various Antennas (DIGIDOPS and Telemetry)

b. Mobile Ground Station (MGS)

The MGS is a redundant self-contained mobile control facility used for launch/recovery. It consists of two control consoles, UHF and VHF communications, encoding and decoding equipment, and a CPR 4010 tape recorder. Its primary radar has a maximum range of 50 nautical miles. Should the radar lose track, an omnidirectional backup radar is available for reacquisition within a range of 10 nautical miles (Figures 3 and 4).

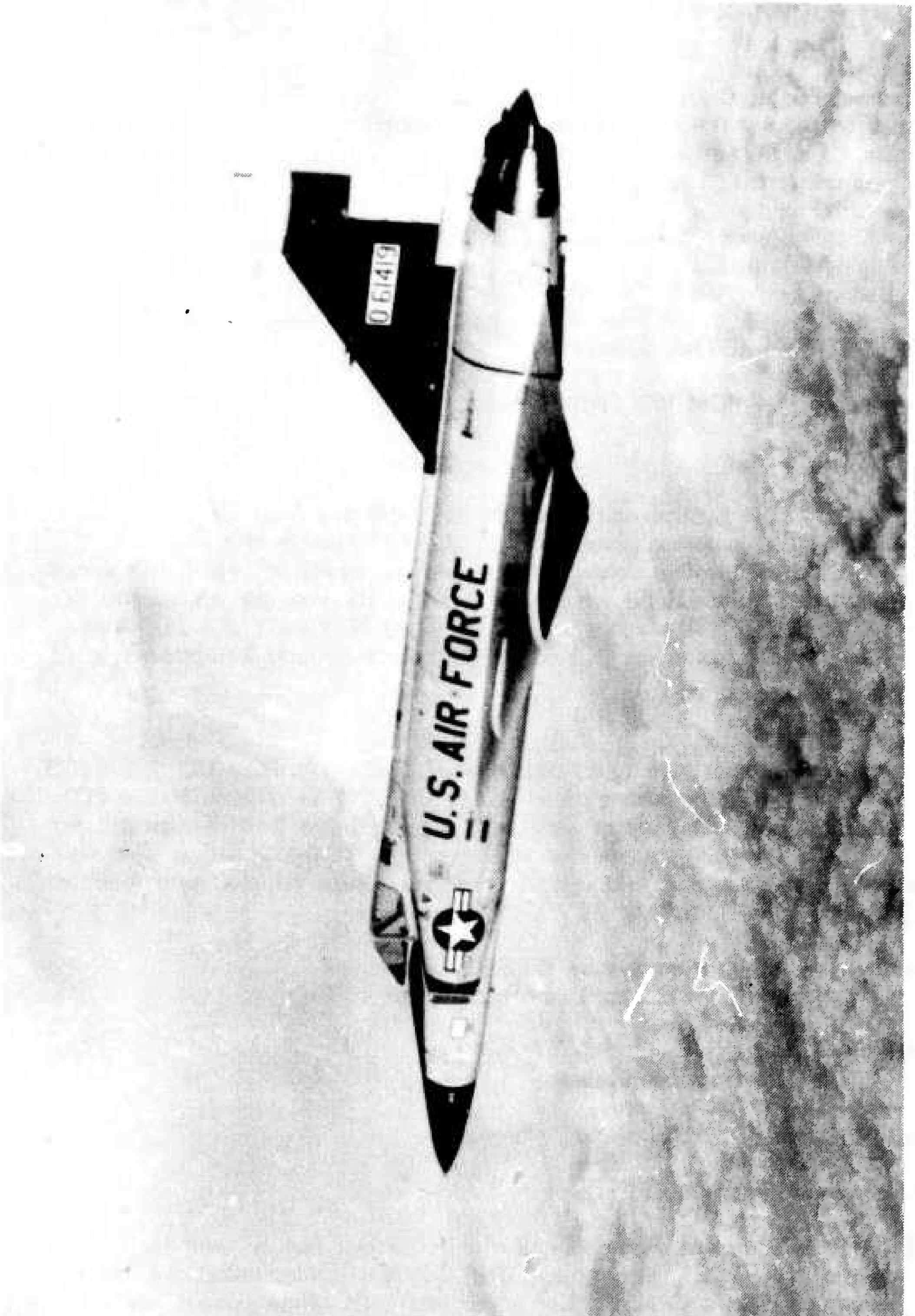


Figure 1. PQM-102 Drone

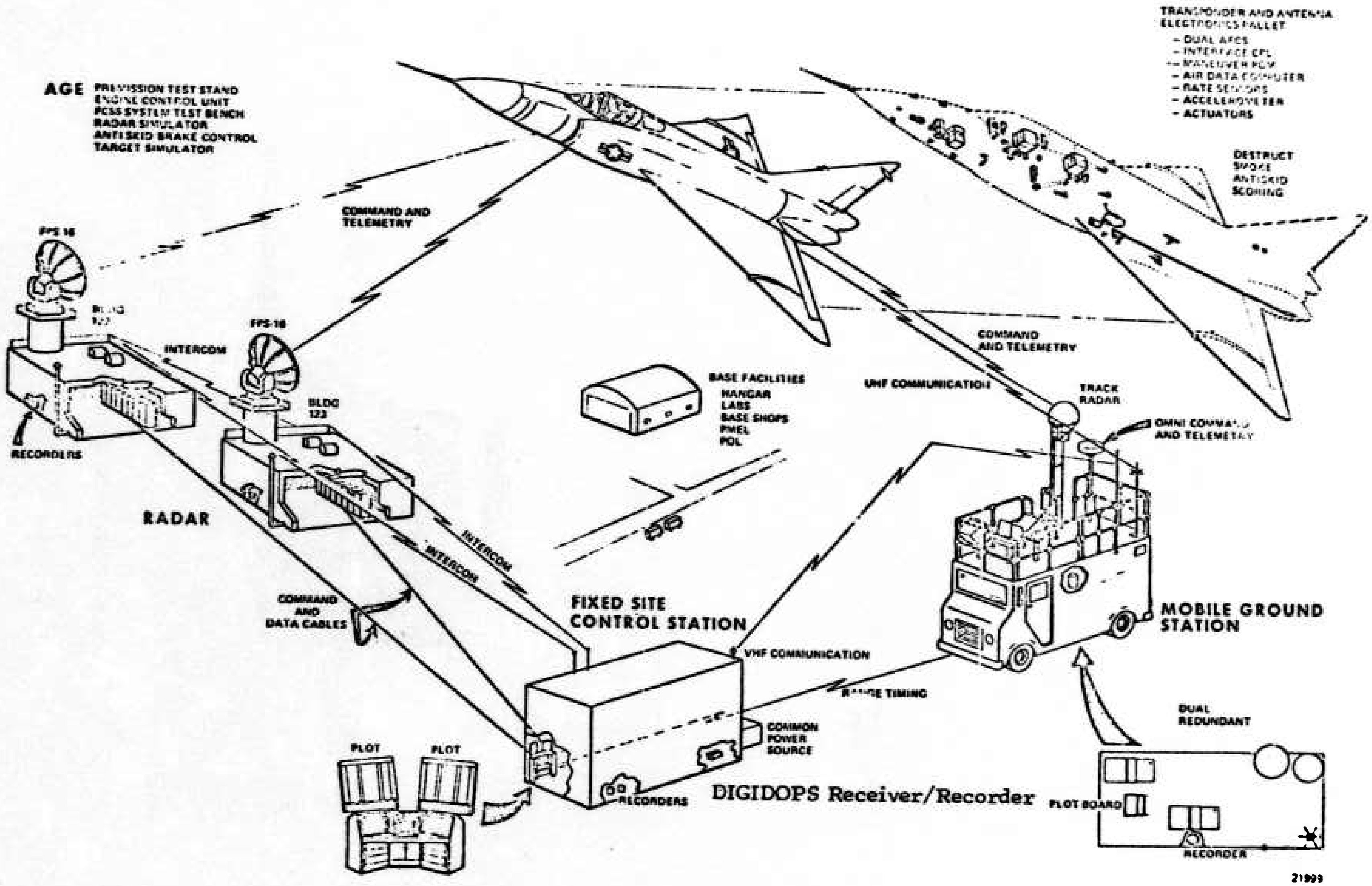


Figure 2. PQM-102 Target System Configuration

Figure 3. QF-102 Landing (with Mobile Ground Station)

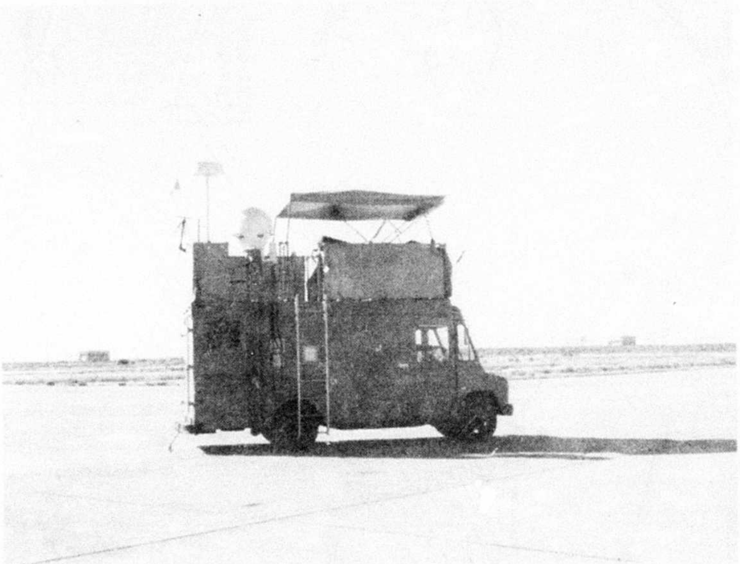


Figure 4. Mobile Ground Station

c. Fixed Ground Station (FGS)

The FGS uses AN/FPS-16 radars. The system is composed of a dual unit control console, UHF and VHF communications, encoding and decoding equipment for command initiation and telemetry reception, a monitor test set, an FR 1800 tape recorder, and format converters/modems for transmission of information from King I to R-122/123. The FGS is completely redundant and has a range limited by the power of the AN/FPS-16 (200 miles) (Figures 5 and 6).

4. QF/PQM PECULIAR SUBSYSTEMS

a. Flight Control Stabilization System (FCSS)

The FCSS is contained in an airborne pallet (Figure 7). In the QF-102, the pallet is installed in a compartment behind the cockpit. Commands can be given to the FCSS by either the command and control system or from a special remote control data panel installed in the cockpit. This latter system resembles the control consoles in the MGS and FGS and is used for controller training. In the PQM-102 the pallet is installed on the ejection seat rails. Major components contained in the pallet and a brief description of their functions are as follows:

(1) Flight Reference Computer (FRC). The FRC is the basic flight control computational unit. It accepts aircraft attitude, rate, normal acceleration parameters from aircraft sensors and air data status from the air data computer.

(2) Air Data Computer (ADC). The ADC computes barometric altitude, Mach number, and calibrated airspeed. It also accepts mode engage commands (Mach hold, airspeed hold, and altitude hold) and provides error signals (Mach, airspeed, and altitude).

(3) Interface Coupler (IFC). The IFC contains the logic and control circuitry necessary to engage and disengage modes, take over control due to a loss of the ground control data link, process uplink and downlink signals, and to destruct the aircraft if required.

(4) High Altitude Maneuver Programmer. The maneuver programmer contains the backup auto-pilot plus the circuitry required to initiate preselected commands. The programmable maneuvers are combinations of g (-1 to +8), bank angle (0 to +180 degrees), and airspeed commands (250 to 650 knots) as a function of preset time (1 to 99 seconds). The four programmable maneuvers are obtainable in two, two-phase maneuvers, or two, single-phase maneuvers, all selectable by ground command (Figure 8).

(5) Low Altitude Maneuver Programmer. The low altitude maneuver programmer (Army PQM-102 only), is capable of performing three ground-settable, command-selected maneuvers (two basic maneuvers and one low altitude maneuver). The programmable low altitude maneuvers can be selected from either barometric altitude (0 to 10,000 feet) or radar altitude (0 to 2000 feet) for the presentation altitude reference, with a combination of Mach number (0 to 1), pitch-up attitude (0 to 60 degrees), and preset time (0 to 99 seconds) (Figure 8).

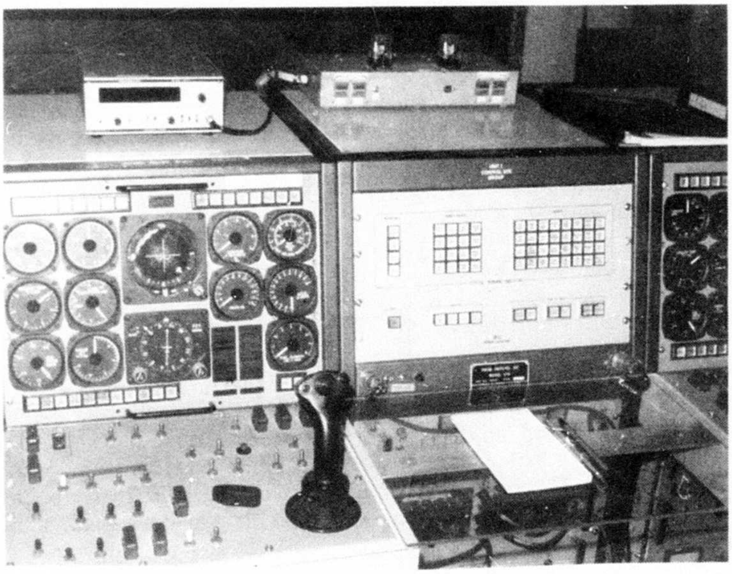


Figure 5. Fixed Ground Station Console

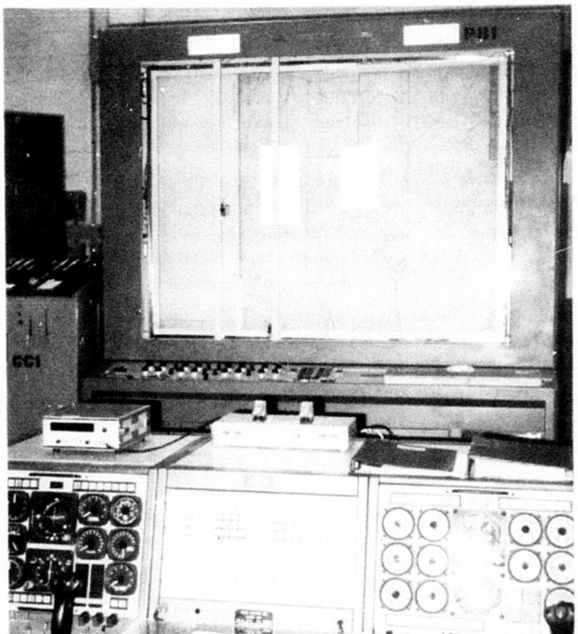


Figure 6. Fixed Ground Station Console with Plot Board (Ground Track)

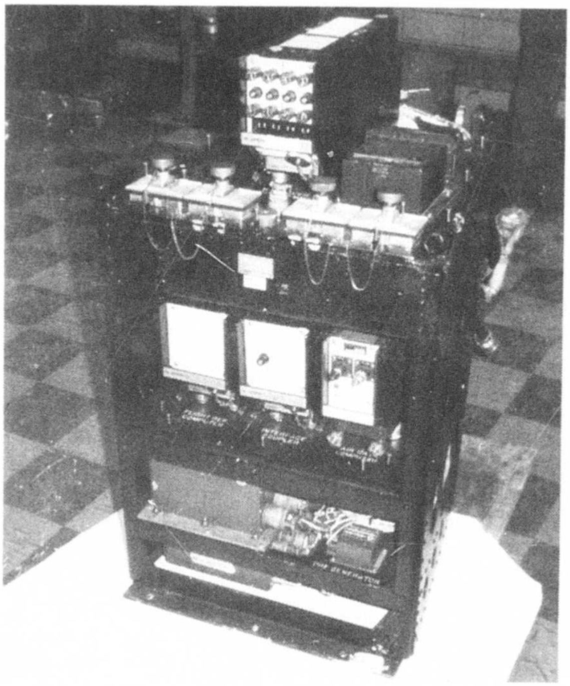
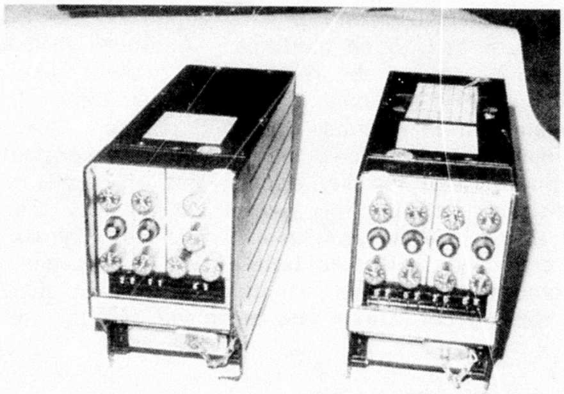


Figure 7. PQM-102 Pallet (LEROI)



Low Alt Standard

Figure 8. Maneuver Programmers

b. Backup Power System (FGS/MGS/PQM)

The FGS is powered by several electrical power sources. Each console contains several power supplies dependent on commercial 115-volt AC, 60-cycle power. In addition, two 28-volt DC and 115-volt AC, 400-cycle sources are required.

The MGS contains two independent gasoline-powered generator systems (6.5 kw) which provide 115-volt AC, 60-cycle power, 115-volt AC, 400-cycle power, and 28-volt DC power. Automatic/manual switchover is provided with ability to provide adequate power for continuous operation of all critical command-control equipment.

The PQM-102 aircraft contains two lead-acid, 24-volt, 36-ampere-hour batteries in addition to the basic F-102 backup power systems. The added batteries provide a capability to recover the target in the event complete AC and DC power fails.

c. DIGIDOPS Scoring System

The DIGIDOPS (Digital Doppler Scoring) system is used to provide a digitized, scalar miss-distance for missiles fired at the PQM-102 aircraft. The system consists of two basic subsystems, a narrow pulse doppler radar system (on 1775 MHz) and a UHF telemetry system (1435 to 1540 MHz). Four aircraft antennas are used on the radar system and a dual antenna is used on the telemetry system. The radar system, which transmits RF energy and measures the resulting doppler frequency shift of the energy reflected from the fired missile, provides miss-distances in 5-foot steps from 0 to 100 feet and in 10-foot steps from 100 to 200 feet. The miss-distance information is transmitted to ground receiving equipment via the aircraft UHF telemetry transmitter. On-board telemetry recording is not provided (Figure 9).

d. Anti-Skid Brake System

In order to obtain satisfactory braking action on the PQM-102 aircraft, the basic F-102 brake system had to be modified. Additions included wheel speed transducers, solenoid shut-off valves, brake relay valves, a servo valve, and a control box containing electronic circuitry. Braking action is accomplished by the initiation of the brakes-on command via the normal command system. The system applies the wheel brakes in a manner which slows the aircraft at a constant rate of deceleration while continually compensating for any erratic rates of deceleration (skids) after touchdown. Stopping distances utilizing this system are typically shorter than that obtained by manual braking action. While each wheel individually senses changes in deceleration rates, a composite command is sent to both brakes to provide proper braking. The system does not compensate for small variations in braking effectiveness of the individual brakes, and minor steering corrections (via command system) are required to maintain a constant heading.

e. Visual Augmentation (Smoke) System

The generation system is installed in the QF/PQM-102A. The system consists of a 50-gallon oil storage tank (tank assembly), cradle assembly, hydraulic pump, shut-off valves, vent valves, check valves, drain valves, nozzle assemblies, associated plumbing, and electrical system (Figure 10). (Note: Oil capacity for the Smoke System in production PQM-102 aircraft is 28 gallons.)

Figure 9. DIGIDOPS Scoring Antenna

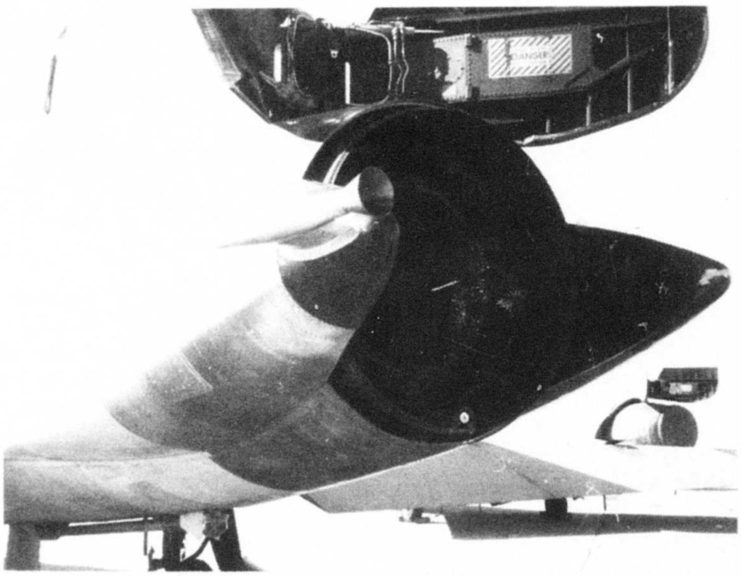


Figure 10. Smoke Nozzles

f. Destruct System

The destruct system, used to terminate aircraft flight when control of the PQM is lost, consists of two independent methods of destruct. One method, called maneuver destruct, is accomplished via the command system by executing the HOLD-TO-ARM, ARM, and MANEUVER DESTRUCT commands. This causes a hard-over, pitch-down maneuver. This mode is proposed for use only when the aircraft altitude is below 1500 feet AGL during takeoff and landing approach. The other method, called explosive destruct, consists of a Mark 48 warhead (explosive charge), a warhead adapter assembly, two exploding bridgewire detonators (EBW), one high energy firing unit (HEFU), one key switch assembly, one weight-on-gear (WOG) relay, one UHF command destruct receiver including antenna, one 28-volt DC ni-cad battery, and associated wiring harnesses. The explosive destruct is accomplished by any of the command or automatic means listed below:

(1) Command Destruct. Execution of the HOLD-TO-ARM, ARM, and DESTRUCT command sequences on the system processes signals through the FCSS IFC, which in turn supplies 28-volt DC (from either the destruct battery or aircraft battery) through the WOG and key switch to the HEFU. The voltage is only applied to the HEFU when the key switch is in the arm position and the aircraft has weight-off-gear. If the command sequence is executed in the proper order, the HEFU converts the 28 volts to approximately 2000 volts, which is in turn applied to the EBW. Also, destruct arm telemetry is received from the HEFU. Activation of the EBW initiates the explosive chain and subsequent destruct.

(2) UHF Command Destruct. When the UHF command receiver is powered ON (via the beacons-on command system) execution of the ARM and DESTRUCT commands via the UHF destruct system applies 28 volts to the HEFU independent of the beacons-on command system and the IFC. Destruct action takes place as previously described.

(3) Failsafe. The target is also equipped with a commandable failsafe system. When the failsafe mode is ON the fast destruct timer (preset 1 to 30 seconds) is automatically activated in the event of loss of carrier (LOC) or loss of all DC or AC power.

(4) Orbit Maneuver. A preprogrammed climbout/orbit maneuver is initiated after 1.5 seconds in the event of uplink LOC. If the failsafe mode is OFF, the orbit maneuver is continued until expiration of the 1 to 15 minute time (preset), at which time the target self-destructs. A ground abort program is initiated which shuts the aircraft down and inhibits the explosive destruct if the aircraft should experience LOC while on the ground.

g. Command Control/Telemetry System

The Command Control/Telemetry System provides for positive flight control of the target system for all flight regimes from takeoff to 200 nautical miles distance and recovery. The Command Control/Telemetry System consists primarily of three main elements: two ground stations (one mobile and one fixed) and the airborne equipment in the QF/PQM-102 aircraft. Only the airborne portion of the Command Control/Telemetry System is described herein since the MGS and FGS were described earlier. The major components and a brief functional description of each are as follows:

(1) Radar Transponder. Two radar transponders (Type 308C-8) are employed. One is located in the vertical fin and the other is located in the armament bay. Their function is to receive RF pulses and to provide video pulses to the interrogation decoder. In addition, they accept coded pulse groups from the data encoder and transmit RF pulse groups.

(2) Directional Coupler. Two directional couplers are utilized. One is located in the vertical fin and the other is located in the armament bay. They provide for sampling of microwave energy. These units preclude the continuous connection and/or disconnecting of transponder cables during test checkout.

(3) Antenna Switch. The antenna switch is located in the armament bay. The switch automatically selects one of two antenna systems which provide interrogations.

(4) Interrogation Decoder. The interrogation decoders (two) are located in the pallet. The decoders accept video pulse groups from the transponder from which it derives command information for application to the FCSS IFC and/or data encoder.

(5) Data Encoder. The data encoders (two) are located in the pallet. The encoders accept information from the FCSS IFC and/or interrogation decoder and assemble the information into coded pulse groups for application.

(6) PRF Generator. The PRF generator is located in the pallet. It generates internal PRF to trigger the data encoder if enabled by a signal from the FCSS IFC.

(7) Antennas. One antenna is located on the fin and two antennas (upper and lower aft) receive and transmit coded RF pulse groups from and to the ground stations.

5. QF/PQM-102 PECULIAR AEROSPACE GROUND EQUIPMENT (AGE)

a. System Test Bench (STB)

The STB provides the capability to test the QF/PQM-102 FCSS components connected together as a system and to test each line replaceable unit (LRU) independently. On a system basis the STB is designed to isolate a fault to a LRU and on a component basis permits fault isolation to a replaceable subassembly within a LRU (Figure 11).

b. Premission Test Stand (PMTS)

The PMTS consists of a mobile (trailer-mounted) unit to house all the equipment and is electrically connected to the aircraft by five 40-foot cable assemblies. A comprehensive test procedure is followed to evaluate each of the aircraft subsystems after connecting the PMTS to the aircraft under test (Figure 12).

c. Engine Control Unit (ECU)

The ECU is a portable test set which, in conjunction with the MD-3 power cart and MC-11 air compressor, provides the capability of remotely starting the QF/PQM-102 engine and evaluating its performance to ensure proper operation prior to flight.

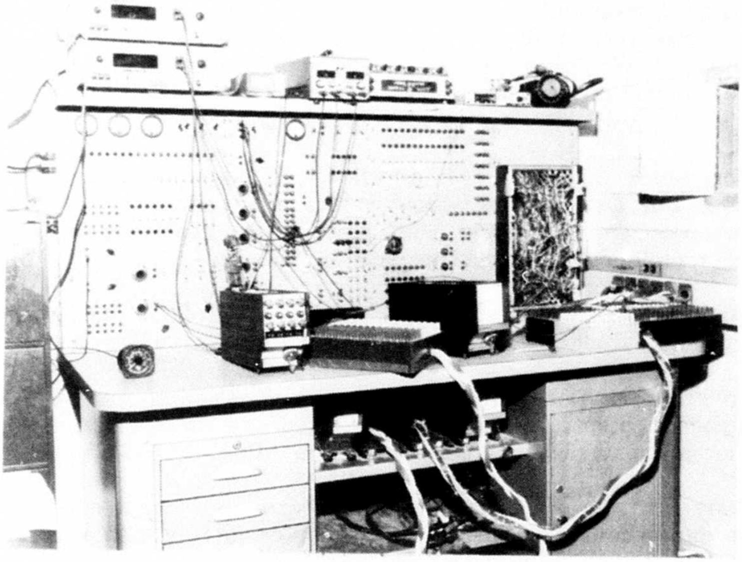


Figure 11. System Test Bench

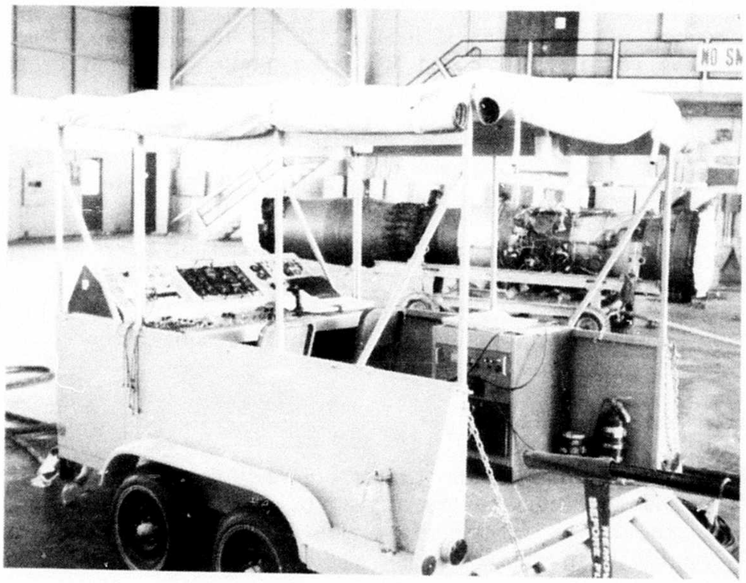


Figure 12. Premission Test Stand

The functional characteristics of the ECU consist of engine performance monitoring, start control, ignition control, throttle control, AC/DC power monitoring, failure warning indication, and auxiliary control elements. No external power is required for the ECU as all power is derived from the aircraft (Figure 13).

d. Brake Control Test Set

The brake control test set is a self-contained unit which, when used in conjunction with a standard voltmeter, permits the operator to test the QF/PQM-102 aircraft anti-skid brake control system. It is rack mounted in the PMTS to support premission testing and may be removed to in-aircraft testing. The test set is electrically connected to the skid control system test connector and simulates all aircraft inputs as well as providing a readout for all system parameters (Figure 14).

e. Radar Simulator

The radar simulator (Model 616C-4B) is a portable C-band test set for testing the RF portion of both the QF/PQM-102 airborne command and telemetry system and the MGS. It may be used in the open loop mode through an antenna for the purpose of qualitative checkout, in the closed loop mode via a directional coupler, or directly connected for a more accurate quantitative measurement of the RF of either the airborne system or the MGS. The radar simulator measures transmitter frequency, power and pulse width, and receiver frequency and sensitivity. A double-pulse code is provided to test the pulse code spacing of the airborne transponder and the MGS. External connections are also provided to permit the insertion of command pulses and to provide data readout capability (Figure 15).

f. Target Group Simulator

The target group simulator (Model 663-2) is a portable test set used to check-out the MGS. It replies to radar interrogations from the MGS by simulating downlink data from the airborne portion of the command telemetry system. It may be used via RF coupling to check altitude readout, range tracking, azimuth tracking, range read-out, code spacing, system delay, and eight data channels. It may be hard-wired, by-passing the RF section for logic circuit tests in the digital portion of the system (Figure 16).

Figure 13. Engine Control Unit

Figure 14. Brake Control Test Set

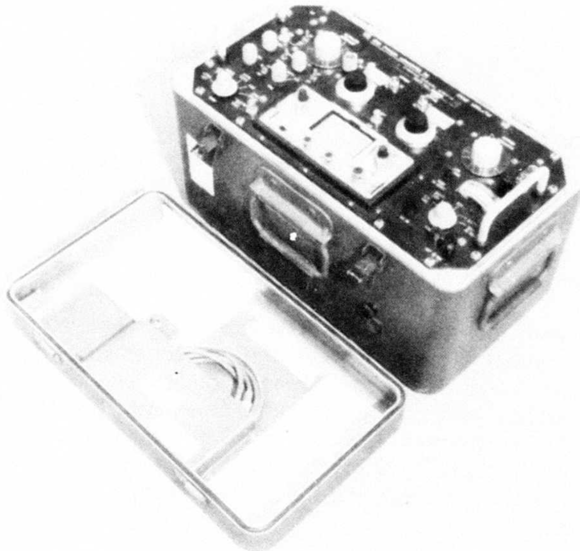


Figure 15. Radar Simulator

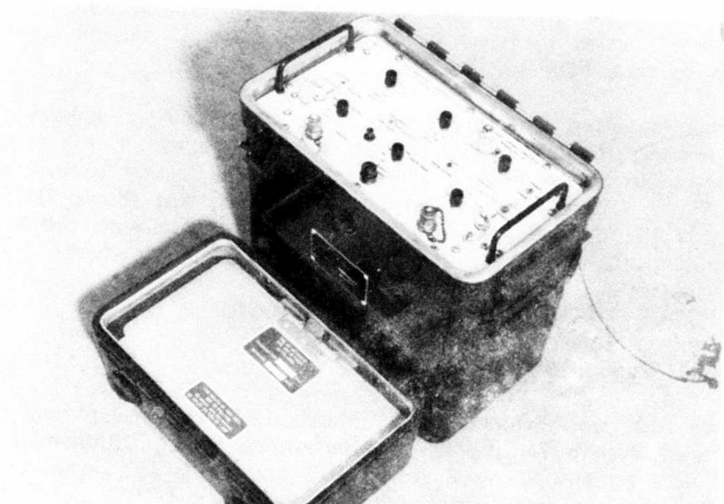


Figure 16. Target Group Simulator

SECTION III

DT&E/IOT&E PROGRAM

1. INTRODUCTION

The purpose of the DT&E/IOT&E program was to demonstrate and evaluate the feasibility of converting surplus F-102 aircraft to non-manrated PQM targets and the contractor's capability to operate and maintain the PQM-102 target and peculiar equipment on a continuous basis in an operational environment.

In accordance with the plan, three F-102 aircraft were converted to QF-102 manrated targets at Crestview, Florida, to support the contractor's development engineering, systems interface, and initial flight performance objectives. Provisional acceptance of the three QF-102 aircraft was accomplished by the PQM-102 SPO prior to ferrying by the contractor to the government test site at Holloman Air Force Base. One of the three QF-102 aircraft (FAD 601) was converted to a non-manrated target at Holloman Air Force Base and was flown successfully against AIM-9J and AIM-9L missile firings during January 1975.

Five additional F-102 aircraft were converted to PQM-102 targets at Crestview (two were option vehicles purchased by the Army for their Stinger Missile Program). The PQM-102 targets contain subsystems identical to the QF-102 and certain design changes. Provisional acceptance was performed by the PQM-102 SPO and consisted of ground tests by the contractor utilizing peculiar ground checkout equipment. These five PQM-102 targets were ferried to Holloman Air Force Base by the contractor for final reconfiguration to pure PQM-102 targets.

The program was originally planned to be completed by January 1974. However, due to unforeseen technical delays and an ambitious schedule, the program was not completed until November 1974. The program, as it related to milestones, initial engineering (Phase I) at Crestview, engineering development (Phase II) and flight test program (Phase III) at Holloman Air Force Base, together with the test objectives, methodology, and flight test profiles, is outlined in the remainder of this section.

2. MILESTONES - SCHEDULED VERSUS ACTUAL

a. Initial Program Milestones

A contract was awarded on 31 March 1973 to develop and flight test the PQM-102 Target System for use as an afterburning target. Individual engineering assignments were established by 2 April 1973 and work was begun to establish the system configuration in compliance with the contract.

The prime contractor was responsible for the development of the entire system. The prime contractor's activity in brief terms included the design and development of the FCSS; development of peculiar AGE, including PMTS, ECU, and STB for testing of the entire target vehicle; management of the overall program and administering of major selected subcontractors, including procurement of the guidance equipment; and modification, conversion, and test of the F-102A aircraft to a QF- (quantity 3) and a PQM-102 (quantity 5) configuration. The prime contractor was also responsible for operating the vehicle to meet the performance requirements of the SOW.

Major subcontractors were selected to assist the prime contractor in performing aircraft modifications and maintenance during the developmental flight test phase at Crestview and the operational phase at Holloman Air Force Base. Subcontractors were also selected to provide the guidance system, brake control system, and the major destruct system components for the QF/PQM-102 targets.

The initial R&D schedule given in Table 1 depicts a fairly accelerated development schedule for the QF/PQM-102 Target System. This schedule shows the general milestones attached to this program at its initial onset. The basic design and analysis was scheduled for completion by the middle of July 1973, culminating in the delivery of the FCSS related hardware by mid-September 1973. The required AGE, aircraft modification (on the first QF-102), and MGS were also scheduled to be completed near that time to allow system integration of all the varied subsystems of the QF/PQM-102. Systems integration was expected to be completed by mid-November 1973 at the contractor test site (Crestview). Transition would be made to the Holloman Air Force Base site for continuance of PQM-102 aircraft testing and demonstration NULLO flights. Total R&D program completion was scheduled for mid-June 1974.

b. Program Milestone Summary

Many factors proved the initial schedule imposed on this contract to be unrealistic. Integration of the varied and complex subsystems of the QF/PQM-102 required more time than originally anticipated. However, the first NULLO was successfully completed on 13 August 1974, less than 18 months from the contract award date. The major unanticipated factors that caused schedule delays are itemized as follows:

- Abnormally long lead times were encountered on many standard electronic parts due to the state of the electronics industry during this time period.

- The PQM-102 SPO and the prime contractor had continuous problems in achieving approval of the destruct system and approval to fly NULLO flights from the White Sands Missile Range, Range Safety Office. This resulted in a considerable delay in the scheduling of the first NULLO.

- Several design changes that were made as a result of Design Review No. 1 caused some delay in the initial development stages.

- Insufficient time was allowed in the initial program schedule to accommodate the technical problems that are itemized in paragraph 4.c. of this section. For example, Hydraulic Elevon Package (HEP) valve lockout of the existing F-102A HEP valves resulted in significant delays.

TABLE 1. QF-102A/PQM-102A TARGET SYSTEM PROGRAM MILESTONES

CONTRACT ITEM NO.	ITEM	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
	YEAR	1973									1974					
1	DESIGN AND ANALYSIS	▬	▬	▲												
	DESIGN REVIEW 1			▲												
	DESIGN REVIEW 2								△				▼			
2	FCSS DEVELOPMENT	▬	▬	▬	▬	▬	▲	▼								
3	AIRCRAFT CONFIGURATION/MODIFICATION															
3AA	F-102A SN 56-1347						▲									
3AB	F-102A SN 56-1400						△		▼							
3AC	F-102A SN 56-1475 (LATE)							△	▼							
4	PECULIAR AGE															
	PREMISSION TEST STAND						▲ 1	▲ 1								
	ENGINE CONTROL UNIT					▼ 1	▲ 1	▼ 1								
	SYSTEM BENCH						▲ 1	△ ▼ 1								
	BRAKE CONTROL TEST SET				▼ 1	▼ 1	△									
	RADAR SIMULATOR (VEGA)						△	▲ 1	▲ 1							
5	COMMAND, CONTROL, AND DATA SYSTEM															
5AA	FIXED GROUND STATION						△				▼					
5AB	MOBILE GROUND STATION						△	▼								
5AC	AIRBORNE UNITS					△	△	△	▼ 2	▼ 1	▼ 3	▼ 2				

- INITIAL MILESTONE △
- ACTUAL MILESTONE ▽ (WHERE DIFFERENT FROM INITIAL SCHEDULE)
- SHADED AREAS INDICATE ACTUAL COMPLETION SCHEDULE
- NUMBERS IN SCHEDULE INDICATE DELIVERY QUANTITIES

TABLE 1. QF-102A/PQM-102A TARGET SYSTEM PROGRAM MILESTONES (CONCLUDED)

CONTRACT ITEM NO.	ITEM	YEAR	1973									1974									
		MONTH	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
6	TRAINING																				
7	INTEGRATE SYSTEMS																				
7AA	QF-102																				
7AB	PQM-102																				
8	TEST SUPPORT SERVICES																				
8AA	AT CONTRACTOR'S FACILITY																				
8AB	HOLLOMAN AFB, NM																				
			PER PRIME CONTRACTOR'S DATA SCHEDULE																		
9	PQM-102A TARGET FIRST NULLO																				
9AA	F-102A FAD 604																				
9AB	F-102A FAD 605																				
9AC	F-102A FAD 606																				

- A strike imposed by a subcontractor's personnel lasted two weeks during February 1974. This complete work stoppage had far reaching effects that considerably impacted the overall schedule.

- Ground checkout of the aircraft prior to a mission was found to take more time than originally anticipated. This was due to the high degree of confidence that the test must provide. On previous programs this confidence was provided by means of inflight evaluation of the system with a man on board. While the PMTS test had been very successful in providing the degree of confidence necessary for the unmanned PQM-102 aircraft concept, future RPV programs where the vehicle is totally unmanned should consider a more automated method of premission test during initial design stages.

- Additional work scopes were added during the program, e.g., the low altitude modification and destruct system redesign. These additional requirements extended the total program lengths.

3. ENGINEERING DEVELOPMENT - PHASE I

a. Initial Design Requirements

The scope of the initial design covered development and definition of the Flight Control and Stabilization System (FCSS), Command and Control System, Aerospace Ground Equipment (AGE), and aircraft modification. These systems were to be designed to meet or exceed the requirements of the R&D SOW. Each of these subsystems are discussed briefly in relation to their design requirements.

(1) Flight Control and Stabilization System (FCSS). The FCSS was developed to provide automatic control and stabilization of the QF-102 and the PQM-102 target system in response to remote commands or in the event of a loss of remote command and control. The FCSS was designed to provide:

- Automatic takeoff program

- Automatic runway takeoff abort routines

- Automated program to recover the aircraft from unusual attitudes in the event of a LOC or completion of maneuver

- Automatic LOC programs to place the vehicle at safe attitudes, altitudes, thrust settings, and airspeeds depending on the orientation of the vehicle at the time of LOC

- A command destruct maneuver

- A remote command and failsafe explosive destruct capability

- A capability for automatic maneuver presentations

- Proportional data for telemetry purposes

- Backup FCSS electronics and actuators that allowed remote control of the aircraft in the event of a secondary hydraulics failure or primary FCSS electronics failure. The majority of the FCSS design requirements imposed by the SOW were realistic requirements that were achievable with the present state of the art design and analysis techniques. Some areas that presented additional hardware requirements were:

  - The roll attitude hold requirements were found to require a roll error integrator during the high performance maneuver presentations

  - The requirement for attaining 5g in four seconds required the addition of a g error integrator to achieve the g rapidly coupled with a rate limit on the command to prevent overshooting of the g-setting. (Other design problems are discussed in paragraph 4. of this section.)

The system design, however, was a fairly complex one due to the numerous modes of operation and automatic programs. Future programs may want to closely evaluate the need for each of the modes. However, the most significant design constraint was the design schedule requirement.

(2) Command and Control System. The requirements for the command and control system were basically to provide a remote command and control via either an FGS (control to 200 miles line-of-sight) or via an MGS (control to 50 miles line-of-sight). In addition, the frequency of operation was specified to be within the DoD approved command/control frequency spectrum. The system was required to interface with the existing FPS-16 radar system. Transfer of control between the fixed site and mobile stations was to be accomplished without interruption of positive ground control.

The above requirements were met via implementation of a command and control system by modifying existing equipment designs; however, some problems were experienced with multipath during the development phases of the program (this is discussed in paragraph 4. of this section).

(3) Aerospace Ground Equipment (AGE). The following peculiar AGE were developed under this contract:

- System Test Bench (STB), SPN 4015239

- Premission Test Stand (PMTS), SPN 4015240

- Brake Control System Test Set, SPN 4019261

- Engine Control Unit (ECU), SPN 4015238

- Radar Simulator, SPN 4019263-901

(4) Aircraft Modification. The aircraft modification design and analysis was undertaken to accomplish the following:

- Removal of unnecessary equipment

- Installation of new hardware (electronics gear, control actuators, antenna installation, aircraft wiring modification, Explosive Destruct System, and Smoke System)

- Structural integrity stess analysis

- Electrical load analysis

b. Modification of the F-102A Aircraft

The initial design effort for the modification of the F-102A aircraft into the QF/PQM-102 Target System took place in April and May of 1973. Engineering information used to coordinate the design was provided to the subcontractor via prime contractor engineering bulletins. These engineering bulletins contained electrical and mechanical information on how to modify the aircraft to properly interface with the FCSS pallet.

The subcontractor's engineering department used these engineering bulletins as design guidelines along with applicable Military Standards to formulate the aircraft modification. In addition, a prime contractor engineer was at the subcontractor site during the design period to coordinate any interface problems and assist with the aircraft modification design. The major areas of aircraft modification design were pallet installation, servo actuator installation, brake control system installation, electrical modifications, and the Smoke System design.

The pallet and pallet installation were designed at the same time in the design phase; therefore, all changes to the pallet had to be kept to an absolute minimum. When the first pallet sheet metal was assembled it was taken to the subcontractor site for a fit check in the aircraft. This check pointed out the need for some minor changes in the aircraft to finalize the pallet installation design. This design philosophy proved beneficial in mid-September 1973 when the first fully assembled pallet and modified aircraft were interfaced.

Rotary servo actuators installation design presented no problems except for the throttle installation. Since the throttle linkage uses an enclosed cable (Teleflex) from the throttle lever to the engine, a special gear box had to be used to interface the servo actuator to the throttle control.

The control brake installation required special attention during the design phase to control the interface of equipment in that the aircraft had to be modified to accommodate the brake components.

The electrical wiring modification of the aircraft was twofold. First, designing the interface between the aircraft and FCSS to provide aircraft sensor information and the capability to actuate the flight controls and aircraft subsystems. Second, modifying the aircraft electrical power distribution system to provide a power system consistent with the demands of unmanned flight. The Air Force suggestions as a result of Design Review No. 1 weighed heavily in the final design of this system.

The Smoke System design progressed smoothly during the initial design phase. The major change in the system prior to flight was due to changes in the oil tank to provide enough strength to withstand the 8g PQM-102 aircraft mission requirements.

The evolvement of the Group A acceptance testing philosophy and test procedures was critical to the overall PQM-102 Target System concept. This test checks each wire that was added or changed by the aircraft modification for proper continuity and insulation. Modified systems are functionally tested to determine proper operation prior to unmanned flight.

c. Subsystem Integration and Checkout

The extent of installation, ground testing, AGE verification, and flight tests that were accomplished at the subcontractor's facility (Crestview) were as follows:

(1) AGE Usage, Installation Procedures, and Ground Test Validation. Three aircraft were involved in the ground testing at Crestview. Two aircraft (FAD 601 and FAD 602) were used as the primary test bed vehicles for the flight control and stabilization system, while the Smoke and brake control systems were evaluated on the third aircraft (FAD 603).

Aircraft modifications were tested by the subcontractor in accordance with their Group A test plan. Installation of FCSS hardware and subsequent ground testing of the various FCSS subsystems was accomplished in accordance with the prime contractor's ground test engineering bulletin. This procedure formed the basis for FCSS integration and premission testing since the premission test procedure had not been written and validated at this time. The majority of all testing was accomplished utilizing the PMTS. This allowed a continuous and thorough evaluation of the usage of this piece of AGE. Additional capability was added to this piece of AGE during the course of evaluation by means of addition of test points within the FCSS circuitry. The ground test procedure was streamlined at a later date when the PMTS procedure had been validated.

The STB provided an additional means for system integration and checkout capability. While testing was being accomplished on the aircraft, additional subsystems could be checked and interfaced on the system bench. This capability was extensively utilized in the checkout of the maneuver programmer and backup autopilot.

System testing of the brake control system was aided by means of the brake control test set. The design and performance of this test was adequately demonstrated at that time.

The usage of the ECU was not validated at Crestview due to the emphasis placed on the QF-102A aircraft and integration of the basic FCSS; however, the ECU was subsequently validated at Holloman Air Force Base.

(2) Extent of System Integration. The system integration that was accomplished at Crestview consisted of the following:

- Flight test evaluation and establishment of all of the gains of the primary FCSS

- Integration of the maneuver programmer on the STB

- Basic integration of the Command Control/Telemetry System to the FCSS. Final integration was accomplished at Holloman Air Force Base after resolution of some of the multipath problems.

- Brake control system integration

- The visual augmentation system was tested. Visual augmentation performed poorly when the afterburner was on. This was not resolved until the Holloman Air Force Base phase of the program.

d. Flight Test Summary

The major achievements of the flight tests conducted at Crestview entailed:

- FCSS gain optimization

- LOC program verification and optimization

- Verification of the brake control system

- Evaluation of the Command Control/Telemetry System

- Evaluation of the primary and secondary radar systems of the MGS and its plotting capabilities

A total of 21 engineering flights were flown during the Crestview flight test phase. This comprised 50 percent of the total number of flights actually flown. A number of flights were for demonstration.

At this point in time, maximum effort was extended to provide demonstration flights and maintain the original schedule. This pressure to maintain schedules tended to be counter-productive because meticulous analysis of each flight was needed to pinpoint problem areas.

e. Problem Areas

Some of the more relevant technical problem areas and respective solutions are summarized below:

- Elevon feedback signals were washed out to provide precise attitude control at any flight condition.

- Primary and standby automatic direction indicator validity circuits had to be revised for proper operation.

- A rate compensation circuit and associated HEP valve amplifier gain increase was removed when it was found that desired loop response could be obtained with nominal gain and no rate compensation.

- System noise resulting in erratic surface fluctuations was reduced by more carefully routing box grounds and by removing unused HEP valve center tap wires which were unterminated and ran considerable lengths.

- Various system logic interlocks were changed to provide desired operational characteristics and to relieve pilot workload.

- System test points were added to allow more complete ground testing.

- Roll surface limiting to ± 2.5 was found to be due to weak HEP valves. (HEP valves breaking-out at low force levels.)

- Airborne telemetry system decoders were modified to eliminate noise spikes superimposed on the received proportional signals.

- Erratic downlink proportional data was eliminated by connecting digital register overflow problems.

- Excessive downlink data problems were resolved by eliminating the possibility of enabling fore and aft telemetry systems simultaneously.

An extensive stability and control analysis was conducted prior to the flight test activity which provided optimum gain data for the longitudinal and lateral axes. This analysis was conducted utilizing Convair stability derivative data. The simulation utilized three degrees of freedom per axis and was limited to small perturbation equations. This simulation proved to be very well ballparked by this analysis. Some gains required only a slight reduction, as would be expected, since the simulation was conducted in a noise- and turbulent-free environment. Outer loop air data gains required a substantial increase in gain to achieve snappy and tight altitude, airspeed, and Mach hold control loops.

A design deficiency was discovered early in the flight test program. It was found that automatic pitch trim was necessary in the FCSS electronics. The original philosophy entailed that the pilot supply a trim command.

This was found to be unacceptable because the remote pilot did not have adequate cues to rapidly accomplish this task. Also, trim changes due to speed changes accomplished while engaged in an attitude hold mode would be accounted for by the autopilot. When the pilot attempted to take his stick out of detent, the attitude hold mode would be reset and the trim would revert to the pilot's trim. This was noted to cause transients on disengaging modes. The aircraft would also occasionally pitch in the wrong direction when the remote pilot moved his stick fore or aft. This was particularly objectionable during final approach.

The HEP valve lockout problem of the standard F-102A was discovered at Crestview. This problem results in loss of FCSS control of the control surfaces. No concrete solution was obtained at Crestview. Further HEP evaluation was performed at Holloman Air Force Base during maneuver programmer high g evaluation.

Numerous command/data dropouts were apparent at Crestview. In addition, the plotting capability of the MGS was found to be very poor. These problems were resolved at Crestview.

Several modifications to the brake control were discovered to be necessary and are discussed as follows:

- During initial brake system testing it was found that secondary hydraulic pressure used to operate the brake control system caused a small buildup of manual brake pressure so that when the automatic system was disengaged the manual brake pressure would not allow complete brake release. To alleviate this problem a pressure relief system was added to the master brake cylinder.

- Additional testing revealed that engagement of the anti-skid brake system followed by disengagement and reversion to the manual brake system caused a soft pedal condition indicative of air in the brake lines. This problem was finally tied to air leakage in the relay valves which was aggravated by step fashion removal of anti-skid brake pressure. Relay valve rework was required to remove worn areas and to install improved O rings on the valve piston. This provided an effective solution to the problem.

- A wheel spinning device was originally procured to spin the wheel to check for wheel transducer output. It was later determined that the transducer output voltage gradient was large enough that the same test could be achieved by jacking each wheel and rotating the tire by hand. This procedure is presently being used in the premission test.

4. ENGINEERING DEVELOPMENT - PHASE II

a. Finalization of Aircraft Modifications

During the flight test program several problems were solved by changes to the aircraft itself rather than changes to the added aircraft systems.

(1) Smoke System. The Smoke System functioned very well at military power and below; however, the oil used to generate smoke would burn during afterburning operation producing no smoke. Several modifications to the nozzle were tried but would not provide satisfactory results for both afterburner and non-afterburner operation. The final resolution of this problem added a second smoke nozzle on the aspirator to operate during afterburner operation. This nozzle mixes engine bleed-air with oil to produce smoke outside the high temperature area of the afterburner plume.

(2) Brake System. Two problems associated with the brake system were discovered during the flight test. First, since the anti-skid brakes operate in parallel with the aircraft manual brakes, fluid from the anti-skid brakes transferred in the manual brake reservoirs causing a malfunction, locking the wheels. A vent was added to the brake master cylinder to allow excess brake fluid to overflow into an added receptacle. Second, an oscillation in the hydraulic and pneumatic portions of the brakes resulted in a distinct choo-choo sound when the brakes were applied and ultimate overheating of the aircraft hydraulic system. Orifices were added to the brake relay valves to damp the oscillations which also cured the problem of hydraulic overheating.

(3) Antenna Relocation. LOC occurred occasionally during takeoff with the C-band antennas located on the nose and center fuselage of the aircraft. These LOC were caused by shielding of antennas by the aircraft. This was solved by removing the forward antennas and adding an antenna to the tip of the vertical fin. No further occurrence of LOC during takeoff has been attributed to antenna shielding.

(4) Auto Trim. The wiring of the aircraft auto-trim system was modified (QF and PQM) and the force feel system was disabled (PQM only) to allow compatibility of the FCSS to aircraft interface when high g maneuvers were required. These modifications allowed the FCSS nearly full authority in positioning the elevons.

(5) LOC Tone. The UHF communications radio was used to alert ground controllers to an aircraft LOC. The LOC keyed a tone (pickle tone) on the UHF mission frequency by way of an added panel in the aircraft which was in turn connected to the aircraft AN/ARC-34 radio.

Due to the high g environment of the PQM-102 aircraft and the possibility of Ram Air Turbine (RAT) extension during these high g, the RAT was removed and the door secured on all PQM-102 aircraft.

b. Finalization of Test Procedures

Three categories of test procedures were used to test, evaluate, and repair the PQM-102 Target System. A ground procedure was used with the PMTS to conduct initial test and calibration of the aircraft. A premission procedure was used with the PMTS to test, troubleshoot and certify the airborne system prior to flight. Procedures were also maintained to conduct tests on the STB, FCSS, and on each of the major components. The procedures covered testing, calibration, and isolation of failures to the lowest repairable level.

(1) Ground Test Procedure. The ground test procedure was implemented at the beginning of the testing phase of the program at Crestview. The procedure was serviced and expanded to allow in-depth testing of the FCSS and its interface with the aircraft. At Holloman Air Force Base the procedure was reorganized to facilitate testing and expanded to cover government furnished equipment systems on the PQM-102. Calibration procedures were developed for the stall warning vane, rudder center position, and elevon position feedback sensors. As the target system was finalized, the ground test procedure was updated as required to test the new parameters.

The major aircraft modifications which required changes to the ground test procedure are as follows:

- New transponders
- Changes to the automatic takeoff program
- Changes to system gains
- Addition of g error integrator
- Optimization of backup autopilot
- Implementation of low altitude mode
- White Sands Missile Range changes to the destruct system
- Optimization of maneuver programmer operation
- Addition of roll integrator
- Changes to nosewheel steering operation
- Changes to brake control system
- Addition of pitch trim

(2) Premission Test Procedures. The development of the premission test procedure was started during the initial testing at Crestview. The interface with the target system was established based on the information obtained during the ground test, and on system test requirements to isolate failures to a major replaceable component level. At Holloman Air Force Base the procedure was formalized and used to test all the PQM-102 aircraft before flight. During this time, a number of modifications were implemented to facilitate testing and to correct discrepancies which had developed.

To facilitate testing, switches were added to the PMTS to allow the operator to have primary FCSS function commands remote from the aircraft cockpit. Light indicators were added to increase the number of function displays available to the operator. Target system modifications also required modifications to the PMTS to allow testing of new functions. Controls and indicators were added as a result of the following changes:

- Addition of g error integrator - addition of a switch to bypass the integrator to test gain of pitch channel
- Implementation of low altitude mode - addition of a switch to command radar altitude test mode
- White Sands Missile Range destruct test - addition of a switch to command failsafe OFF and a light indicator for WOG signal

- Addition of roll integrator - addition of a switch to bypass integrator to allow gain test of roll channel

- Operation requirements - a throttle limit bypass command was added to the RF control link. A switch was also added to prevent the ground controller from transmitting an unintentional pitch command

Modifications to correct discrepancies were as follows:

- Cable clamps - large cable clamp boots were added to the aircraft PMTS interconnect cables to protect the wiring insulation from damage

- Grounds - signal and power grounds were separated in the PMTS to reduce conducted noise

- Backup VG torquing - the harness required modification to provide backup rotary inverter power when torquing the backup vertical gyro

- Connector covers - covers were added to protect the connector pins when the cables were not in use

The test procedure was revised as needed to correct deficiencies and to implement new requirements as a result of aircraft modifications. The changes due to deficiencies are as follows:

- The test of the aircraft HEP valve and trim circuit was inadequate to determine proper operation. The procedure was changed to incorporate the Air Force Technical Order procedures for testing the trim system and the servo-HEP valve test was changed to allow testing of each elevon individually. Operation of the target system has proven that the test is now effective.

- A test was added to test the power-on and the calibration commands to the DIGIDOPS system.

Target system modifications which required procedure changes are as follows:

- New transponders - addition of test for Automatic Gain Control (AGC) commands and signal levels

- Automatic takeoff mode optimization - changes to airspeed and altitude command levels, gains, and resultant modes

- System gains - changes to measured parameters

- Addition of g error integrator and roll error integrator - change to procedure to conduct gain test and addition of test of integrator

- Backup autopilot - changes to gains measured

- Implementation of low altitude mode - addition of test for low altitude configuration and radar altimeter

- White Sands Missile Range destruct test - complete revision of destruct test to comply with White Sands Missile Range request

- Maneuver programmer - changes to results measured

- Nosewheel steering modification - test revised to cover new operating mode

The STB procedures for use on major components were direct adaptations of the factory test procedures used to conduct final test of the units before delivery. They were updated wherever a change was implemented in the factory procedure. The system procedure was adapted from the PMTS premission procedure to maintain continuity between bench testing and aircraft testing.

The success of the program has shown that the test procedures that were used did test the target system to a level of confidence needed for flight. The discrepancies of the procedures were correct and the procedures were updated as required to test the system whenever a modification was implemented.

c. Finalization of Target System Integration

Many small changes, briefly discussed below, were made to the target system during R&D. These changes could be grouped together under a single general heading such as Flight Control System Gain Optimization. Other modifications of a more major nature are also discussed, together with details of the original problem and the effectiveness of the implemented solution. The changes are arranged in chronological order, however, many tasks overlap considerably. The dates in parenthesis give the approximate completion date for a particular modification or group of changes. A minority of these changes to the airborne system caused corresponding changes to the PMTS and associated AGE; however, changes to AGE, particularly the PMTS, were minimal. Discussion of test procedure evolution can be found in paragraph 4.b. of this section. The most significant impact on AGE was the result of major destruct system changes by direction from the White Sands Missile Range Safety Office. Several special test fixtures were fabricated to test the destruct system at the PMTS and pre-flight levels of test. The development of this AGE had not been anticipated before the Holloman Air Force Base phase of the R&D program.

(1) Airborne Antenna Relocation (February 1974). Results of antenna evaluation flights conducted during the Crestview phase indicated significant interrogation loss when commanding via the fore telemetry system. Due to the fuselage blockout the problem was more severe because the aircraft was pointing directly away from the control station. In order to optimize the antenna coverage the two antennas of the fore system were replaced by one bent stub type fin antenna located on the top edge of the fin. The new implementation flights conducted at Holloman Air Force Base revealed excellent results.

(2) New Transponder, Modified Decoder (March 1974). Flight test during the early part of the flight test program demonstrated the need for a transponder with AGC capability. The AGC was especially needed when changeover was attempted between the FGS and MGS with their respective wide difference in radiated power. New transponders (Type 302C-8) with AGC and greater sensitivity were installed. Results of further flight tests indicated that the new transponders greatly improved system performance.

(3) Multipath. The multipath problem was first observed at Crestview but not fully recognized until early in the Holloman Air Force Base phase of the program. During a remote QF approach the infamous Christmas Tree effect (many command indicators flashing on and off at the same time) was observed. Evaluation with aircraft FAD 601 and FAD 602 on the ground revealed the cause to be reflected (multipath) pulses interspersed with direct transmission pulses being received and decoded by the airborne system. These extra pulses gave the effect of sending commands when, in fact, none were sent.

Additional tests were made with different transponders and modified decoders in order to further resolve the problem. The final resolution was to use a decoder with a parity check (rejects uplink pulse groups with more than four pulses within the pulse group window). Additionally, a different transponder with a receiver AGC capability was installed. The AGC function allowed direct path transmissions to be decoded with a lower receiver gain and thereby eliminated most of the reflected pulses because of their lower signal strength.

(4) Automatic Takeoff Optimization (March 1974). Optimization of the automatic takeoff sequence is summarized as follows:

- The climbing pitch attitude reference was increased from 10 to 13 degrees

- Rotation speed was changed from 135 KIAS to 150 KIAS

- Automatic takeoff was changed to engage after the ground roll had been started manually by the controller. (This allowed for alignment corrections, stick inputs, and engine performance evaluations prior to initiating the automatic takeoff.)

- The airspeed on the pitch speed switch point was decreased from 250 KIAS to 240 KIAS

- When the airspeed on pitch mode was engaged with a large reference error, the aircraft responded with large and rapid pitch attitude change. To overcome this problem, a lag/integrator network was connected to the airspeed error path. When the mode was engaged, the integrator switched from its synchronized state to an effective lag which allowed the error signal to propagate through to the HEP values. This effectively produced a slow-in for the airspeed error signal. Flight test results at Holloman Air Force Base indicated the modification performed well.

- Airspeed on the pitch mode, which previously engaged at 3500 feet, was changed to 6100 feet. (Altitude 2000 feet above ground level switch for White Sands Missile Range.)

- Orbiter altitude was changed from 14,000 to 20,000 feet.

(5) System Gain Optimization (March 1974). A great deal of the system gain optimization was performed at Crestview; however, a minor part of this basic calibration was performed at Holloman Air Force Base during January and February 1974. The original computer simulation gave extremely accurate gain predictions for most of the system gains.

(6) G Error Integration (April 1974). Preliminary flight tests performed on the maneuver programmer indicated that g holding was usually out of specification during preprogrammed maneuvers. The problem was eliminated by adding an error integrator which corrected for small g errors occurring in the g command path. Later flights flown with the error integrator revealed improved g accuracy.

(7) Smoke System Redesign (April 1974). Flights conducted at Crestview indicated that augmentation of visual acquisition of the target system utilizing a smoke trail was inadequate when operating in the afterburner range. The system was modified by adding an afterburner nozzle assembly which received oil and mixed it with the engine bleed-air before spraying it into the afterburner exhaust stream. When the target was not operating in the afterburner, the oil was directed to the primary nozzle. The nozzle was positioned to direct the oil stream to impinge on the engine exhaust gasses which produced the smoke trail. Flights flown with the new implementation produced good results.

(8) Backup Autopilot Optimization (July 1974). One of the major tasks accomplished in the early phases of the Holloman Air Force Base test program was optimization of the backup autopilot gains. Aircraft FAD 603 was flown to verify the stability and the controllability of the backup FCSS during level flights through banks of at least 30 degrees and pitch attitudes as necessary for approach and landing conditions. In addition, recovery from unusual flight conditions, pitch and roll damping, and direct throttle and rudder were functionally checked. Test results indicated that overall backup autopilot gains were high. Better stability and controllability were achieved by reducing the gains approximately 50 percent.

(9) Low Altitude Implementation (August 1974). The low altitude flight testing was completed to the limits of the QF-102 flight envelope. The presentations included low passes of 400 feet AGL using barometric altitude sensing and 200 feet AGL using radar altitude. The major changes made to the system during low altitude evaluation were as follows:

- A gain switch was added on the altitude error path to allow the altitude flare to begin at 1300 feet above the programmed altitude (the previous switch point was 500 feet).

- A washout was added to the pitch attitude command to reduce the pitch attitude rate. This modification allowed the transition from high pitch attitude to level without negative g transients.

- Landing/takeoff mode and heading hold on rudder were changed to inhibit about 240 knots.

- The pull up time constant was increased from 0.4 to 1.75 seconds and g feedback was added during the pull up phase. This modification was made to provide an 8g pull up at 600 knots airspeed with 60 degrees pitch attitude.

(10) White Sands Missile Range Required Destruct System Modifications (August 1974). During the course of flight testing at Holloman Air Force Base a great deal of time was spent in liaison with White Sands Missile Range Safety personnel. The Range Safety Office followed the flight testing progress very closely and in several cases directed changes to be made to the circuitry or system design. The most significant changes that were made to the destruct system are listed below:

- The failsafe latch was designed symmetrically so that it would be set with a failsafe ON command and reset with a failsafe OFF command.
- The LOC logic was redesigned so that a failure in the circuitry would indicate a failsafe of LOC condition.
- Orbit altitude was changed to 20,000 feet.
- Downlink telemetry of WOG condition was added.
- Downlink telemetry of failsafe battery voltage was added.
- HEFU Arm comparator was changed to 1920 volts.

In addition to the above changes to the airborne system, special test equipment was fabricated and associated procedures were written. This effort was necessary to accommodate the requirements of the White Sands Missile Range Safety Office.

(11) Maneuver Programmer Validation (October 1974). Two main problems surfaced during the maneuver programmer flight test: (1) premature programmer resets and (2) HEP valve lockout problems.

The first problem manifested itself in a number of different ways. Usually the maneuver would reset to recovery before the maneuver time had expired but occasionally the programmer would skip its second phase entirely or run for an excessively long time. The problem could only be repeated on the ground by special equipment and elaborate troubleshooting techniques. Using these techniques, high voltage noise transients were injected into the automatic flight control stabilization system and all the problems found during flight test could be duplicated. It was a relatively simple matter to add two noise filters to the maneuver programmer circuitry to reduce noise susceptibility. The erratic maneuver programmer performance was eliminated completely by these changes.

HEP valve lockout problems were only seen when flight profiles called for maneuvers in excess of 4g. Simply, the HEP valves reached an operating regime during high g maneuvers that caused the valve not to respond correctly to further command. This was seen in flight as uncommand aircraft roll and occasionally excessively high g load factors. Various unsuccessful attempts were made to cure the problem. Eventually the force feel system used to provide artificial control stick feel to the original F-102 pilot was disabled which resulted in greatly improved HEP valve performance. However, the basic HEP valve lockout problem still remains and can only be completely eliminated by major changes to the F-102 HEP valve design.

(12) Roll Integration Addition (October 1974). It was found that roll attitude hold during maneuver programmer was not consistently within specification tolerance. The bank angle tended to either over- or undershoot the required value, which was especially noticeable at high bank angles. A roll integrator was added to the roll command path when the maneuver programmer was engaged and roll error was less than 10 degrees. This implementation performed well and gave excellent roll attitude hold performance.

(13) Nosewheel Steering (January 1975). Poor aircraft response to nosewheel steering command and the danger involved in a heading reference system hard-over failure during landing or takeoff ground roll led to a modification of the nosewheel steering control law. The new system employed a lagged command amplifier instead of an integrator and resynchronized the heading reference signal whenever a skid command was received. To compensate for nosewheel steering actuator dead zone the time to clamp to a new heading reference was delayed 1 second after termination of a skid command. The new system was flight tested extensively in December 1974, January 1975 and February 1975 and proved to be a marked improvement over the old configuration.

(14) Brake Control System Modifications. The initial brake control system design was demonstrated during the Crestview phase of the program. The demonstrations went well although several changes to the brake system were made at this time and also later at Holloman Air Force Base. A narration of the testing, problems, and modifications of this system can be found in this section, paragraph 4.a.

5. FLIGHT TEST PROGRAM - PHASE III

The DT&E/IOT&E flight test program was conducted at Holloman Air Force Base between January and November 1974. This program was in concert with the Phase II engineering development effort that was required for finalization of system performance integration and development of ground test procedures. After the start of system verification and QF-102 record flights, other unforeseen technical problems and requirements arose that precluded uninterrupted conduct of the formal flight test program. As a result, numerous engineering evaluation flights and demonstration flights were needed on an as-required basis throughout the program. A recap of the requirements and problem areas is as follows:

- White Sands Missile Range demonstration flights were required for simulated destruction of the target and support of destruct system reliability.
- Roll attitude hold was not consistent during presentations. The corrective roll error integrator circuitry provided excellent roll attitude hold but required extensive evaluation.
- The brake control and nosewheel steering systems required modifications to eliminate overheating and to improve directional control below 85 knots, respectively.

- The automatic takeoff mode pitch attitude required optimization to assure rotation to 11 degrees pitch at 150 knots.

- G overshoot was experienced and g holding was usually out of specification during presentations. The corrective error integrator required extensive evaluation.

- The Smoke System required redesign to assure sufficient smoke during afterburner operation.

- The backup autopilot gains were in need of optimization to assure stability and controllability.

- The low altitude maneuver programmer required addition of a gain switch and modification to provide an 8g pullup at 600 knots with 60 degrees pitch attitude.

- HEP valve lockout occurred during high altitude presentations in excess of 4g. Usually, the maneuver would accomplish recovery prior to expiration of the maneuver time. Extensive in-flight troubleshooting was required. The remedial action which consisted primarily of disconnecting the force feel system on PQM-102 aircraft notably improved HEP valve performance.

During the flight test program, the AFSWC test director monitored the contractor's progress and compliance with flight plans and procedures. Additionally, the test director evaluated the quality of data gathered from QF/PQM-102 record flights and associated ground tests, all of which are shown in Section IV and Appendix A of this report.

The PQM-102 SPO maintained a flight test director and engineering representative on the test site for rendering final decisions on contractual test matters, providing overall technical direction, and performing the duty of government acceptance pilot.

The overall and specific flight test objectives, flight test methodology, test profiles, and typical 48-hour flight plan were as follows:

a. Overall Flight Test Objectives

The primary program test objectives at Holloman Air Force Base were the conduct of 13 hands-off QF-102 reliability flights, 14 hands-off QF-102 record flights, and 5 PQM-102 record flights for the successful demonstration of:

- All ground and airborne systems associated with the target system.

- Target system reliability and operational effectiveness and maintainability.

- PQM-102 de-manrated concept.

- Contractor capability to maintain and operate the target system in an operational environment.

- Target profiles providing the necessary variations/combinations for both IR and RF missiles.

- DIGIDOPS interface with the QF/PQM-102 Target System to provide adequate scoring data for air-to-air missile performance evaluations.

The specific test objectives and allowable tolerances and/or parameters are contained in Table 2.

b. Flight Test Methodology

The contractor's flight test program was conducted in a progressive and systematic method via the directed use of the 30-day schedule, 48-hour test plan, and the PQM-102 SPO/AFSWC test director's monitorship of all flight tests.

(1) The 30-Day Schedule. This schedule was prepared by the contractor and approved by the PQM-102 SPO/AFSWC test director. It included a breakdown of the individual flights to be flown the following month, availability time of White Sands Missile Range radars, general purpose of each flight, date, and profile.

(2) The 48-Hour Test Plan. This plan was prepared by the contractor, approved by the PQM-102 SPO/AFSWC test director, and was formally briefed and debriefed by the contractor to the JTF prior to and after any flight referenced in the 30-day schedule and/or blackboarded mission. Essentially, this plan delineated the detailed/specific events to be demonstrated or practiced with the associated parameters as outlined in the SOW. Additionally, the plan contained the modes and one of the six approved profiles showing the ground track as it related to White Sands Missile Range.

The plan was briefed two hours prior to the scheduled takeoff time. During this meeting, the contractor addressed each event, mode, controller techniques, emergency procedures, and aircraft status. In addition, the AFSWC test director assigned JTF members to the tow caravan, when applicable, and the MGS and FGS to monitor and observe compliance with procedures and to document the instrument readings as noted on the controller panels.

The debriefing was held 30 minutes after each mission and covered every aspect from the start of preflight checks of the remote control equipment to engine shutdown. The debriefer followed the plan and solicited chronological and detailed accounts from the respective ground chief, safety pilot, and MGS/FGS controllers. The meeting concluded with a summation of the successes and failures and joint agreement among the PQM-102 SPO/AFSWC test director and the contractor. The contractor was also tasked to provide documentation to the PQM-102 SPO/AFSWC test director outlining the cause for any unsuccessful event and the fix prior to any rescheduling and/or redemonstration.

TABLE 2. SPECIFIC OBJECTIVE MATRIX

Objectives/Parameters	Evaluation Site	Test
Flight Control and Stabilization System		
Positive control handoff within 50 nmi of MGS	Government	Air
Automated takeoff with afterburner; runway 8,000 feet long by 200 feet wide	Government	Air
Automated ground abort routines landing and takeoff	Government	Ground
Airborne abort routines; ground inserted programs	Government	Air
Destruct capability/procedures:		
Positive Command	*Government	Air
Positive command hard-over	*Government	Ground
Failsafe	*Government	Air
Performance parameters, initiated by ground command, programmed and manual:		
A level, constant altitude, constant +5g turn established in 4 seconds	Government	Air
Two or more ground-programmed, command selected two-plan maneuvers	*Government	Air
Altitude envelope: QF-102 surface to 45,000 feet; PQM-102 surface to 55,000 feet	Government	Air
Low altitude performance: 400 feet AGL without radar altimeters; 200 feet AGL (100 feet desired) with radar altimeter (±25 feet desired, ±50 feet required); 500 feet AGL with 4g level turn	Government	Air
Altitude hold: +1.0 foot/degree of bank plus the greater of ±50 feet or ±0.5 percent (±2 percent for preprogrammed)	Government	Air
Airspeed capability: QF-102 refer to Technical Order 1F-102A-1; PQM-102 1.35 Mach at 35,000 feet	Government	Air

TABLE 2. SPECIFIC OBJECTIVE MATRIX (CONTINUED)

Objectives/Parameters	Evaluation Site	Test
Flight Control and Stabilization System		
Airspeed Mach hold: ±0.03 Mach except 0.95 to 1.05 Mach; ±2.0 knots below 275 knots, ±10 knots above 275 knots	Government	Air
Attitude capability: pitch up to ±60 degrees; roll up to ±135 degrees	Government	Air
Attitude hold (measured excursion of the pitch and roll gyro reference):		
±0.5 degree pitch for bank angles less than 20 degrees	Government	Air
±1.0 degree pitch for bank angles 21 to 45 degrees	Government	Air
±2.0 degrees pitch for bank angles more than 45 degrees and accelerated flight or configuration change	Government	Air
±1.0 degree roll for bank angles to 45 degrees	Government	Air
±2.0 degrees roll for bank angles more than 45 degrees	Government	Air
Heading hold: ±1 degree (measured excursions of heading gyro)	Government	Air
G capability: PQM-102 only - 1.0g to 8.0g with 1.0g overshoot	Government	Air
G hold: ±0.5g (±0.1g design goal) once maneuver is established	Government	Air
Control limits to preclude exceeding aircraft aerodynamic capability	Government	Air
Target Configuration/Modification		
High voltage safety provisions	Contractor	Air
Airborne backup power sources	*Government	Air/Ground

TABLE 2. SPECIFIC OBJECTIVE MATRIX (CONTINUED)

Objectives/Parameters	Evaluation Site	Test
Target Configuration/Modification		
Backup flight control systems	*Government	Air/Ground
Air conditioning - target cooling requirements/ capability	*Government	Air/Ground
GFE scoring (DIGIDOPS) interface downlinking and command system	Government	Air
Nonessential equipment removal	Contractor	Ground
Subsystem additions performance		
Anti-skid braking system	*Government	Ground
Drag chute/drag hook deployment by remote command	*Government	Ground
Telemetry data downlink installation and capability	*Government	Air
Radar beacon transponder	*Government	Air
Visual augmentation	*Government	Air
Fuel boost pumps remote activation/de-activation	*Government	Air
Command and Control		
Simultaneous activation of separate continuous commands	Government	Air
Compatibility of C&C and GFE data recording equipment	*Government	Air/Ground
Airborne/Ground C&C Compatibility		
MGS positive control of QF/PQM-102 within 50 nmi radius including takeoff and landing	*Government	Air
MGS/FGS positive control hand-over	Government	Air
FGS positive control of QF/PQM-102 within a 200 nmi line-of-sight radius	Government	Air

TABLE 2. SPECIFIC OBJECTIVE MATRIX (CONTINUED)

Objectives/Parameters	Evaluation Site	Test
Command and Control		
Adequacy of voice communications air-to-ground and ground-to-ground	*Government	Air/Ground
MGS X-Y plot adequacy	*Government	Air/Ground
Flexibility of MGS: primary power; 30 minutes backup power; mobility; and visibility of operators	*Government	Air/Ground
Destruct system security from activation by extraneous signals	*Government	Air/Ground
Data system capability		
Monitoring function accuracy	*Government	Air
Pitch and roll proportional channel resolution of 1 and 2 percent, respectively	Government	Air
Simultaneous display of air-to-ground data at the FGS and MGS	Government	Air
Radar beacon remote operation	*Government	Air/Ground
Airborne/Ground antenna compatibility	*Government	Air/Ground
Aerospace Ground Equipment		
System test bench	*Government	Ground
Premission test stand	*Government	Ground
Engine control unit	*Government	Ground
Brake control system test set	*Government	Ground
Radar simulator	*Government	Ground
Target group simulator	*Government	Ground
Other Requirements		
Safety	Contractor	Air/Ground

TABLE 2. SPECIFIC OBJECTIVE MATRIX (CONCLUDED)

Objectives/Parameters	Evaluation Site	Test
Other Requirements		
Maintainability	Contractor	Ground
Reliability	*Government	Air/Ground
Interchangeability	*Government	Ground
Environment	*Government	Air/Ground
Electromagnetic interference	*Government	Air/Ground
Transportability	Contractor	Air/Ground
Human engineering	*Government	Air/Ground
System Integration and Test		
Fourteen QF-102 flights; five PQM-102 flights	Government	Air
Contractor capability to maintain the target system	Government	Air/Ground
Adequacy of technical data, parts lists engineering data, and checklists	*Government	Ground

*Initiated at contractor's facility

c. Test Flight Profiles

To demonstrate all contractual tasks in a unified flight test program, a series of standard profiles were generated. Each profile required certain tasks be demonstrated over a standard ground track:

Profile I (Figure 17) demonstrated:

(1) Response from both MGS and FGS positions
(2) Attitude accuracy in turns
(3) Altitude and heading hold accuracy
(4) Mach and airspeed hold accuracy
(5) LOC above 2000 feet AGL
(6) Programmed maneuver

Profile II (Figure 18) demonstrated:

(1) Response from both MGS and FGS positions
(2) Attitude accuracy in turns
(3) Altitude and heading hold accuracy
(4) Mach and airspeed hold accuracy
(5) Pitch attitude accuracy during configuration and/or airspeed changes
(6) LOC at lower reference altitude
(7) Programmed maneuver

Profile III (Figure 19) demonstrated:

(1) Response from both MGS and FGS positions
(2) Attitude accuracy in turns
(3) Altitude and heading hold accuracy
(4) Mach and airspeed hold accuracy
(5) Pitch attitude accuracy during configuration and/or airspeed changes
(6) Smoke at high altitude
(7) Programmed maneuver

Profile IV (Figure 20) demonstrated:

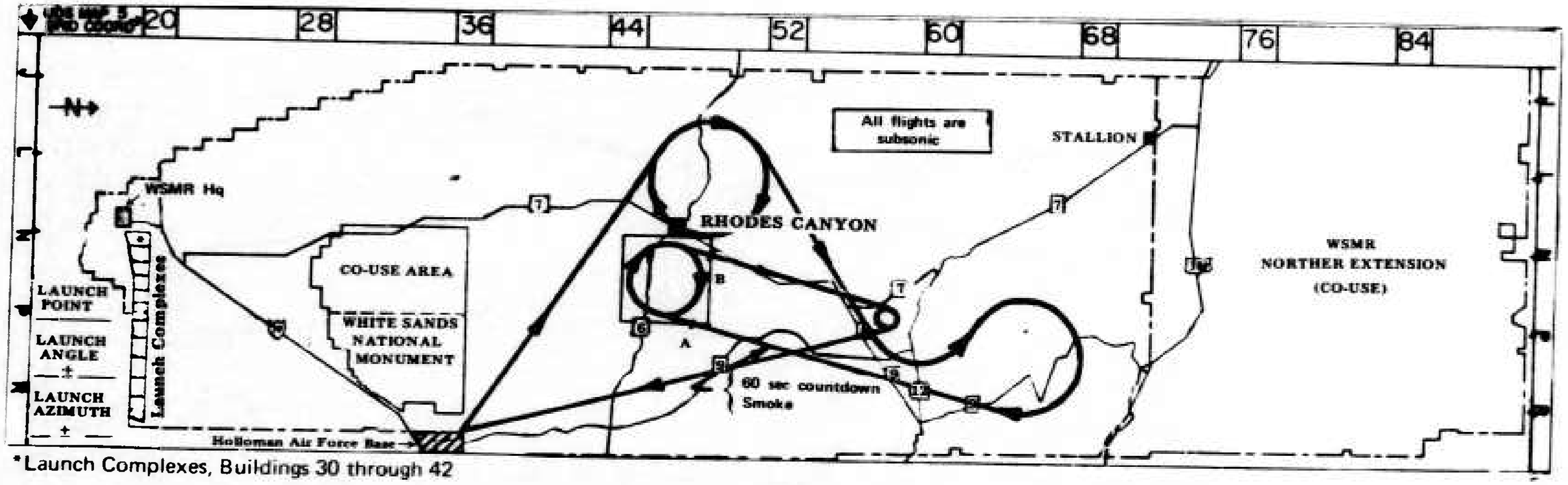
(1) Response from MGS and FGS with hand-over
(2) Mach, altitude, and heading hold accuracy
(3) Afterburner Smoke
(4) Programmed maneuver
(5) High altitude and high Mach performance
(6) LOC above orbital altitude

Profile V (Figure 21) demonstrated:

(1) Response from MGS and FGS with hand-over
(2) Pitch and roll extremes (±60 degrees and 135 degrees, respectively)
(3) Medium and low altitude performance
(4) Mach, altitude, and heading hold accuracy
(5) Medium and low altitude Smoke
(6) Programmed maneuver (two-phase)
(7) Normal g limits
(8) Minimum altitude maneuver

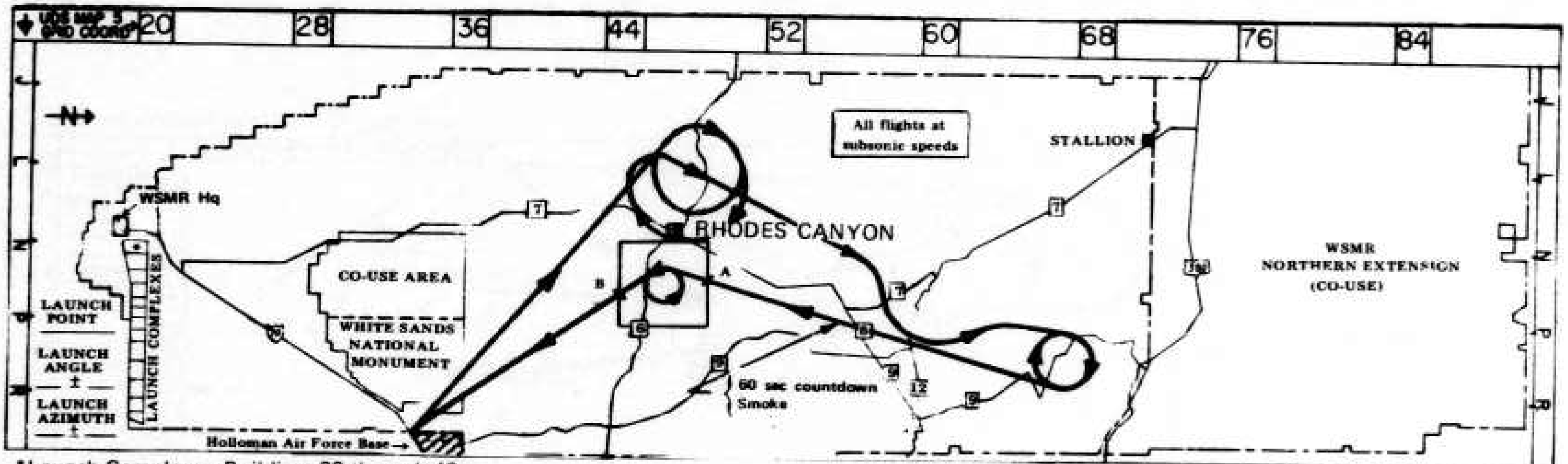
Profile VI (no standard groundtrack) demonstrated:

(1) Maximum range control for MGS and FGS
(2) LOC on runway and command takeoff abort
(3) MGS backup radar capability



*Launch Complexes, Buildings 30 through 42

Figure 17. Test Flight Profile I



*Launch Complexes, Buildings 30 through 42

Figure 18. Test Flight Profile II

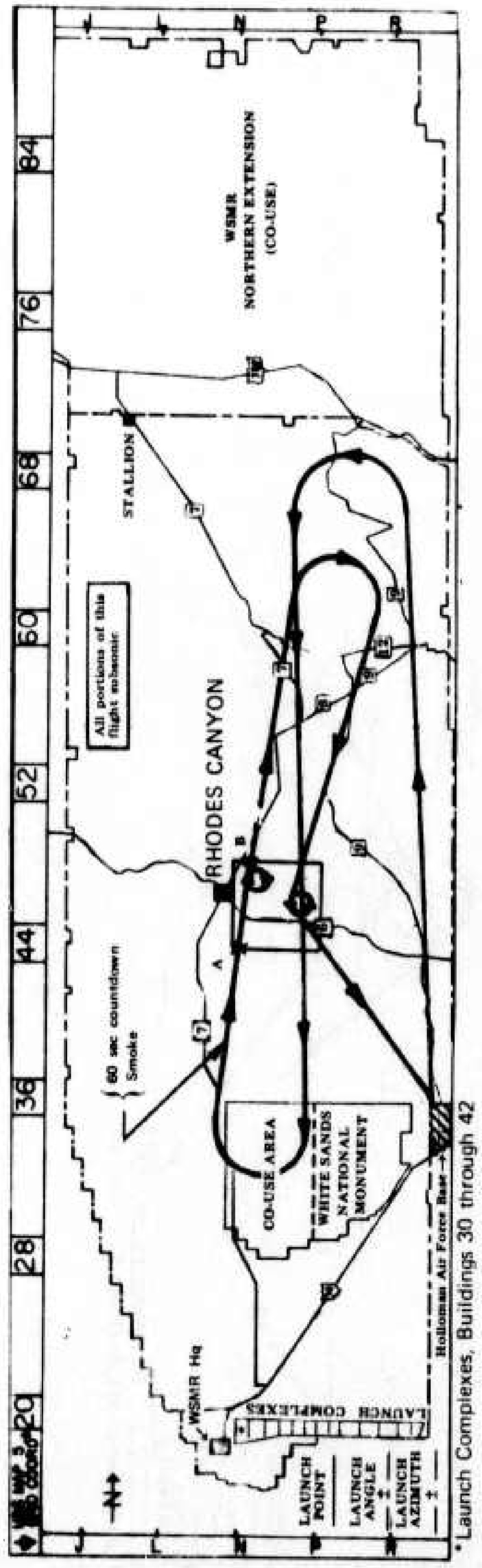


Figure 19. Test Flight Profile III

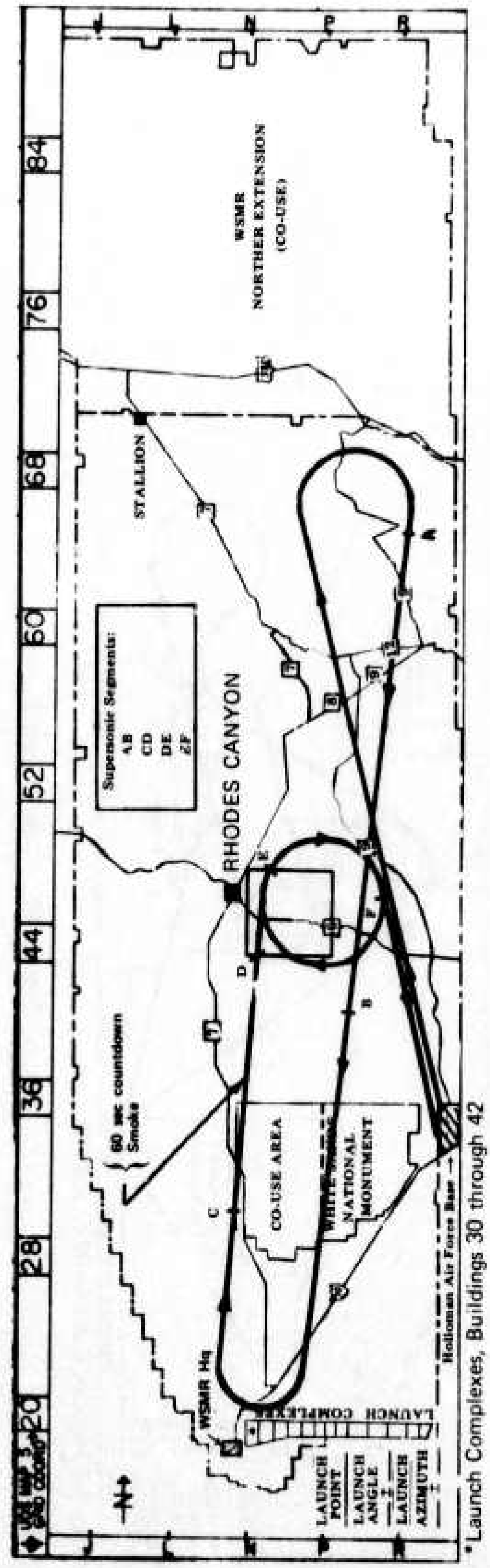
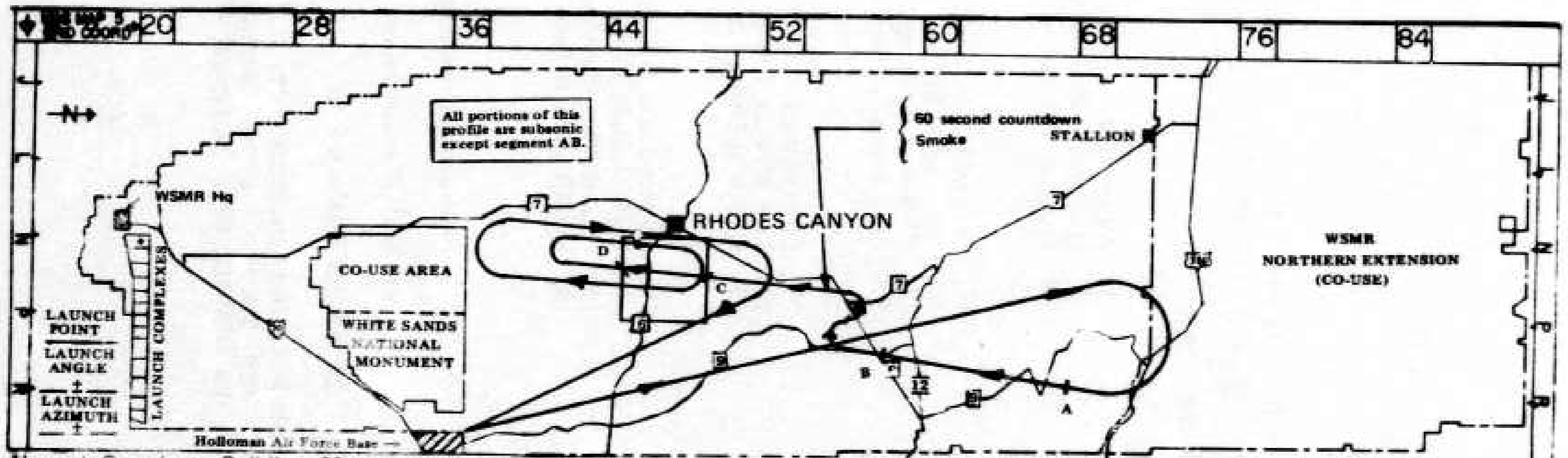


Figure 20. Test Flight Profile IV



*Launch Complexes, Buildings 30 through 42

Figure 21. Test Flight Profile V

Profiles VII and VIII (no standard groundtrack) demonstrated:

(1) Data link interface
(2) Pilot/Controller training

Profiles I through VIII were used for the QF-102 operation. Profiles I through VI were flown for DT&E and record flights. Profiles VII and VIII were used for training. All of these profile flights were flown several times to vary flight parameters and establish repeatability.

New profiles were generated for the NULLO flights (Figures 22 through 27). In general, each profile was designed to meet the requirements of each NULLO. With the exception of NULLO No. 5, they were not repeated. The NULLO No. 5 profile was used for all subsequent NULLO requiring AIM series missile presentation.

NULLO No. 1 and NULLO No. 2 (Figure 24) demonstrated:

(1) Airspeed, Mach, heading and altitude holds
(2) Roll and pitch holds
(3) Programmed maneuver

NULLO No. 3 (Figure 23) demonstrated:

(1) Airspeed, Mach, heading and altitude holds
(2) High speed flight
(3) HVAR presentation
(4) Programmed maneuver

NULLO No. 4 (Figure 24) demonstrated:

(1) Programmed maneuvers
(2) Low altitude flight
(3) HVAR presentation

NULLO No. 5 (Figure 25) demonstrated:

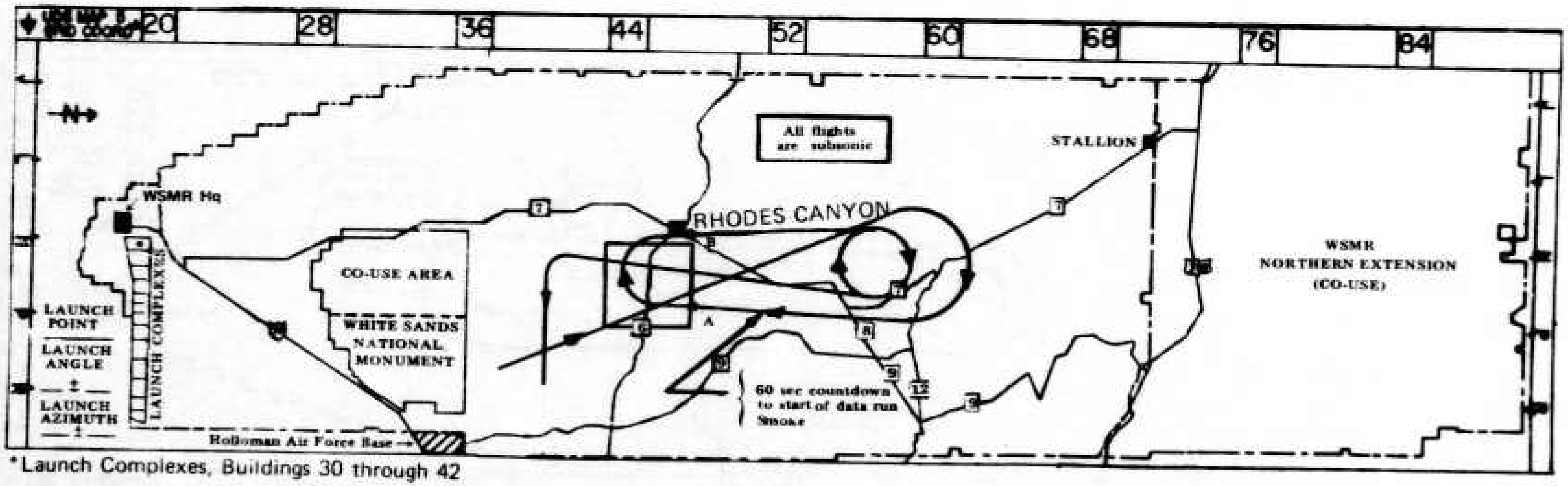
(1) Airspeed and Mach holds
(2) High altitude flight
(3) Programmed maneuver
(4) HVAR presentation

NULLO No. 6, NULLO No. 7, and NULLO No. 8 (Figure 26) demonstrated:

(1) Programmed maneuver (AIM-9J presentations)
(2) HVAR presentation (26 September, only)

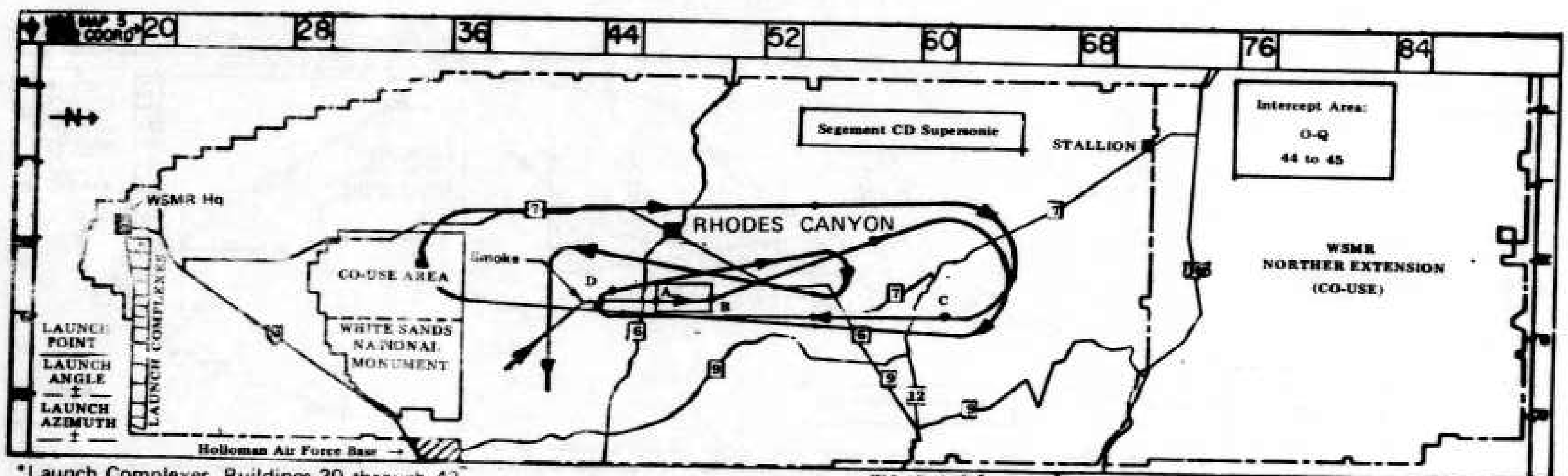
d. Typical 48-Hour Flight Test Plan (QF Record Flight No. 1)

With the exception of pilot proficiency and functional check flights, the 48-hour plan was utilized. Upon completion of each flight, the plan became a permanent record and was maintained in the flight record jacket at the PQM-102 SPO. A typical 48-hour plan is shown in Appendix F.



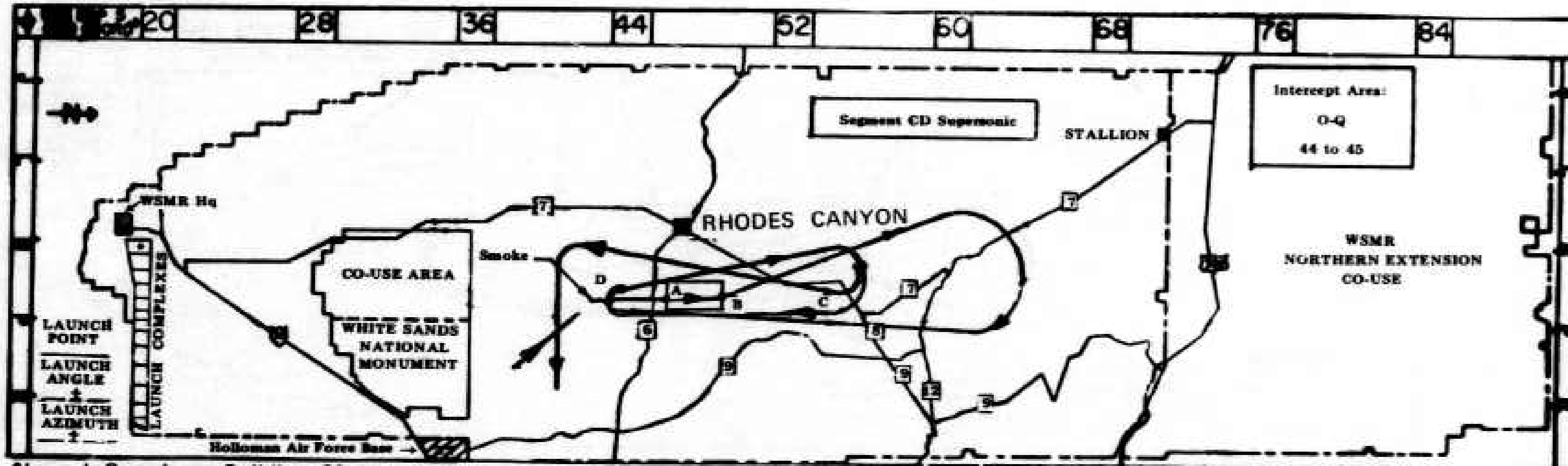
*Launch Complexes, Buildings 30 through 42

Figure 22. NULLO No. 1 and NULLO No. 2



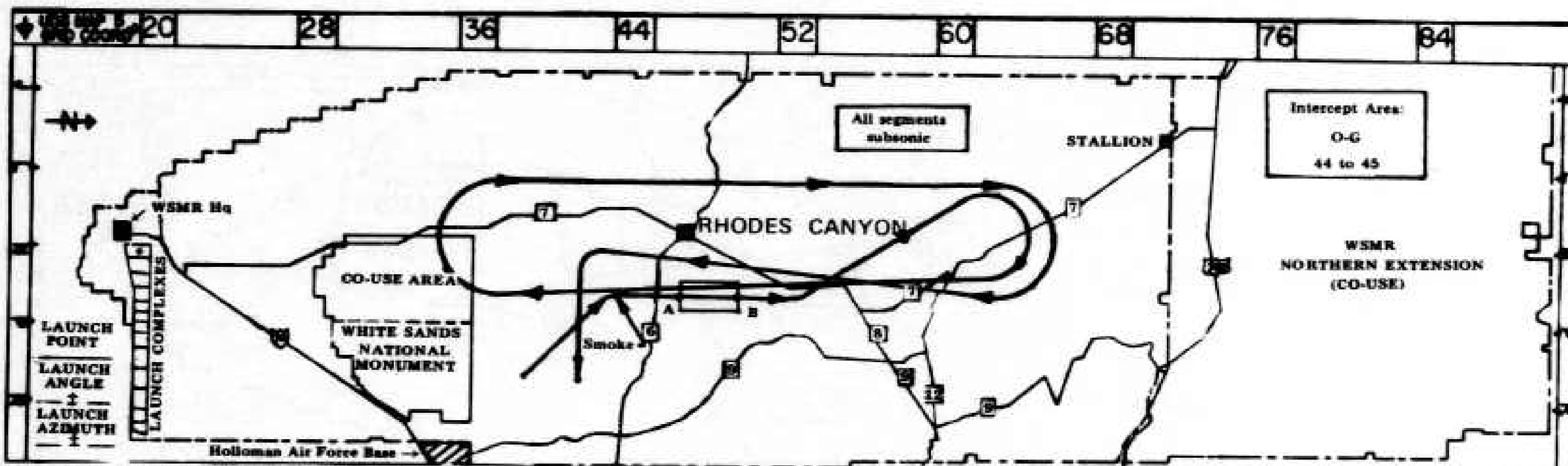
*Launch Complexes, Buildings 30 through 42

Figure 23. NULLO No. 3



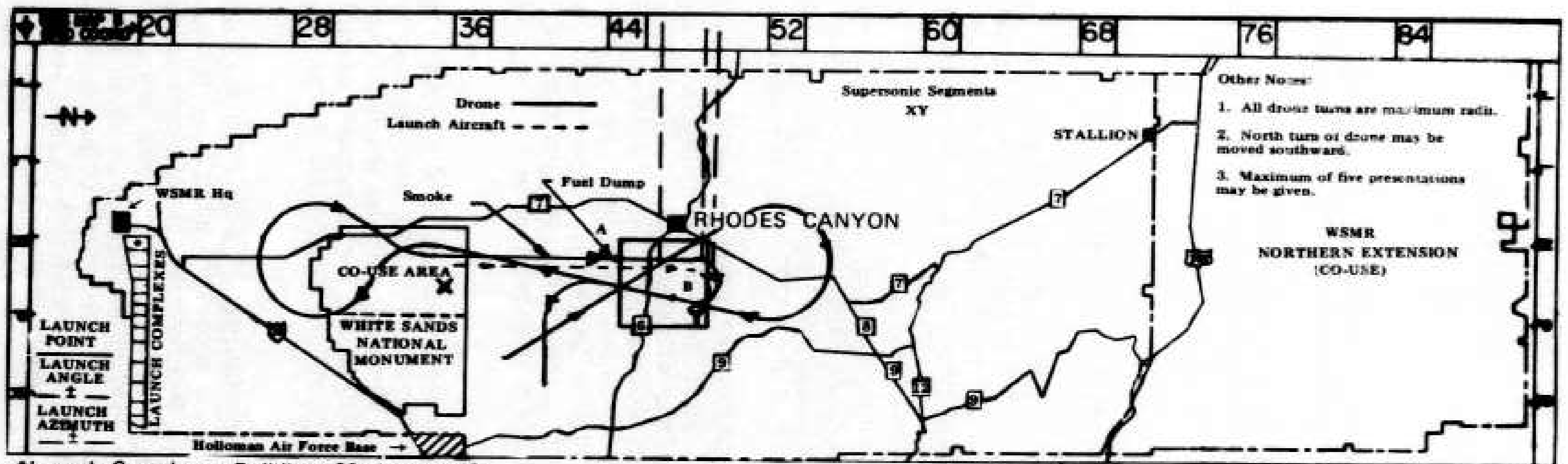
*Launch Complexes, Buildings 30 through 42

Figure 24. NULLO No. 4



*Launch Complexes, Buildings 30 through 42

Figure 25. NULLO No. 5



*Launch Complexes, Buildings 30 through 42

Figure 26. NULLO No. 6, NULLO No. 7, and NULLO No. 8

SECTION IV

EVALUATION

1. INTRODUCTION

Evaluation of the peculiar systems, peculiar AGE that comprised the PQM-102 Target System, and other requirements outlined in the SOW, are discussed in this section.

The evaluation was performed by the AFSWC 6585th Test Group, Holloman Air Force Base. The data consisted of strip chart recordings, digital and analog information on magnetic tapes, and visual observations.

2. PECULIAR SYSTEMS

a. Flight Control Stabilization System (FCSS)

The QF/PQM-102 Target System is controlled by various FCSS modes. It may be operated either by direct control or by automatic control. The automatic control modes include the maneuver programmer and special low altitude maneuver programmer (LAMP) for Army PQM-102 Target Systems; automatic takeoff; takeoff/landing abort; and loss-of-carrier (LOC).

The FCSS test objectives were twofold: (1) to quantitatively evaluate flight performance while the aircraft was under direct FCSS control as commanded by the operator or under automatic FCSS control as commanded by the maneuver programmer; and (2) to qualitatively evaluate the operation of the FCSS automatic control modes.

The quantitative results were taken from selected time intervals called data points or events which were planned to occur throughout the practical mission envelope of the aircraft. To accomplish this a variety of flight profiles were developed, each containing a set of preplanned data points approximately 30 seconds long. During manned test flights, 6 flight profiles were utilized to adequately cover the flight regimes of interest. Examples of these flight profiles are illustrated in Section III. The typical data point in these profiles is 20 to 40 seconds long and, during this time, the actual flight performance (as indicated by downlink data) was recorded using magnetic tape at the Fixed Ground Station (FGS).

(1) Flight Performance Under Direct Operator Control. The flight performance results evaluated the pitch axis, throttle, and lateral axis flight control modes of the FCSS. Each of these flight control modes was controlled by the flight reference computer. Maximum performance capabilities were described where required by the SOW. Overall performance was excellent in the pitch axis and throttle control modes, and satisfactory in the lateral axis control mode.

Pitch Axis and Throttle Control Modes. Pitch hold occurs automatically following a pitch command signal and causes the aircraft to maintain the existing pitch attitude. The remaining pitch axis and throttle control modes are selected by commanding altitude hold or speed/Mach hold on pitch/throttle. These flight control modes operate independently and may be commanded either directly or by an internal automatic program. Deviations sensed by the air data system are relative to the commanded reference airspeed/Mach and the altitude existing at the instant of altitude hold engagement. This initial or reference value is referred to in this report as the nominal value.

A graphical summary of the pitch attitude hold data points is presented in Figure 27. Only one of the 33 data points was out of the SOW tolerance and the recorded deviation in this case was 1.1 degrees. Deviation for a given data point is expressed as a percentage of the SOW tolerance limit. In this way all of the pitch attitude hold data points could be evaluated at one time even though the SOW tolerance limit changed for different flight regimes. The results of a statistical analysis of the pitch attitude hold data points are presented in Table 3. The theoretical justification for these calculations is discussed in Appendix B.

Pitch angle limits of +60 degrees and −60 degrees were demonstrated during the flight of QF-1-V-4b on 26 June 1974. The SOW target limits were ±60 degrees.

The ability of the FCSS to hold altitude was tested throughout the altitude and airspeed flight envelope at bank angles up to 75 degrees. The data points used to evaluate the altitude hold control mode at bank angles up to 60 degrees are depicted graphically in Figure 28. A statistical analysis of the altitude hold capability is presented in Figure 29. The average altitude deviation defines the deviation range expected at a given altitude and bank angle. It must be emphasized that the results presented here assume an initial vertical velocity of zero when altitude hold is engaged. Effects of initial vertical velocities on altitude hold performance were not systemmatically studied due to time and mission constraints. The results of QF Record Flight No. 3 (Appendix A) show that altitude deviations near 500 feet can be expected at high altitude (35,000 feet) when altitude hold is engaged at 60 degrees of bank with vertical velocity near ±2000 fpm.

Beyond 60 degrees of bank the stability of the pitch axis decreased. Because of this, the data points for bank angles above 60 degrees were not normalized and were not expressed as a percentage of the SOW tolerance limit. The capability of the FCSS to hold altitude at high bank angles is depicted in Figure 30. Altitude hold performance during programmed maneuvers at high bank angles is shown in Figure 31. This data is presented here since the altitude hold control mode that operates during a presentation is the same mode that operates during normal flight conditions.

The maximum altitude attained by the drone was 56,870 feet MSL on 4 September 1974 (NULLO No. 4, Figure 24). This converts to a pressure altitude of 56,000 feet MSL. The minimum attitude attained by the drone was 392 feet AGL on 4 September 1974 (NULLO No. 3, Figure 23) during straight and level flight. White Sands Missile Range radar data was the source of the altitude information and these performances exceeded the SOW target performance. The radar altimeter was operational for only one record flight during the test program.

The results from the airspeed-on-pitch data points have been combined with the results from airspeed-on-throttle tests and are presented in Figure 32. The two data points depicting out-of-tolerance performance occurred below 275 KIAS and this was where the restrictive ±2 knots deviation limit was in effect. During the 6 May 1974 profile flight, the actual out-of-tolerance deviation was ±2.5 KIAS; during the 30 May 1974 profile flight, it was −3.7 KIAS.

A similar combination of results was made to present the Mach-on-pitch and Mach-on-throttle data points depicted in Figure 33. Although the pitch axis control system is independent of the throttle control system in the FCSS, the combination of results was considered justified for three reasons: First, the specification tolerances in the SOW were classified by airspeed-hold and Mach-hold only, and no distinction was made between the pitch and throttle control systems. Second, since speed-hold performance was excellent in all cases, combining the data points did not present a misleading performance summary. Finally, the increased number of data points made available by combining results allowed more confidence to be placed in the statistical results which are presented in Table 3.

TABLE 3. FCSS PERFORMANCE RESULTS UNDER DIRECT CONTROL

Flight Parameter Control Mode	Flight Parameter Restrictions	Demonstrated Deviation Range	*Expected Deviation Range - RMS	SOW Tolerance Limits
Altitude Hold	Level below 10,000 feet	32.5 feet	39.8 feet	± 50 feet
Airspeed Hold	Airspeed < 275 knots	1.0 knot	1.2 knots	± 2 knots
Airspeed Hold	Airspeed > 275 knots	5.0 knots	6.6 knots	± 10 knots
Mach Hold	**	0.008M	0.01M	± 0.03M
Heading Hold	**	0.6 degree	0.8 degree	± 1 degree
Roll Altitude Hold	Bank < 45 degrees	0.7 degree	0.9 degree	± 1 degree
Roll Altitude Hold	Bank > 45 degrees	1.4 degrees	1.8 degrees	± 2 degrees
Pitch Altitude Hold	Bank < 20 degrees	0.27 degree	0.4 degree	± 0.5 degree
Pitch Altitude Hold	20 degrees < Bank < 45 degrees	0.5 degree	0.7 degree	± 1 degree
Pitch Altitude Hold	Bank > 45 degrees	1.1 degrees	1.4 degrees	± 2 degrees

*This is the estimated deviation range for future flights calculated at a 95 percent confidence level.
**Not applicable.

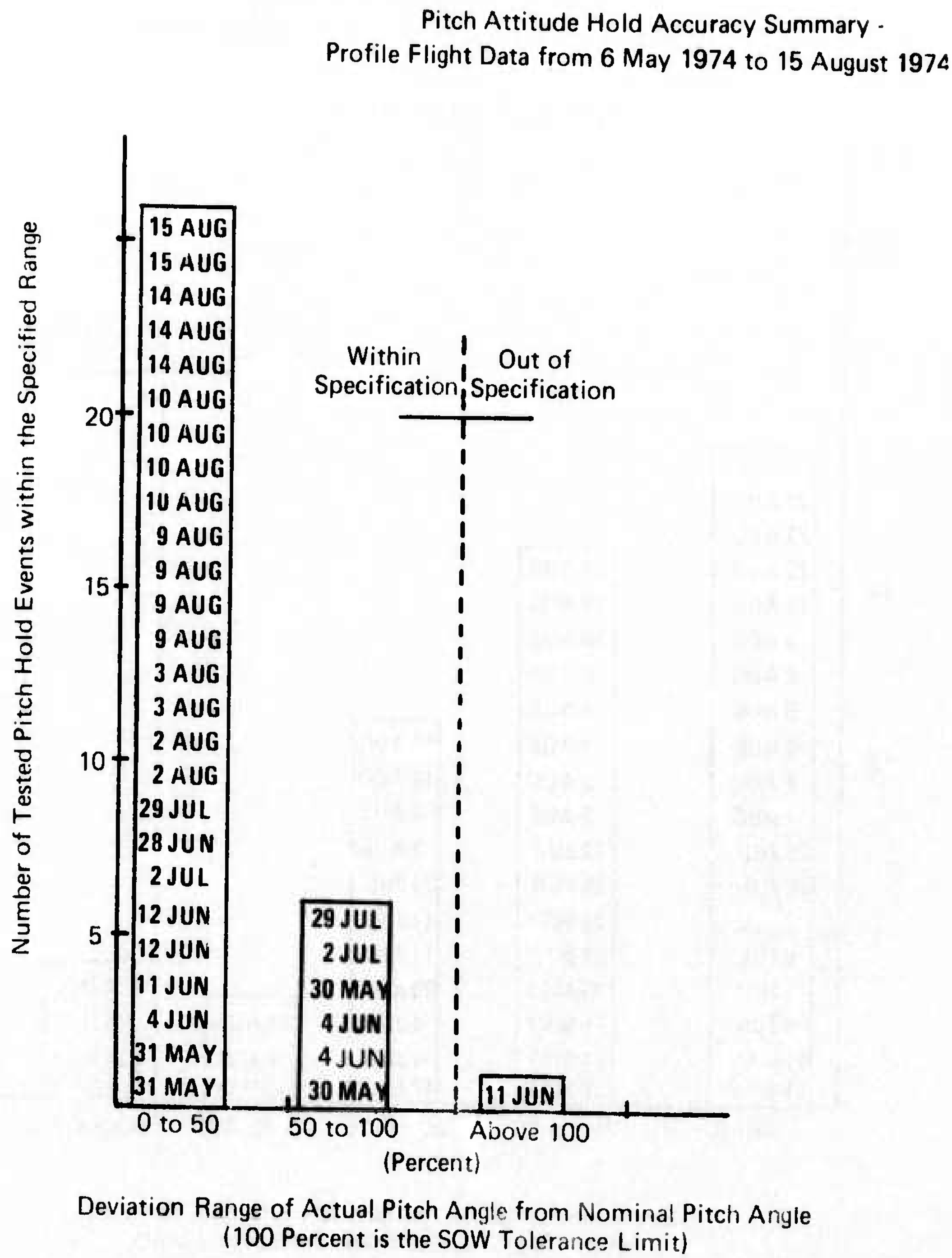


Figure 27. Pitch Attitude Hold Accuracy

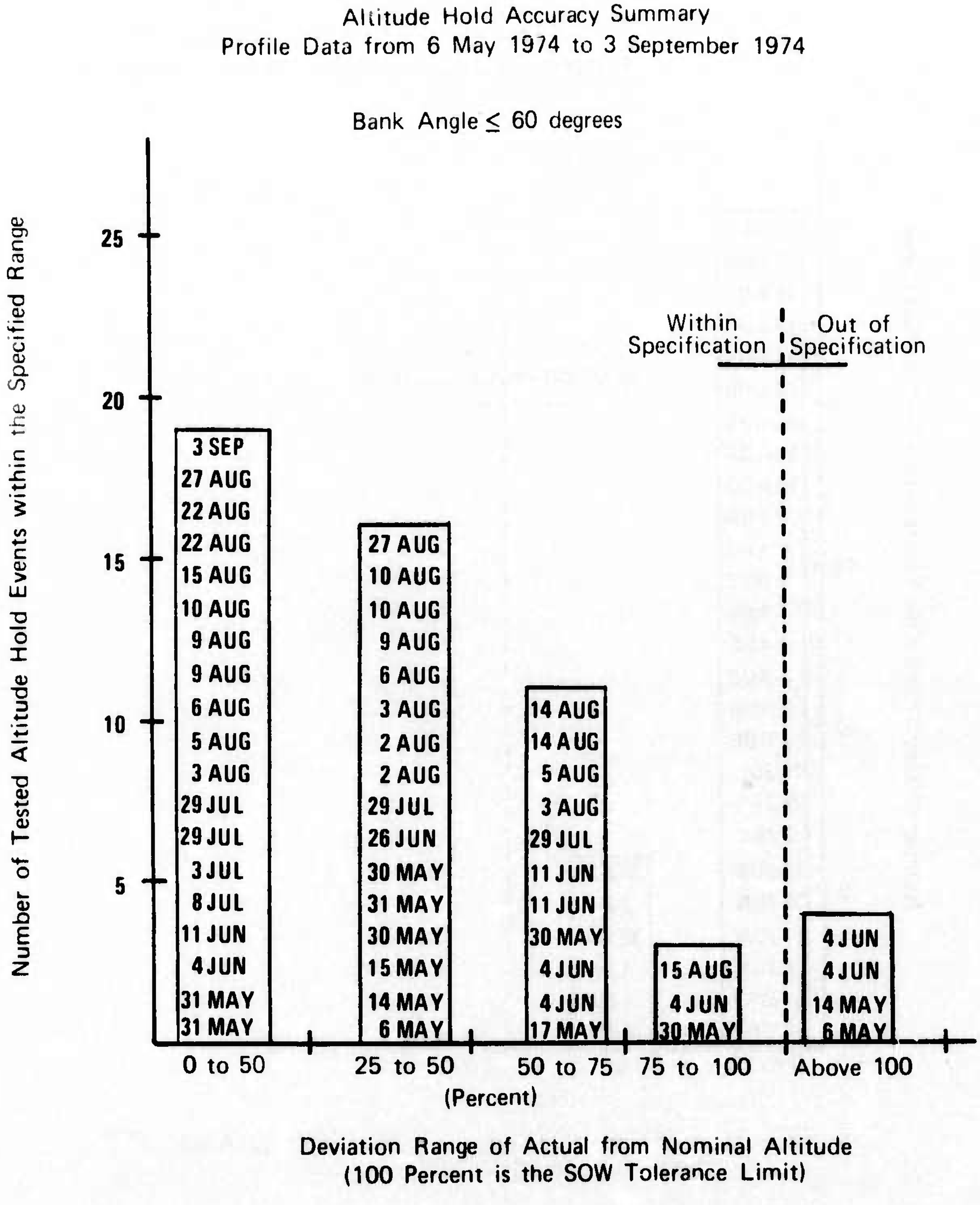


Figure 28. Altitude Hold Accuracy

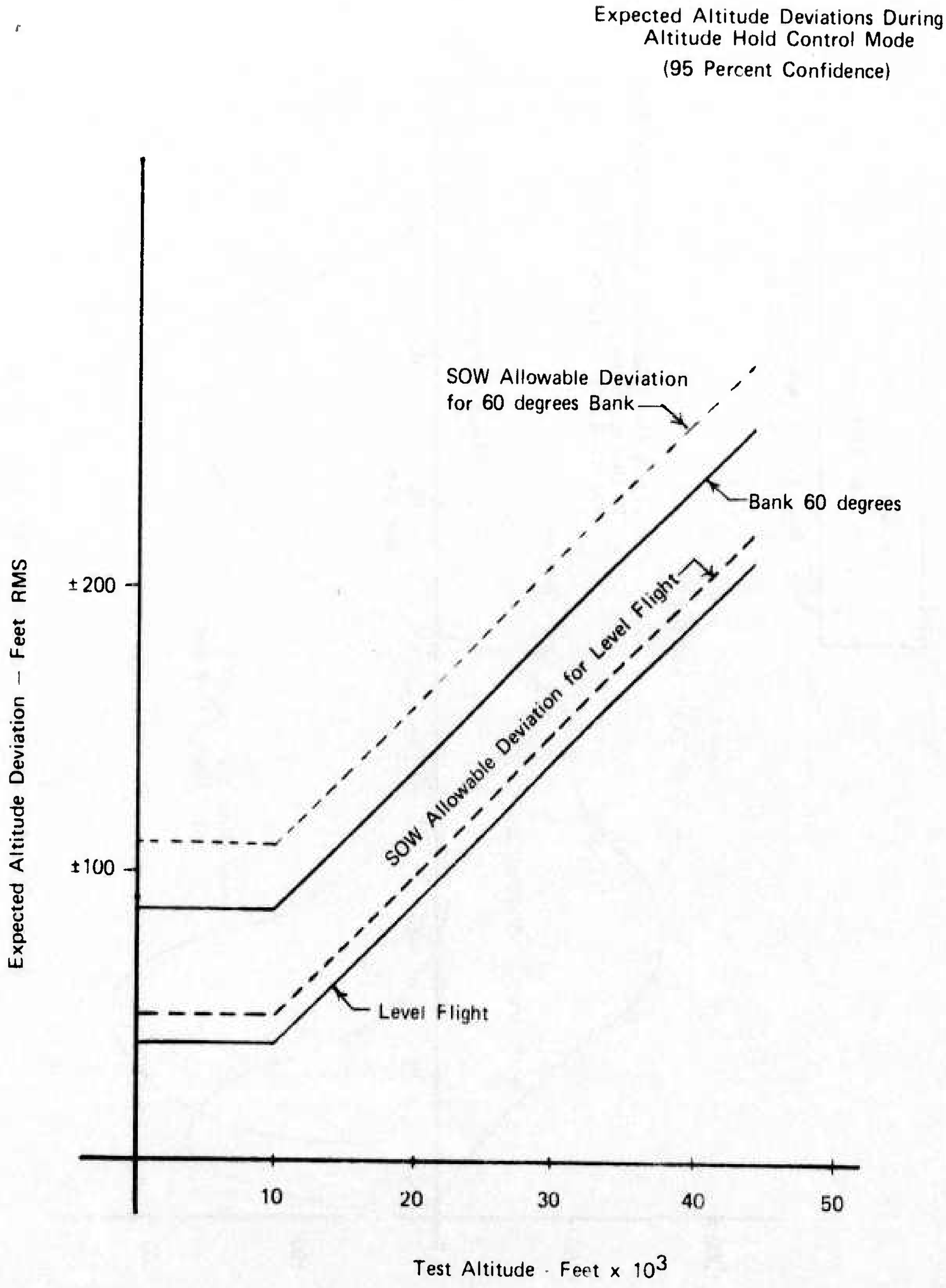


Figure 29. Statistical Analysis – Altitude Hold

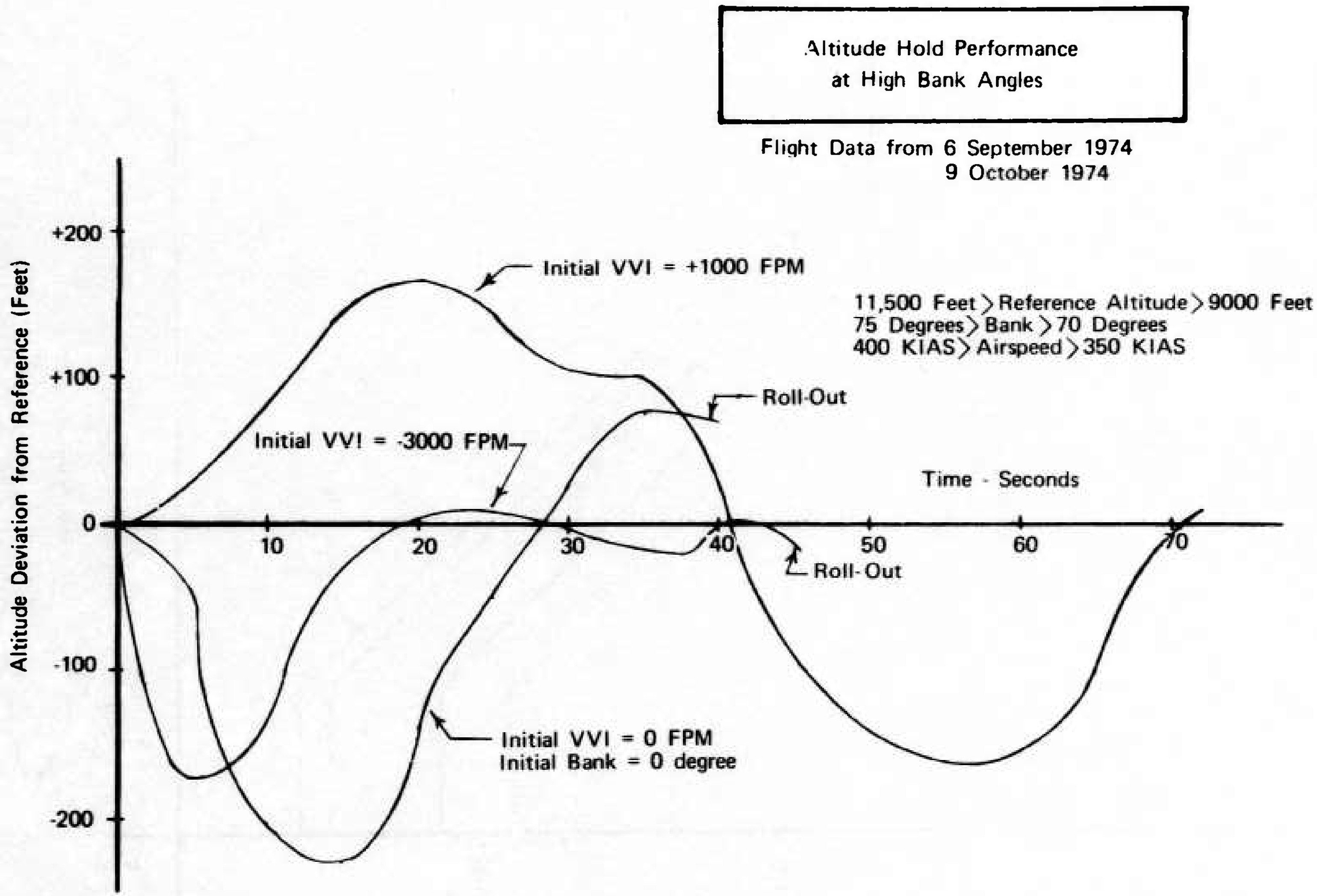


Figure 30. Altitude Hold Accuracy - High Bank Angles

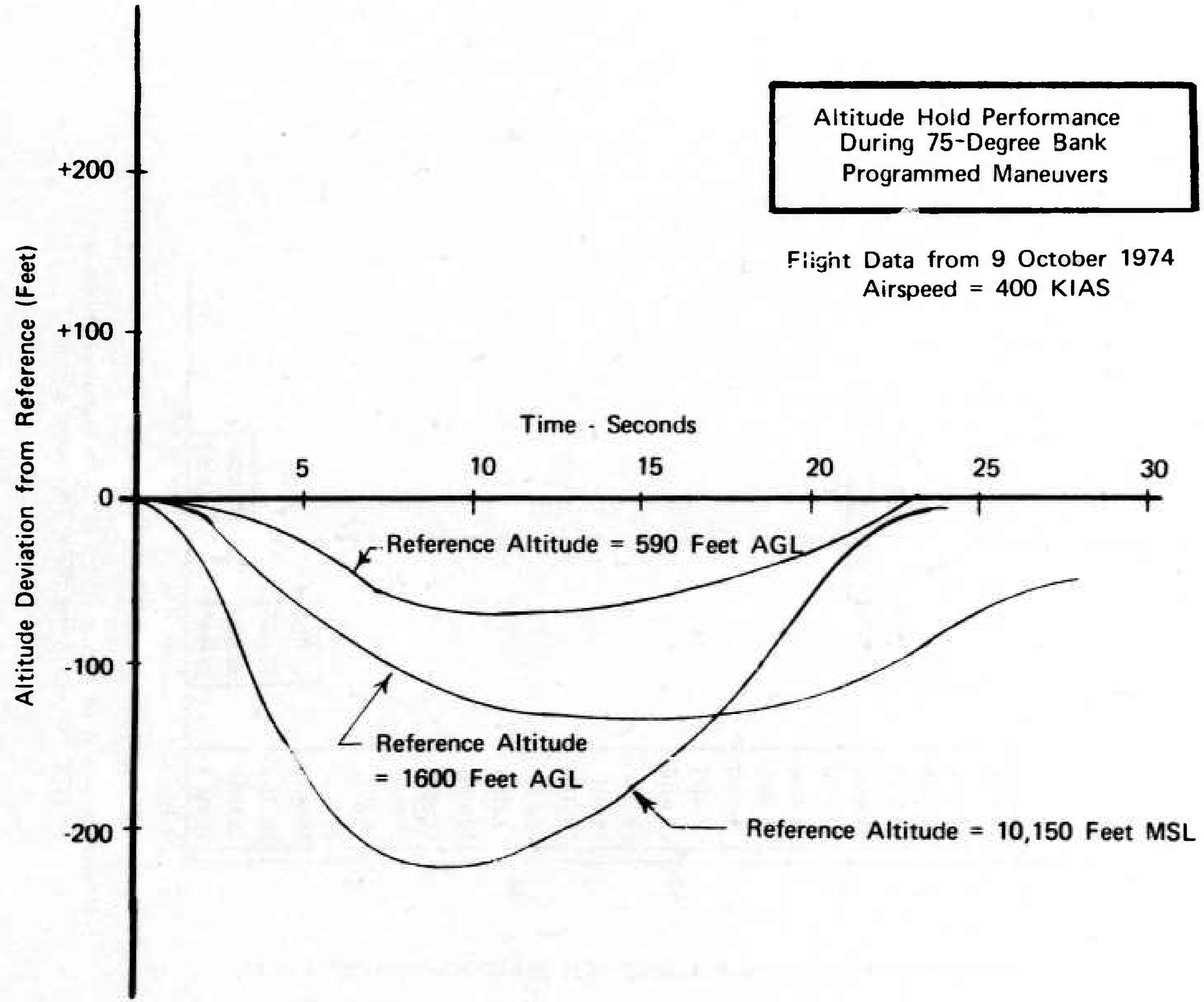


Figure 31. Altitude Hold Accuracy — 75 Degrees Bank Programmed Manuevers

Airspeed Hold Accuracy Summary
Profile Flight Data from 6 May 1974 to 27 August 1974

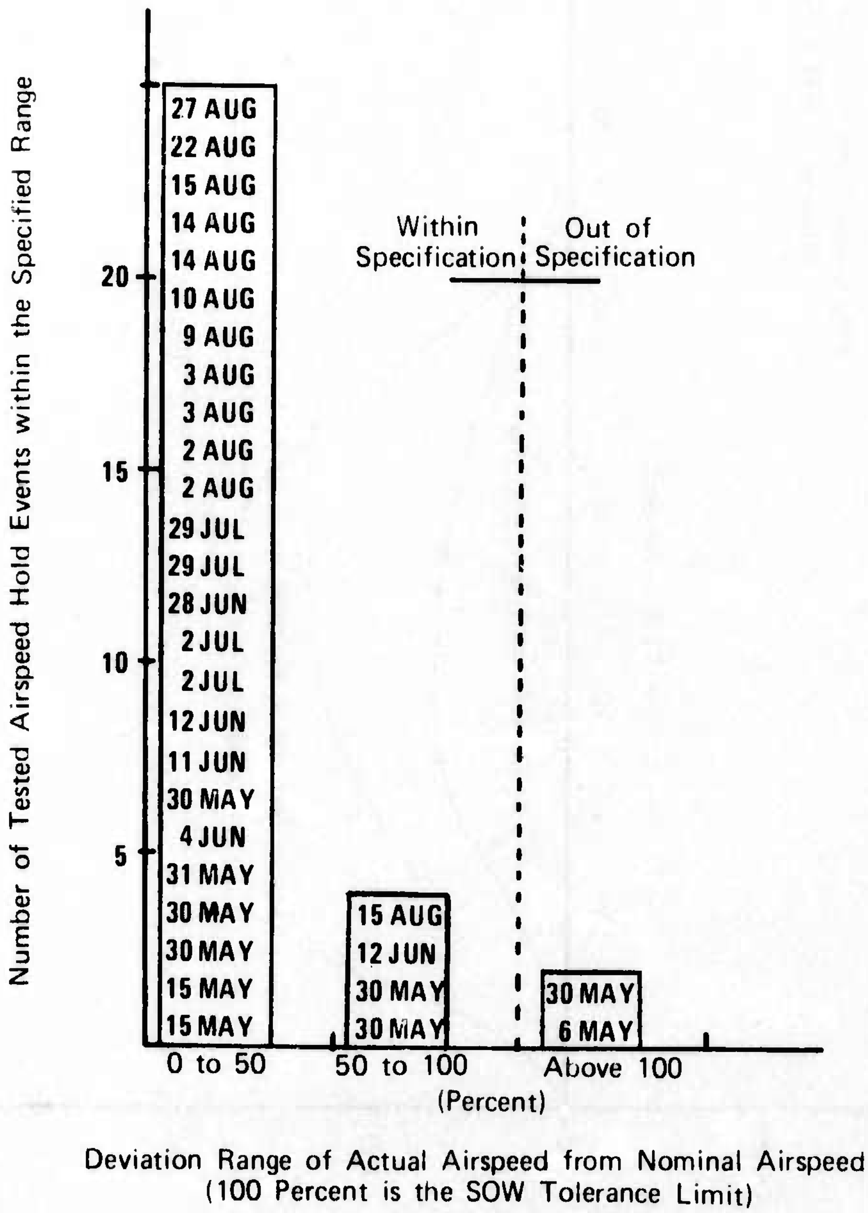


Figure 32. Airspeed Hold Accuracy

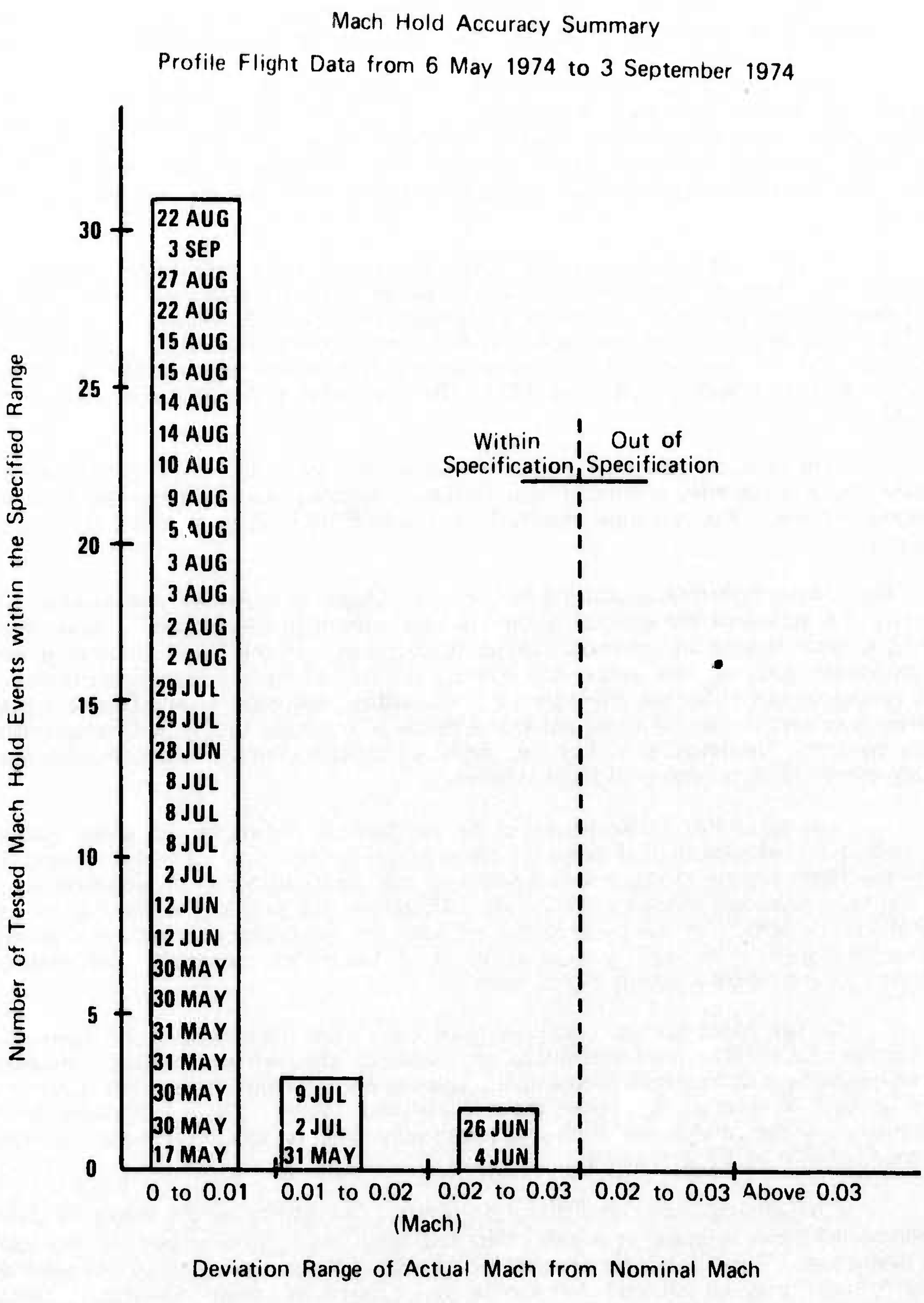


Figure 33. Mach Hold Accuracy

The maximum Mach demonstrated by the aircraft system was 1.3 on 5 September 1974. The target Mach of 1.35 at 35,000 feet could not be reached (SOW requirement).

The basic lateral control mode is roll attitude hold during which the bank angle, commanded by left or right stick deflections, is maintained until the mode is terminated. The additional lateral control modes are heading hold with rudder and heading hold with ailerons (wings level). Heading hold with rudder is qualitatively discussed in paragraph 2.a.(3) of this section. The remaining flight control modes were found to be satisfactory and are analyzed here.

A graphical summary of the basic roll attitude hold data points is given in Figure 34 and the deviations are expressed as a percentage of the SOW tolerance limit. The four out-of-tolerance data points showed bank angle deviations of −1.2 degrees, −1.4 degrees, 2.0 degrees, and 3.5 degrees. The statistical results for roll attitude hold data points are presented in Table 3. The roll authority of the lateral control system was demonstrated at +155 degrees and −155 degrees of bank on 26 June 1974. This exceeded the SOW target performance of ±135 degrees.

The heading hold data points are shown in Figure 35. This flight control mode is initiated by a wings level command and maintains existing heading when the bank angle is 5 degrees or less. The statistical results from the heading hold data points are also presented in Table 3.

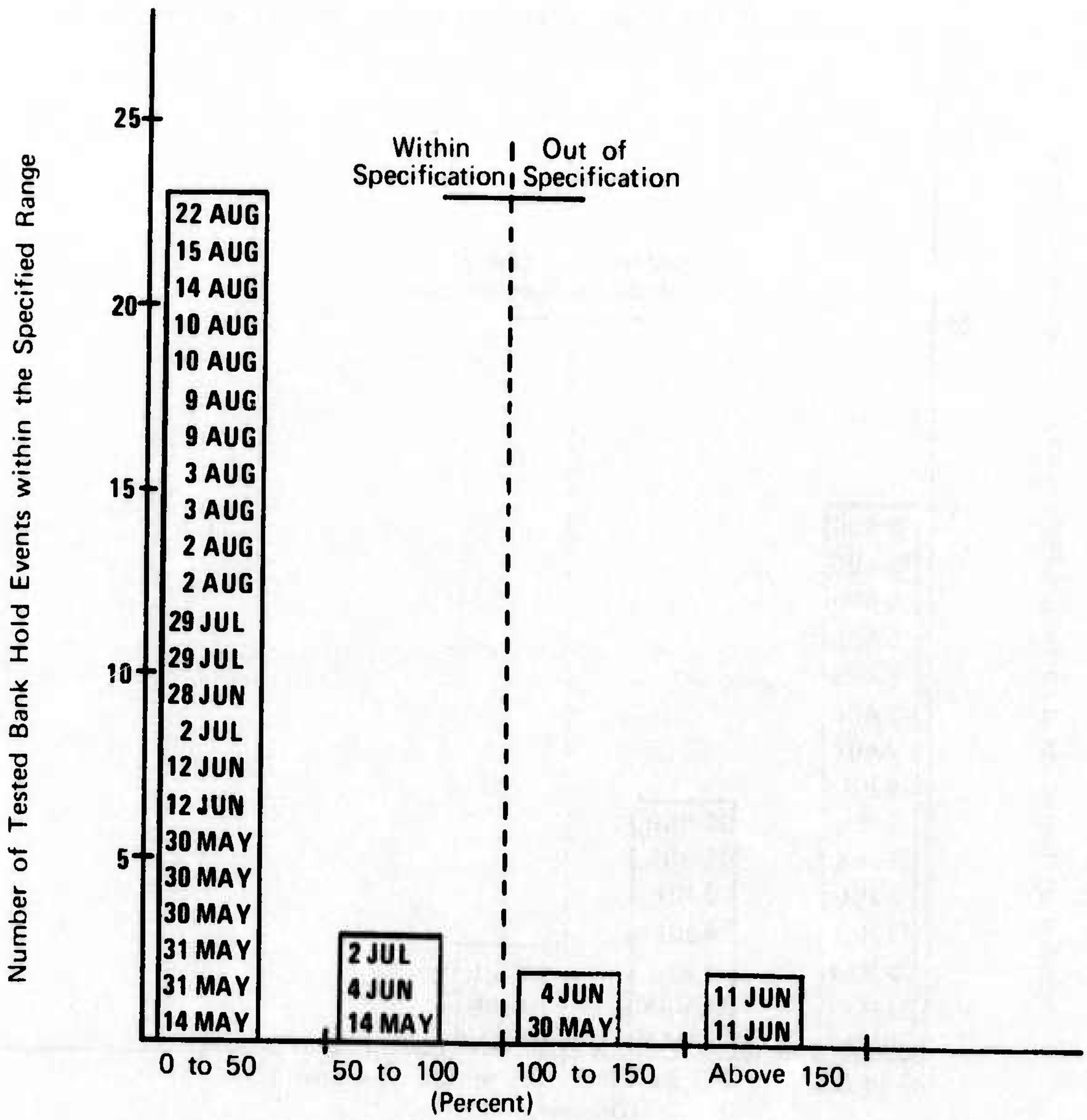
(2) Flight Performance During Programmed Maneuvers. Under programmed flight operations, the ability of the control system to reach and maintain a specific bank angle and a specific g force is of prime interest. Under operator control the initial value of a controlled flight parameter, such as bank angle, was directly determined by the human controller. The various modes of the FCSS subsequently held this initial (nominal) value. During a programmed maneuver, however, the initial flight parameter value is internally preset and independent of operator control. The analysis of flight performance must therefore include the accuracy of the programmer in determining this initial value.

The adjustable preset values in the programmer determine roll angle, airspeed, and g loading (or altitude hold if selected) for a predetermined time interval. Except for g loading, the flight control modes used to maintain roll angle, altitude, and airspeed are identical to the ones discussed in paragraph 2.a.(1). Therefore, the primary purpose of this section is to evaluate the ability of the programmer to reach the scheduled roll angle and scheduled g loading for a given maneuver. Except as noted, all results are taken from demonstrated system performance during record flights only.

Certain flight control system modifications were made between 26 September 1974 and 4 October 1974. The modifications which primarily affected the maneuver presentations were the installation of low pass filters in the programmer to eliminate random timer resets and the removal of airspeed input into the artificial feel system. The justifications for these modifications are discussed in the following paragraphs and the data presentation is divided where required due to these changes.

<u>Programmed Maneuver Entry Parameters.</u> The ability of the target to arrive at a predetermined point in space at a given time and speed was a critical item in the overall system evaluation. These entry parameters for all record flight presentations are summarized in Table 4, and it may be assumed that similar performance will result whenever a competent and alert operator is in control of the aircraft. It must be noted that entry parameter control depends more on operator skill and technique than on the FCSS control modes being used.

Bank Attitude Hold Accuracy Summary
Profile Flight Data from 6 May 1974 to 22 August 1974



Deviation Range of Actual Bank Angle from Nominal Bank Angle
(100 Percent is the SOW Tolerance Limit)

Note: None of these events are from a maneuver program presentation

Figure 34. Bank Attitude Hold Accuracy

Heading Hold Accuracy Summary
Profile Flight Data from 6 May 1974 to 22 August 1974

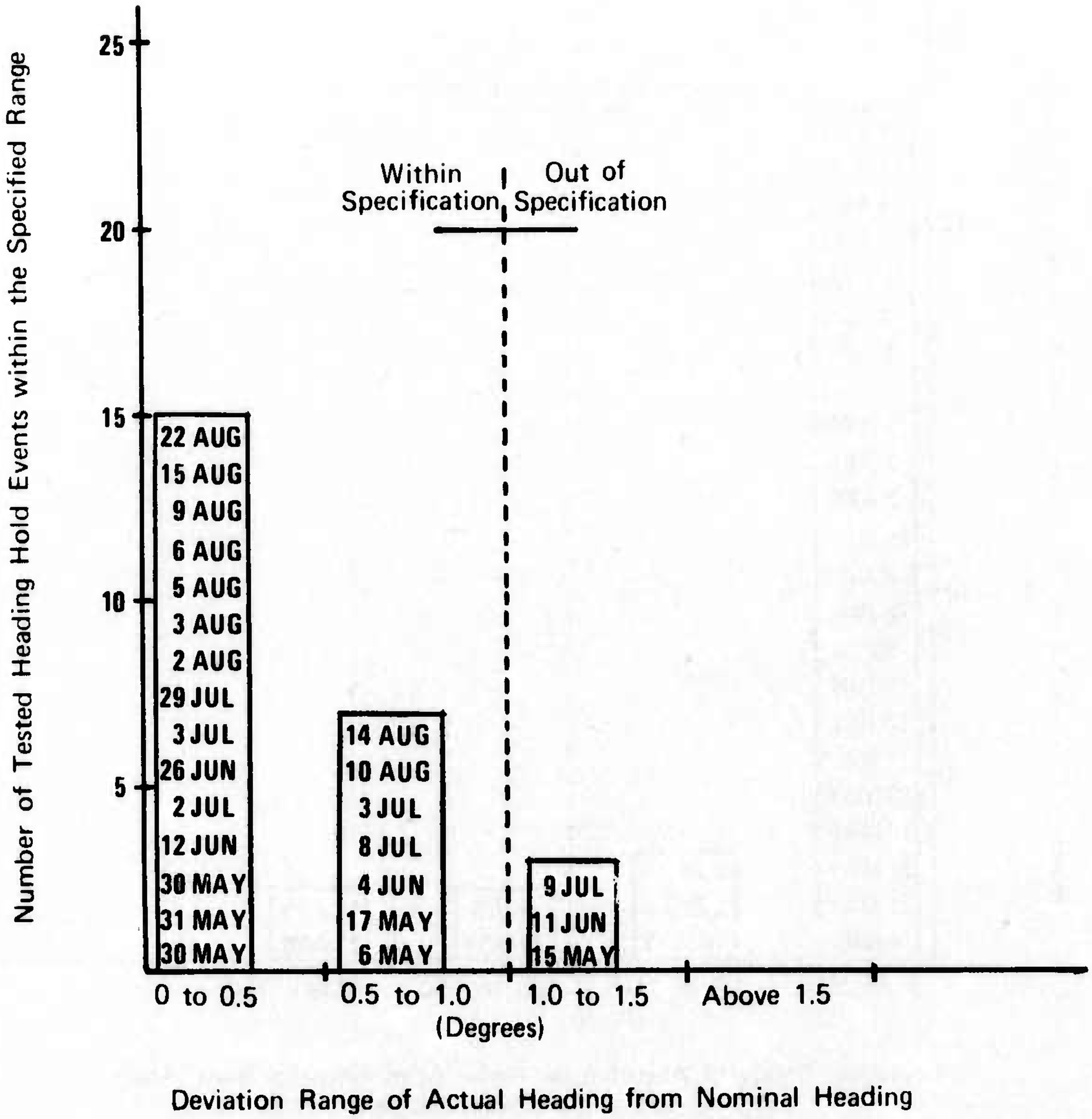


Figure 35. Heading Hold Accuracy

TABLE 4. PROGRAMMED MANEUVER ENTRY PARAMETER SUMMARY

Flight Parameter	Maximum Value of Error	Average Value of Error Magnitudes	Target Error Limits	Number of Graded Presentations
Entry Altitude Error	5,000 Feet	495 Feet	500 Feet	26
Entry Airspeed Error	92 KIAS	26.8 KIAS	10 Knots	26
Ground Track Error	4 Degrees	1 Degree	2 Degrees	20
Radial Position Error (At Initiate Point)	1.4 nmi	0.76 nmi	1 nmi	20
Error in Estimating Maneuver Initiate Time (Takeoff Estimate)	4 minutes, 47 seconds	1 minute, 29 seconds	5 minutes	15
Error in Estimating Maneuver Initiate Time (3-Minute Estimate)	24 seconds	7 seconds	20 seconds	16

<u>Presentation Data Points</u>. Pictorial representation of the maneuver presentation data points are given in Figures 36 and 37. The presentations where g washout occurred are circled and in both cases the cause was low entry airspeed. The presentations covered a considerable portion of the F-102 flight performance envelope.

<u>Roll Attitude During Programmed Maneuvers.</u> During the record flights between 29 July and 6 September 1974, the FCSS had considerable difficulty attaining the scheduled bank angle during maneuver presentations. This problem was especially apparent in aircraft FAD 602 which consistently maintained a nominal bank angle that was 6 degrees right of the scheduled bank. The results from these record flights are summarized in Figure 38.

Analysis indicated that the bank angle offset was caused by a feedback voltage which affected the roll attitude circuitry. This voltage, which normally is zero when the elevons are aligned, became zero on aircraft FAD 602 only when a slight offset existed in the elevons; this offset caused the aircraft to seek an equilibrium position with the right wing 6 degrees low. During nonprogrammed flight the heading hold mode automatically generated a voltage which cancelled this offset and leveled the wings (see subparagraph entitled, <u>Lateral/Directional Control Modes</u>). During programmed maneuvers, however, the heading hold offset voltage was disconnected and the programmer commanded bank angles about the equilibrium elevon position, which was 6 degrees wing low. Consequently, presentations with right turns overshot the scheduled bank and presentations with left turns undershot the scheduled bank.

This problem was solved by checking the feedback voltage prior to each flight with the PMTS and verifying that it was zero when the elevons were aligned. This procedure was started following the manned record flight on 6 September 1974. The results from presentations made after this procedural change are depicted in Figure 39. Although more data points are desirable to draw statistical conclusions, the results indicated that if the aircraft was trimmed for level flight when the elevons were aligned, the system did maintain the preset bank angle. Aircraft which require differential elevon displacements for level flight due to an out-of-trim condition can be expected to bias the bank angle during a presentation. The ability of the FCSS to maintain the nominal bank angle during presentations is also illustrated in Figure 38. The similarity between the programmed results of this figure and the nonprogrammed data points in Figure 34 is expected since the roll attitude hold segment of the FCSS is identical in each case. The main difference in the two sets of data points is that the programmed presentations were consistently made at bank angles above 60 degrees, while normal roll attitude hold data points were taken between 0 and 60 degrees.

<u>G Force During Programmed Maneuvers.</u> The maneuver programmer can be preset to command from −1g to +8g over a time interval from 1 to 99 seconds. Actual testing covered a range from 2g to 8g over intervals from 10 to 20 seconds. The test results of primary interest involved the ability of the control system to attain the scheduled g force (at an acceptable rate) and to hold it for a specified time duration. As previously stated, two sets of results were necessary in certain instances due to the major modifications which were made prior to 4 October 1974.

The test results used to initially evaluate g buildup rate are presented in Figure 40. The correlation between buildup rate and altitude is caused by the response of the pitch trim motor. At a given airspeed, the amount of available elevon deflection about the neutral trim position is limited. If a scheduled g loading requires an elevon displacement which exceeds this limit, the pitch trim motor must move the elevon equilibrium position so that the required surface deflection is attainable. The pitch trim motor moves the elevon surface at an approximate rate of 1 degree per second. Since a given g loading requires more surface deflection at high altitudes than low, the fixed operating speed of the pitch trim motor causes relatively long buildup times above 25,000 feet.

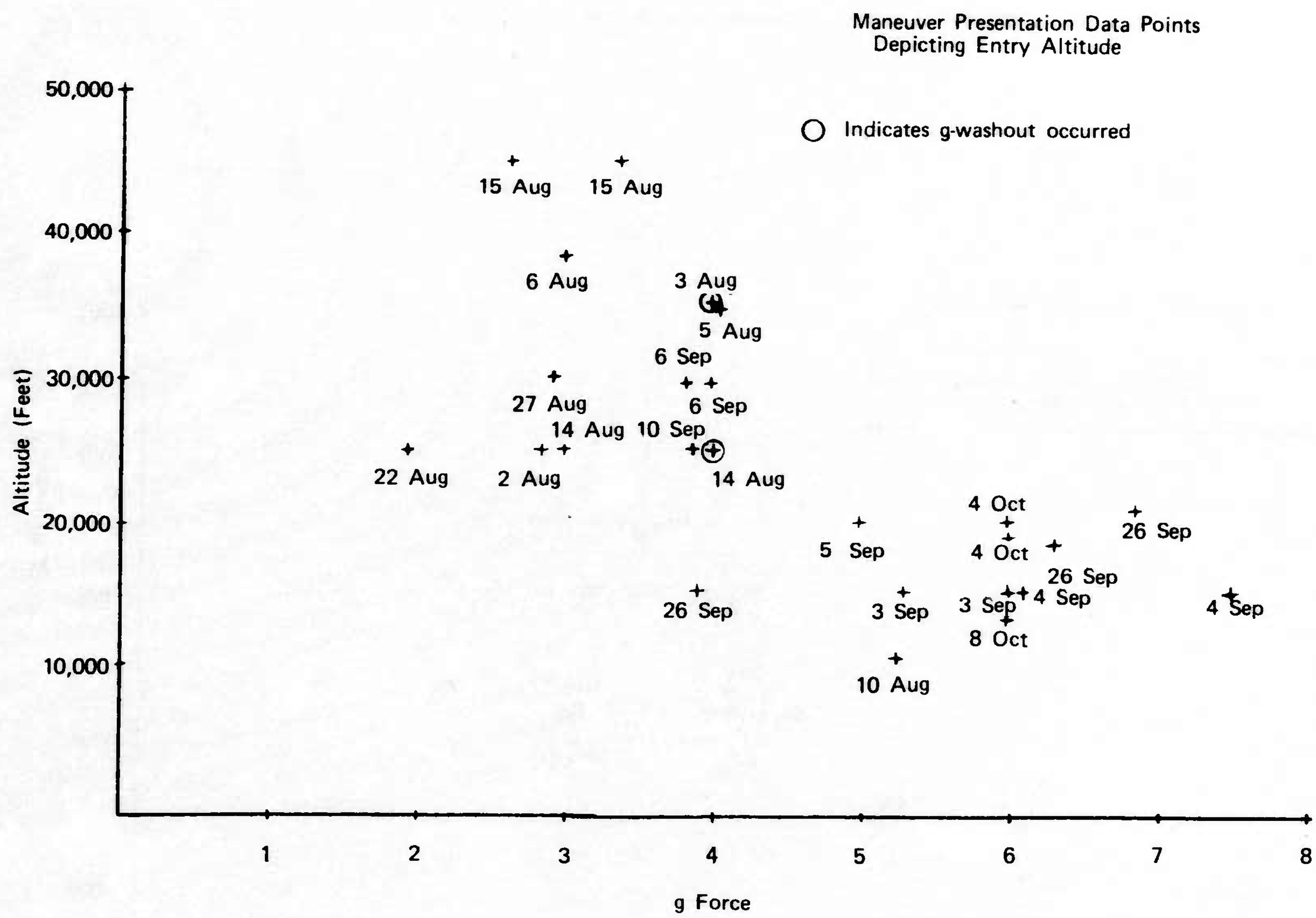


Figure 36. Maneuver Programmer (Entry Altitude)

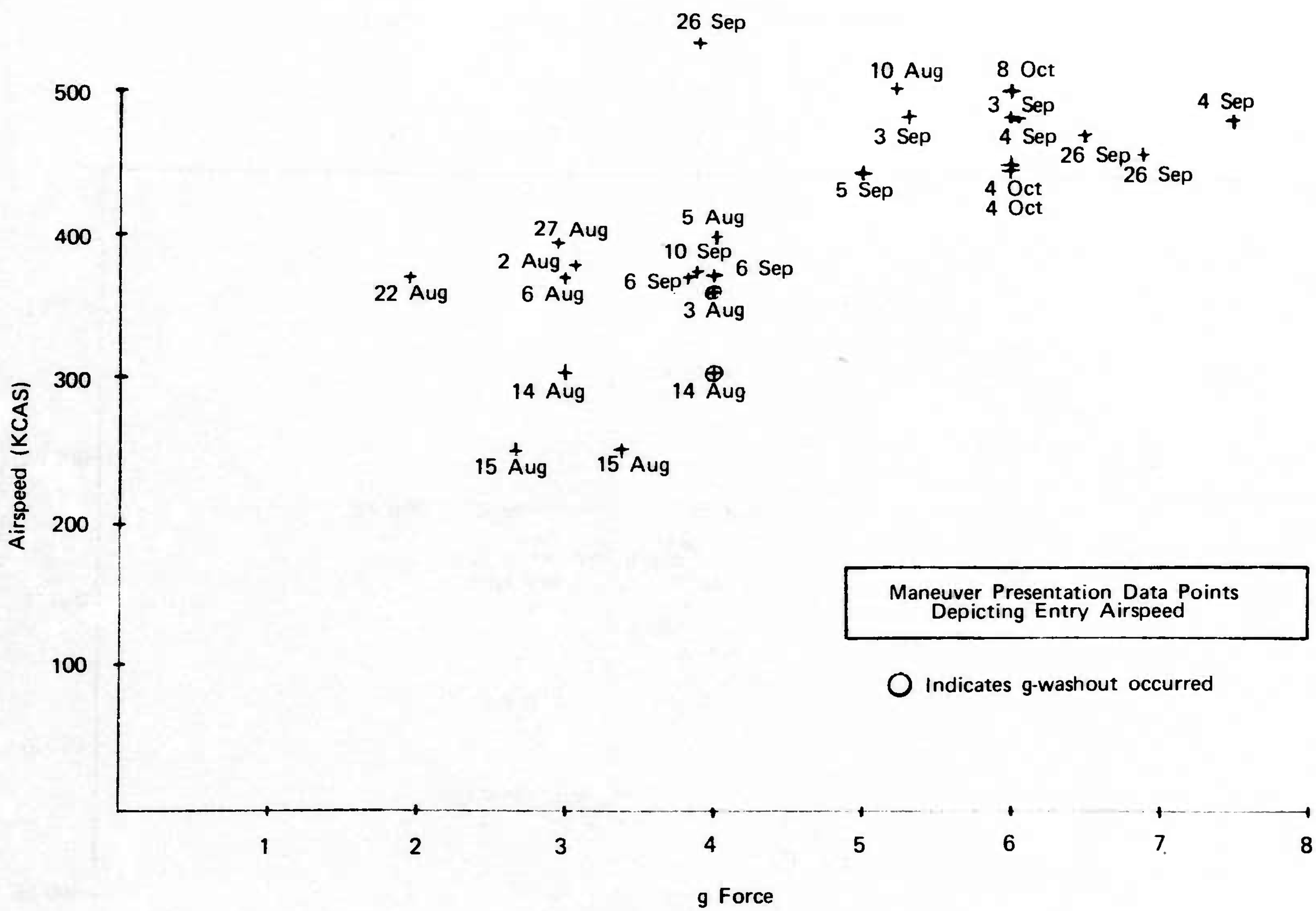


Figure 37. Maneuver Programmer (Entry Airspeed)

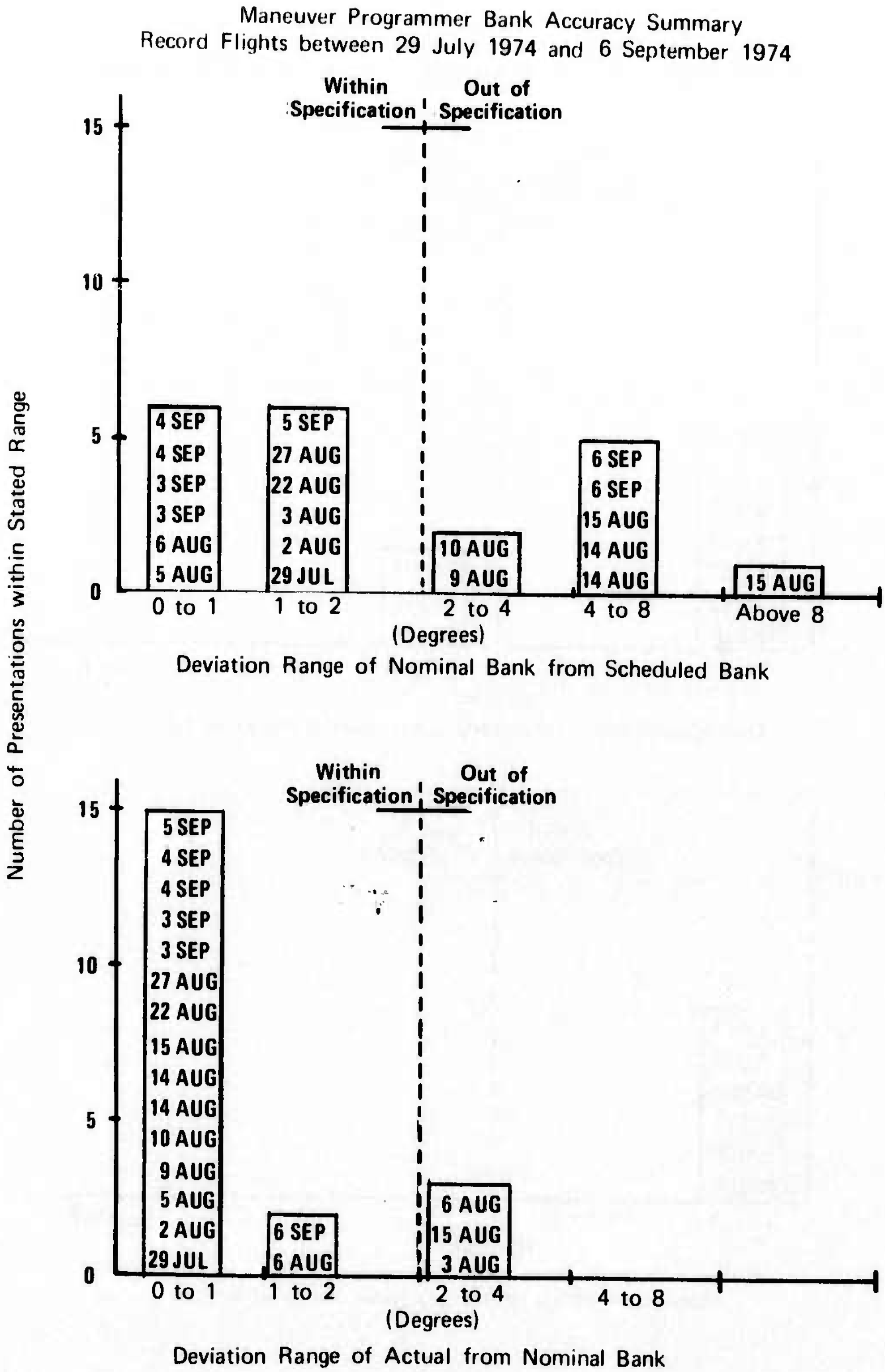


Figure 38. Maneuver Programmer – Bank Accuracy (Prior to Modification)

Maneuver Programmer Bank Accuracy Summary
Record Flights between 10 September 1974 and 9 October 1974

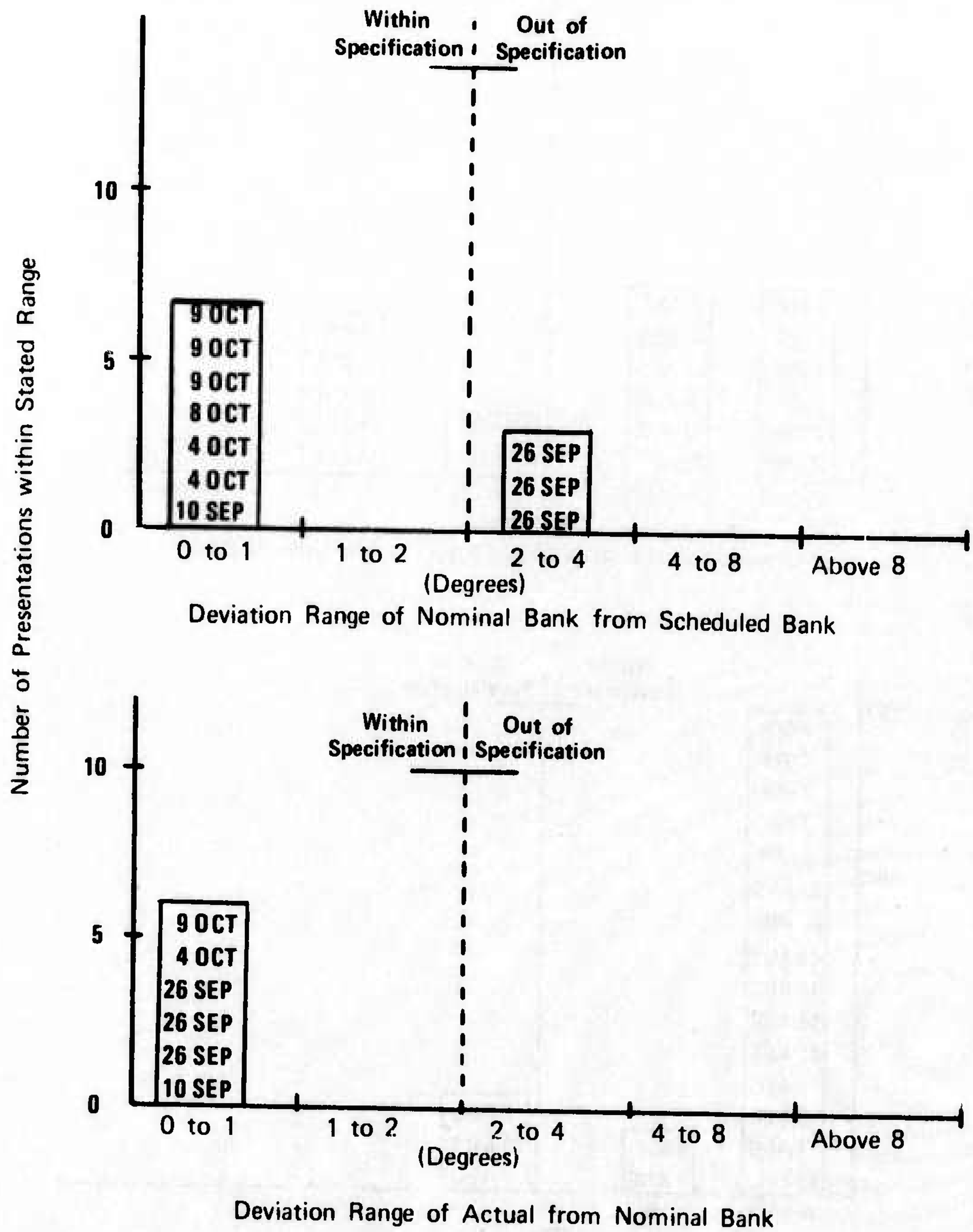


Figure 39. Maneuver Programmer – Bank Accuracy (Subsequent to Modification)

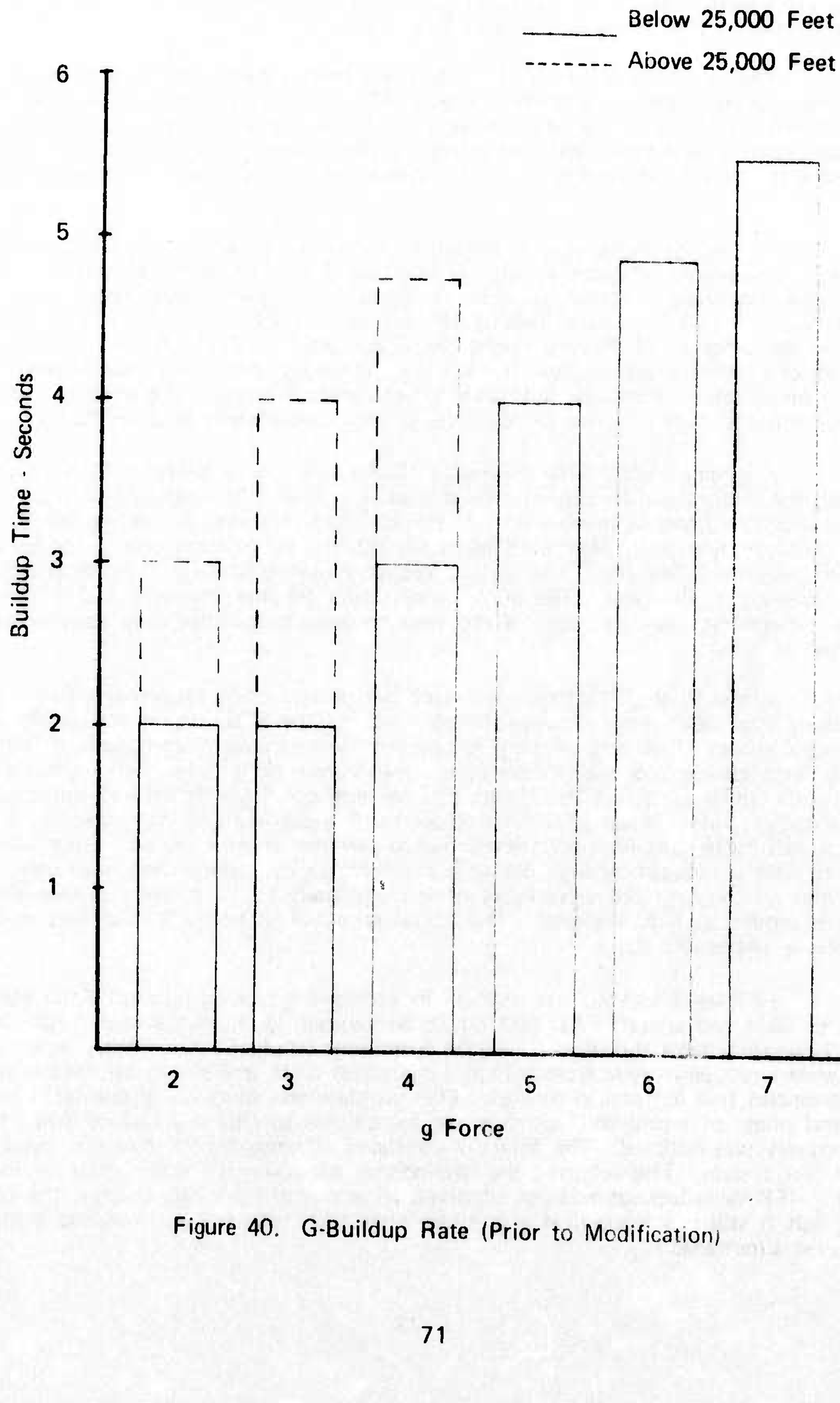


Figure 40. G-Buildup Rate (Prior to Modification)

The system modification which disconnected the airspeed input to the artificial feel system allows a larger elevon displacement about the equilibrium trim position. Buildup rates observed following this modification are presented in Table 5. No significant changes in these rates were noted at the altitudes tested, however, at higher altitudes the modification is expected to produce improved g buildup rates.

The ability of the FCSS to attain and hold a given g force as commanded by the maneuver programmer is depicted in Figure 41. These data points are prior to the modification which disconnected the airspeed input to the artificial feel system. Theoretically, the modification should have negligible effect on the system's capability to hold a given g force and this tends to be verified by the post-modification data points documented in Table 5.

It must be noted that a phenomenon labeled g washout occurred during two of the g force data points described above. G washout is the automatic decrease in commanded g force when the angle-of-attack exceeds 18 degrees. The approximate rate of decrease is 0.2g per degree angle-of-attack, exceeding 18 degrees, and the typical result of g washout can be seen in the plots of QF Record Flight No. 3 contained in Appendix A. The primary cause of g washout is an airspeed too low for the commanded g force. The low airspeed may result from low presentation entry airspeed, afterburner blowout during a presentation, long programmer timer settings, high presentation altitude, or any combination of these factors.

Programmed Maneuver Recovery Modes. At the termination of a programmed maneuver, the aircraft can be returned to straight and level flight automatically by the all attitude recovery system or manually by the FGS operator. The various modes of the all attitude recovery system are illustrated in Figure 42, and all of them except modes 3 and 6 have been tested satisfactorily. The vertical recovery modes have not been tested due to safety of flight considerations. The SOW specifications require that only ±60 degrees of pitch be demonstrated and the vertical recovery modes are operative only above or below 70 degrees of pitch.

Although the all attitude recovery has performed as expected during the record flights, there have been two serious problems involving the FCSS which are closely related to the recovery modes. The first problem concerned the hydraulic elevon package (HEP valve) which converts electrical or mechanical inputs into elevon deflections. At a given airspeed there is a maximum limit that the elevon can be displaced from its neutral trim position. An electrical command which calls for displacements exceeding this limit may cause control of the aircraft to be automatically transferred to mechanical stick inputs. Since the elevon deflection limit is reduced by high dynamic pressures or by commanding nose down attitudes, this transfer of control (HEP valve lockout) is most likely to occur when surface down commands are present at high airspeeds. The actual sequence of events is described in Record Flight No. 4 (Appendix A).

HEP valve lockout has resulted in excessive g loading (aircraft FAD 601 on 28 August 1974 and aircraft FAD 602 on 25 September 1974), but aircraft response during lockout is unpredictable and erratic. Flight conditions conducive to lockout occur when the aircraft enters recovery mode from a high g maneuver since one elevon receives a large surface down command (roll-out plus reduce g). This problem was temporarily alleviated by using the second phase of a programmed maneuver exclusively to reduce g surface down command when recovery was initiated. The final fix consisted of removing the airspeed input to the artificial feel system. This removed the dependence of elevon deflection limit on increasing airspeed. HEP valve lockout was not observed in any of the test flights after the final modification, but it still is a theoretical possibility when high roll rates and reduced g loading are commanded simultaneously.

TABLE 5. G PERFORMANCE FOLLOWING ARTIFICIAL FEEL MODIFICATION

Date (1974)	Scheduled g Force	Nominal g Force	Average Deviation From Nominal (g)	Altitude (feet)	Time to Reach Nominal (sec)	Average Build-up Time Prior to Modification (sec)	G Over-Shoot
4 Oct	6.0	6.08	+0.09	18,770	4.5	4.8	0.47
4 Oct	6.0	6.01	0	20,530	5	4.8	0.93
8 Oct	6.0	6.03	+0.07	13,270	4	4	0.22

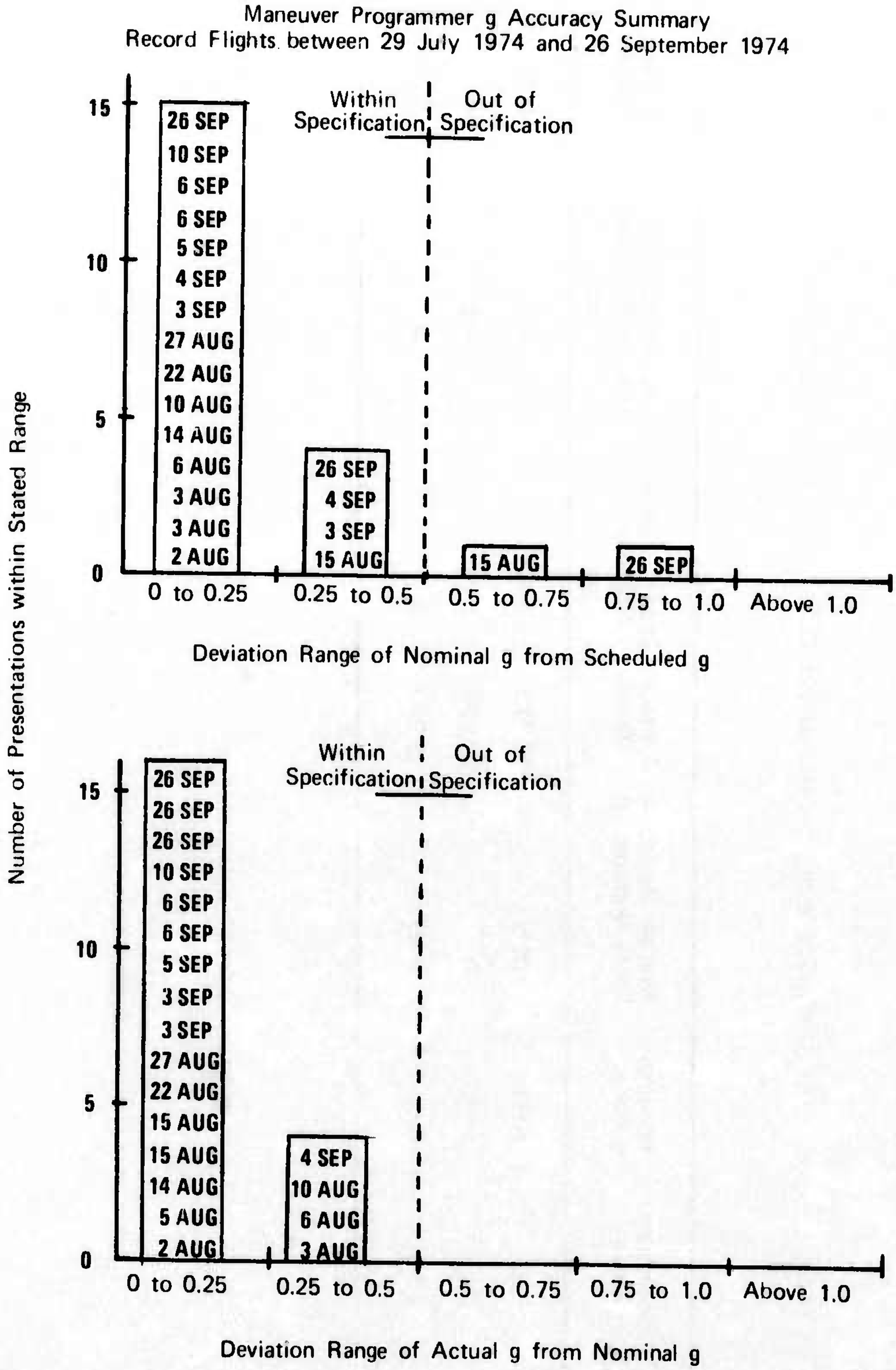


Figure 41. Maneuver Programmer – g Accuracy

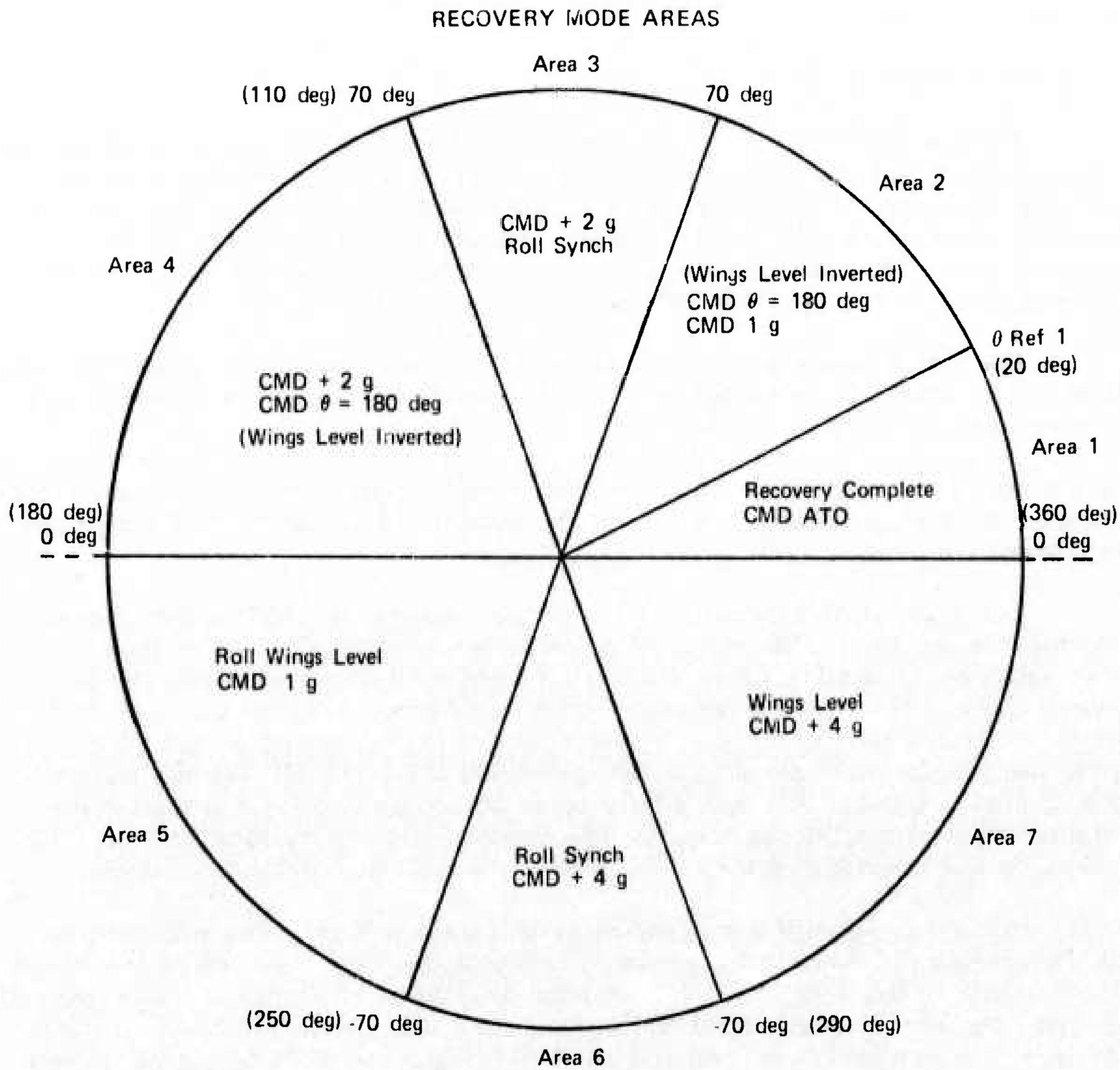


Figure 42. All Altitude Recovery System

(3) Low Altitude Maneuver Programmer (LAMP). The LAMP is designed to present a low altitude, high speed, target-to-ground based missile system. A typical cross section of a LAMP maneuver is depicted in Figure 43. At the initiation of the LAMP maneuver, the aircraft pitches down 15 degrees with a Mach hold-on-throttle reference of 0.67M. The initiation altitude should be equal to or greater than the altitude desired for the low altitude presentation phase. A level-off is started 1300 feet above the programmed altitude for the high speed pass and subsequent pull up.

The low altitude phase can be programmed for a time interval up to 99 seconds long. Altitude hold, and afterburner, if necessary, are turned on when the desired altitude is attained. The Mach hold on-throttle reference can be programmed between 0.2M and 1.0M. At the end of this time interval, a pull up can be programmed between 0 and 60 degrees if the airspeed is above 310 KIAS. If the airspeed is less than 320 KIAS the aircraft enters the automatic takeoff mode even if a pull up has been programmed.

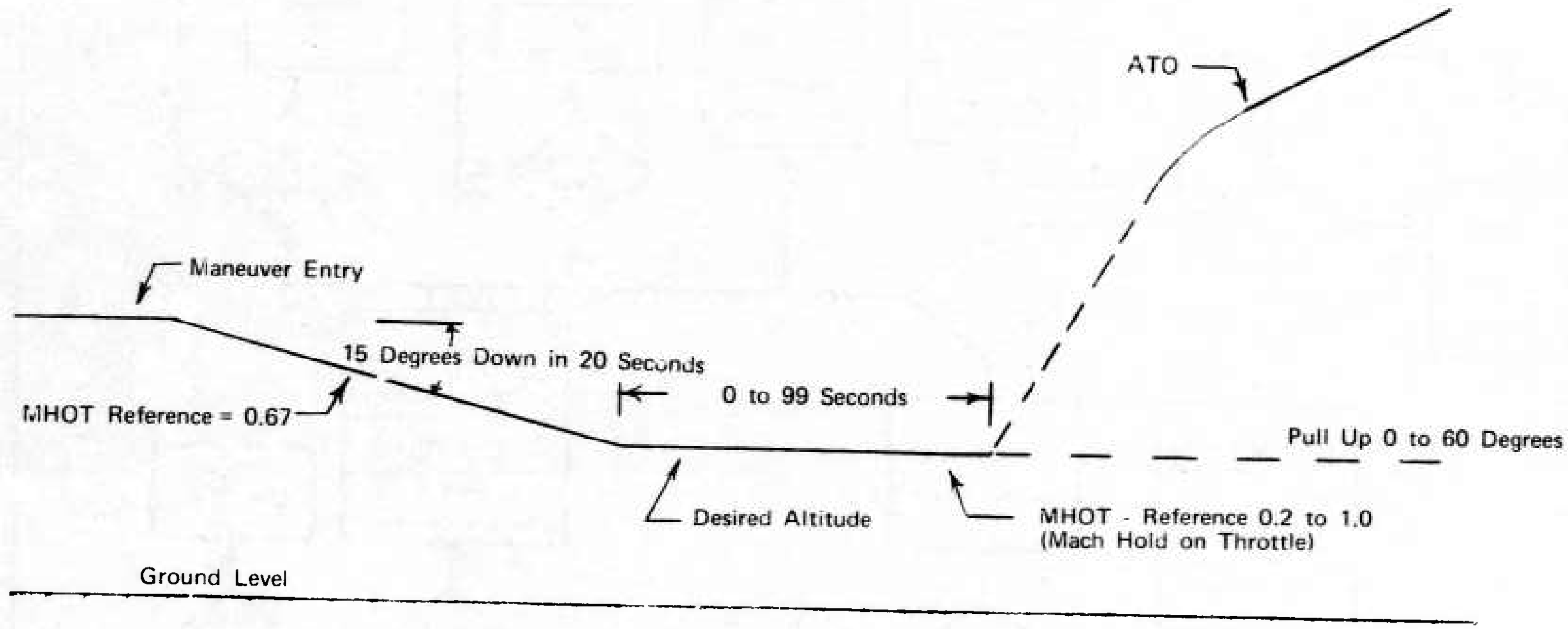
The LAMP presentation will be automatically terminated if any of the following conditions exist: pitch stick out-of-detent command, backup FCSS engaged, automatic takeoff command, altitude less than 250 feet above ground level in barometric mode, altitude less than 50 feet above ground level in radar mode, radar altimeter off flag, or a simultaneous LOC with failsafe on. The aircraft enters the automatic takeoff sequence for all of the above conditions except pitch stick out-of-detent command and backup FCSS engaged. For these cases the programmed pull up will occur.

Due to the time constraints of the testing program the LAMP system was not tested during a record flight. The source of all performance information was engineering flight data taken on 12 October 1974. During this flight the LAMP system was manually overpowered below 250 feet in the barometric mode and below 50 feet in the radar mode. The aircraft correctly responded in both instances by entering the automatic takeoff sequence. During the low altitude phase the aircraft maintained 400 KIAS (0.67M) and 400 feet above ground level as programmed. A scheduled pull up to 40 degrees of pitch was successfully accomplished following the high speed pass. The recovery sequence resulting from an LOC with failsafe on was tested during the second half of the flight and performed properly.

(4) Automatic Takeoff/Abort/Landing/Takeoff Control Mode. The automatic takeoff logic flow diagram is shown in Figure 44. Chronologically after brake release the aircraft holds heading with rudder until 150 KIAS. A pitch rotation of 13 degrees is then commanded and held until the aircraft reaches 2000 feet above ground level, above 240 KIAS. At 200 KIAS the gear is automatically retracted and above 240 KIAS, and 2000 feet above ground level, the afterburner is turned off. At 275 KIAS, airspeed on pitch is engaged to an altitude of 20,000 feet MSL. At this point altitude hold and speed hold on throttle (reference 250 KIAS) are engaged with a simultaneous roll command of +30 degrees.

Although many minor changes have been made in the automatic takeoff flight parameters throughout the test program, overall the system has performed satisfactorily. Directional gyro difficulties caused erratic heading control during takeoff on the NULLO No. 2 flight but since then the automatic takeoff sequence has not malfunctioned.

A takeoff abort command given below 150 KIAS or a LOC with weight on the landing gear will result in the abort sequence being initiated. The abort sequence causes anti-skid brakes to be applied, cuts off the afterburner and pulls the throttle to idle, deploys the drag chute, lowers the arresting gear, extends the speed brake, and engages heading hold using rudder.



Note: Not to scale

Figure 43. Low Altitude Maneuver Programmer Operation

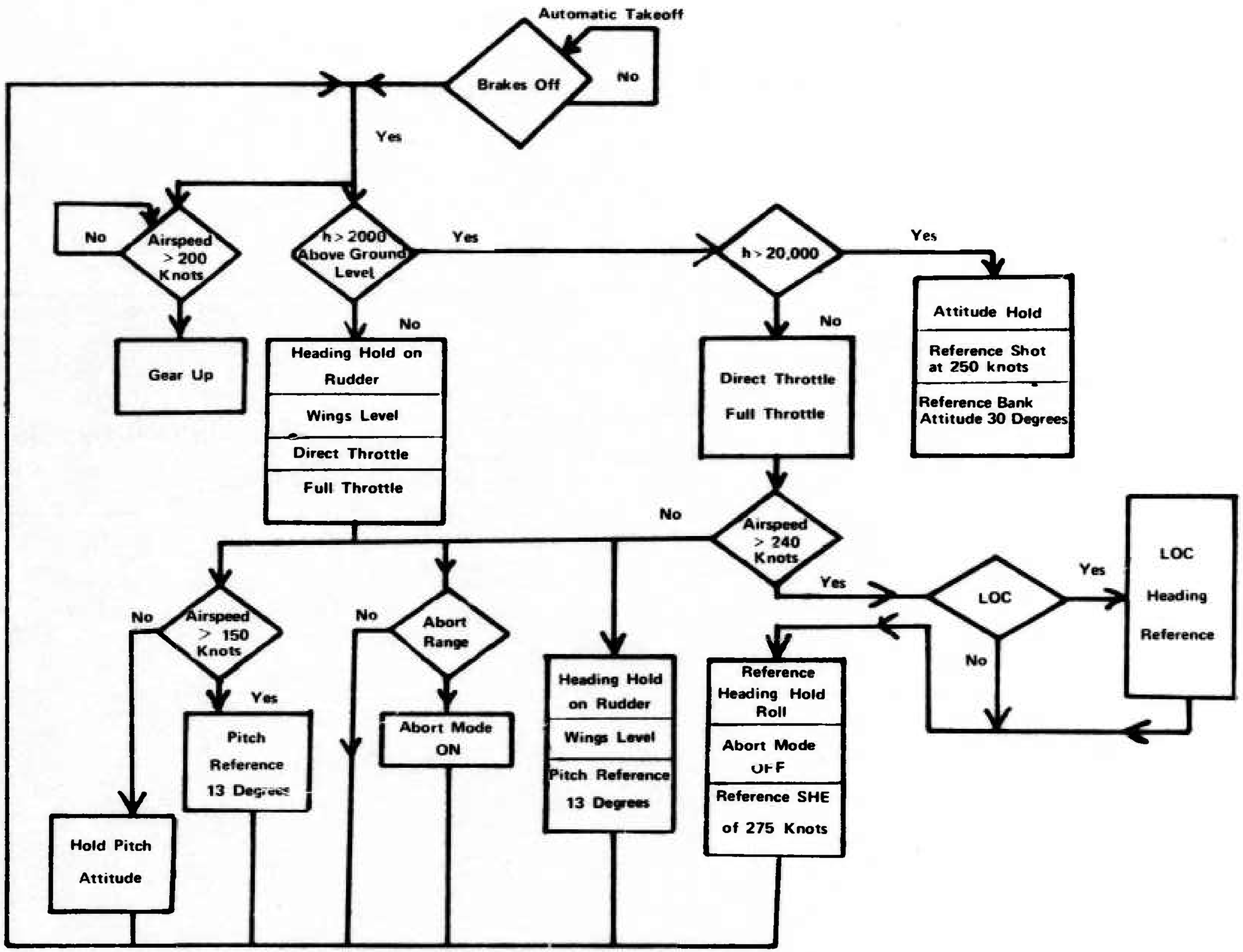


Figure 44. Automatic Takeoff Logic Flow Diagram

At the start of testing the abort sequence did not operate properly. During takeoff on flight QF-3-VI-1 (25 April 1974), a takeoff abort command was sent because of a hot hydraulic oil light. The throttle did not retard and this caused the brakes to overheat and subsequently lock. Two blown tires resulted from this abort. On 14 June 1974 the abort sequence was tested at speeds of 20 and 50 KIAS and operated satisfactorily. In addition, the abort sequence was tested at speeds up to 40 KIAS before each aircraft was cleared for its initial NULLO flight. Test results indicate that the abort sequence now operates properly and reliably.

The landing/takeoff control mode, in contrast to the automatic takeoff and abort modes, was designed to allow manual takeoffs and landings. This mode provides displacement proportional roll control for very precise bank control. Heading hold with rudder is simultaneously engaged and the control stick in detent causes a wings level condition instead of maintaining the existing bank. Skid commands are available in the landing/takeoff mode by using the trim button on the control stick. Taken as a whole, the landing/takeoff mode has performed very reliably throughout the test program. Sensitivity of the nose gear steering system has occasionally caused directional problems but this occurs after touchdown during landing roll. Although one recovery resulted in the drone going over the edge of the runway (160 feet off centerline), the remaining recoveries were well within the SOW requirements.

(5) Loss of Carrier (LOC) Mode. The loss of uplink command carrier logic flow diagram is shown in Figure 45. If weight is on the landing gear when LOC occurs, the auto-abort sequence is commanded as previously described. An LOC during a maneuver presentation does not take effect until the maneuver is completed and the recovery sequence places the aircraft in recovery area 1 (pitch angle between 0 and 20 degrees). Below 20,000 feet the aircraft follows the automatic takeoff sequence heading of 310 degrees. At 20,000 feet attitude hold is engaged and the aircraft enters a right 30-degree bank orbit.

Nearly all testing of LOC sequences was accomplished prior to the NULLO No. 1 on 13 August 1974. Tests were conducted over a wide range of flight regimes and aircraft configurations. With the few exceptions noted below, LOC tests were satisfactory and confirmed the system's reliability in all areas of flight.

During flight QF-1-IV-6b on 8 July 1974, a planned LOC following a maneuver presentation at 40,000 feet resulted in a severe compressor stall. The airspeed reference at the end of the maneuver automatically went to 250 KIAS at a rate of 15 KIAS per second. The throttle movement necessary to attain this airspeed initiated the compressor stall and the increase in throttle as 250 KIAS was approached severely aggravated the stall and caused the safety pilot to take control. This problem was solved by reducing the rate of decrease of the referenced airspeed following a maneuver and by the controller reducing the rate of throttle movement when a throttle position change was commanded.

It should be noted that if LOC occurs above 20,000 feet in the transonic airspeed region, large pitch oscillations (5 to 10 degrees) may occur as the aircraft tries to hold altitude. This was verified during flight QF-1-IV-5a on 3 July 1974 when a planned LOC occurred at 45,000 feet. Because of this problem, all maneuvers which are not subsonic at maneuver initiation must be planned so that a subsonic airspeed will be attained at the completion of the maneuver.

With the procedural and hardware changes described above, planned LOC demonstrations were accomplished on the first seven record flights at altitudes from 500 feet AGL to 40,000 feet MSL. Results indicate the LOC control mode operates properly as planned.

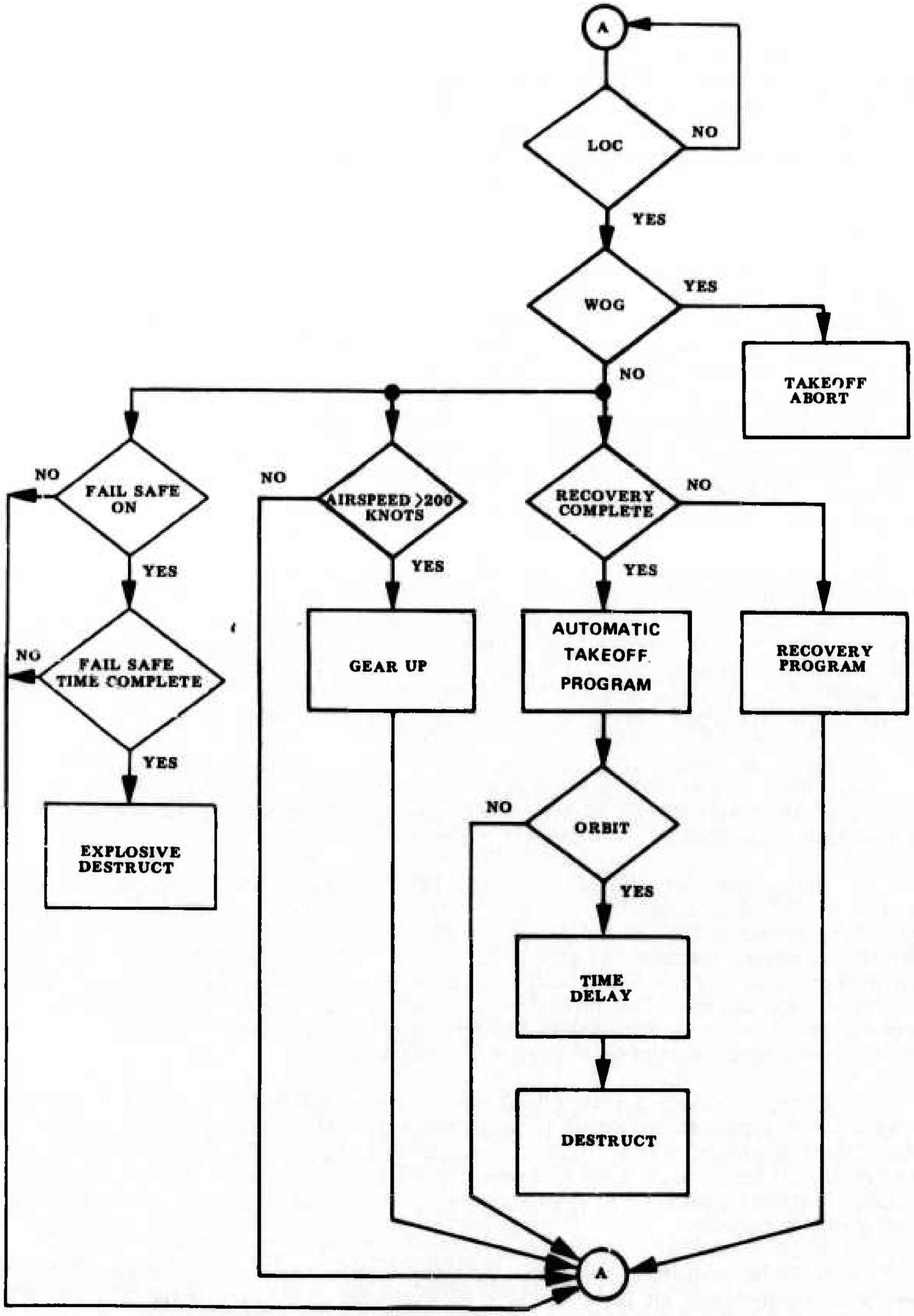


Figure 45. Loss of Carrier Logic Flow Diagram

Evaluation of the overall results of test and record flights indicated the FCSS provided the positive command guidance and flight performance necessary for the PQM target mission and complied with the requirements outlined in the SOW.

(6) Backup FCSS. The Backup FCSS signals from an independent vertical gyro to send proportional rate pitch commands and displacement proportional roll commands which bypass the autopilot circuitry. The backup FCSS was tested successfully on several flights and on PQM Record Flight No. 1 (13 August 1974). Failure of the pitch trim actuator caused the backup FCSS to be used for recovery. Operation of this system during the test program was very successful.

b. Command Control and Telemetry Systems

The airborne system, as originally proposed, consisted of two basically independent subsystems identified as the forward telemetry and aft telemetry systems. Each consisted of two stub antennas, an antenna switch, a transponder (Model 302C-2), an encoder, and a decoder. A single PRF generator connected to one system was used to initiate downlink telemetry in the absence of uplink interrogation. Problems experienced in tracking the aircraft in various flight attitudes resulted in the deletion of the forward telemetry antennas and switch and the installation of a single stub antenna on top of the aircraft vertical stabilizer. The forward system was redesignated as the fin system. Command and telemetry problems necessitated modification of the decoder and upgrading of the transponder to a Model 302C-8, modification A, having more sensitivity and output power.

For evaluation purposes, flights flown after 18 April 1974 with the above configuration were the only ones considered. Flights flown after 2 July 1974 utilized Model 302C-8, modification B, transponders which improved MGS control ability. The modification eliminated transponder automatic gain control (AGC) action resulting from track signals and enabled AGC only in response to control signals.

The ground systems consisted of the FGS and MGS. The FGS, located in the White Sands Missile Range Building No. 1102 (King I), consisted of a dual console with suitable telemetry indications (lamps, meters, and indicators) to monitor the 62 downlink telemetry channels (proportional and discrete) and with a control stick and switches used to select the 52 uplink command functions (proportional, priority discretes, and non-priority discretes). Tables 6 and 7 identify the command and telemetry channels. The console also had a monitor test set used to compare the FGS selected command to the command actually transmitted by the FPS-16 radar. The FGS was connected to two White Sands Missile Range FPS-16 radars (R-122 and R-123) via dedicated hard lines. In operation, one FGS console was connected to a radar operating in the control mode with the other console being connected to a radar operating in the track mode. Radar/console selection can be reversed by control switches on the FGS console.

The MGS consisted of consoles similar to the FGS which were connected to self-contained radar units (primary and backup). One difference was the split mode option which enabled the appropriate console to control those operational systems necessary for the particular operator to control, i. e., yaw and pitch.

Evaluation of the flights after 18 April 1974 considered the range and transfer, uplink adequacy, downlink adequacy, MGS/FGS operations, system redundancy, and data recording/reduction. The most significant problems, primarily those discussed at post mission briefings, are the only ones discussed here; problems experienced during routine preventive maintenance efforts and those prior to 18 April 1974 are not considered in the evaluation:

TABLE 6. CHANNEL ASSIGNMENTS FOR PROPORTIONAL AND DISCRETE UPLINK COMMANDS

Channel	Name	Channel	Name
	Proportional Uplink Commands		
1	Pitch	3	Spare
2	Roll	4	Spare
	Discrete Uplink Commands		
1	Speed Hold on Throttle	25	Maneuver Selector C1
2	Mach Hold on Throttle	26	Maneuver Selector C2
3	Altitude Hold	27	Scoring On
4	Speed Hold on Pitch	28	Scoring Calibrator
5	Mach Hold on Pitch	29	Hold-to-Arm
6	Automatic Takeoff	30	Fail Safe On
7	Throttle Stop By-Pass	31	Guidance Foreward
8	AGC Disable	32	Backup FCSS On
9	Landing/Takeoff Mode	33	Throttle Increase
10	Gear Up	34	Throttle Decrease
11	Gear Down	35	Reference Increase
12	Emergency Gear Up	36	Reference Decrease
13	Brakes On	37	Afterburner On
14	Speed Brakes Out	38	Pitch Stick Out
15	Chute Deploy	39	Wings Level
16	Hook Extend	40	Line-of-Sight
17	Airstart Ignition	41	Skid Right
18	Left Boost Off	42	Skid Left
19	Right Boost Off	43	Spare
20	Right Tanks Fuel Quantity	44	Maneuver Initiate
21	Smoke On	45	Explosive Destruct Arm
22	UHF Destruct System On	46	Explosive Destruct
23	Backup Generator On	47	Maneuver Destruct Arm
24	Radar Altimeter Test	48	Maneuver Destruct

Note: Channels 33 through 48 are priority commands

TABLE 7. CHANNEL ASSIGNMENTS FOR PROPORTIONAL AND DISCRETE DOWNLINK DATA

Channel	Name	Channel	Name
Proportional Downlink Data			
1	Altitude	12	Normal Acceleration
2	Altitude Rate	13	Engine RPM
3	Airspeed	14	EPR
4	Mach	15	Exhaust Gauge Temperature
5	Airspeed/Mach Reference	16	Fuel Quantity
6	Pitch Sin	17	Destruct Battery Voltage
7	Pitch Cos	18	Angle of Attack
8	Roll Sin	19	Radar Altitude
9	Roll Cos	20	Spare
10	Heading Sin	21	Foreward Telemetry AGC Level
11	Heading Cos	22	Aft Telemetry AGC Level
Discrete Downlink Data			
1	Altitude Hold	21	Hydraulic Oil Hot
2	Airspeed on Pitch	22	Primary Aircraft Failure
3	Airspeed on Throttle	23	Backup Aircraft Failure
4	Mach on Pitch	24	DC Power Failure
5	Mach on Throttle	25	Oil Pressure Low
6	Landing/Takeoff Mode	26	Pneumatic Pressure Low
7	Automatic Takeoff Arm	27	Fuel Pump Failure
8	Direct Throttle	28	Fuel Low
9	Nosewheel Steering	29	Tank Pressure Low
10	Weight-Off Gear	30	Boost Pressure Low
11	Aft Telemetry Top Antenna Switch Position	31	Anti-Ice
12	Altitude Low (7440)	32	Primary Hydraulic Failure
13	Throttle Off	33	Secondary Hydraulic Failure
14	Throttle Idle	34	Gear Unsafe
15	Throttle Military	35	Fire
16	Throttle Afterburner Range	36	Stall Warning
17	Carrier No. 1 (Foreward Telemetry)	37	Fail Safe Arm
18	Carrier No. 2 (Aft Telemetry)	38	Destruct Arm
19	Command Foreward Telemetry Active (Carrier No. 1)	39	Vertical Gyro Fail
20	Gear Down and Locked	40	UHF Check Channel

(1) Range and Transfer. A primary test objective was confirmation of the ability of the FGS to provide positive aircraft command control for all flight regimes up to 200 nautical miles within radar line-of-sight conditions and for MGS control up to 50 nautical miles.

FGS control to 200 nautical miles was attempted on two occasions (14 May and 16 May 1974). On the first flight, control was maintained for 200 miles outgoing but was lost during a portion of the return. Analysis of radar data, aircraft position, and terrain indicated that the aircraft evidently went below the radar line-of-sight during the turn at the 200 mile point due to mountainous terrain. On the subsequent flight, the departure heading and 200 mile return point were altered and positive command control with short downlink data losses was confirmed to the 200 mile point and back.

MGS control to 50 (primary radar) and to 10 (backup radar) miles was verified on several flights and MGS control up to 124 miles was accomplished on one occasion.

Additionally evaluated was the ability to maintain positive command control during routine FGS/MGS handover of control and the immediate reestablishment of control in the event of FGS or MGS failure. FGS/MGS data correlation, or the extent of agreement of the telemetry received by the MGS and FGS, was also evaluated. The adequacy of the MGS X–Y plot board used to obtain a ground track while the PQM-102 aircraft was under MGS control was also evaluated.

On one occasion failure of UHF communications just prior to handover created some confusion and a smooth handover was not accomplished. However, controller response was such that the series of LOC were all less than 1.5 seconds and the LOC maneuver was not initiared.

Two significant FGS/MGS handover related problems were experienced. Once during handover the FGS was unable to acquire track (downlink telemetry prior to assuming control). It was also found that the MGS could not acquire track when the FGS was in control. The situation was handled by having the MGS go to track mode prior to the FGS assuming control. The problem was identified as an aircraft decoder problem (lack of track verification) and was corrected.

On the first NULLO flight complete data loss occurred twice (no LOC). The problem was eliminated when both the FGS and MGS selected the forward telemetry system. Subsequent analysis indicated that during backup flight control system operation, when the FGS selected the forward telemetry system and the MGS selected the aft telemetry system, both systems would remain on simultaneously. A modification was incorporated to prevent operation of the PRF generator with the forward telemetry system unless the system was selected by the primary controller. This eliminated recurrence of this problem.

Operation of the plot board was adequate despite numerous problems with its alignment and operation. The ground track obtained, along with the FGS/MGS communications and the MGS operator's familiarity with the expected PQM-102 approach path, always resulted in successful visual acquisition of the drone.

(2) Uplink Adequacy. Uplink adequacy, described as the ability to provide desired commands to the aircraft FCSS, encompasses many variables between the activation of a switch on the FGS or MGS console and the execution of the command. Evaluation included the ability to provide positive command control throughout the mission, the ability to provide several commands simultaneously, and the ability to execute only desired commands.

Although the downlink telemetry system should provide an indication when the aircraft is not receiving a valid command signal, it was found that in the event of marginal radar tracking the downlink telemetry was lost prior to loss of uplink control. To provide a positive indication of uplink loss, a modification was incorporated which provided a steady audio tone transmitted via the aircraft UHF radio (ARC-34). This uplink loss indication proved to be valuable to the ground controller, the chase pilot, and to the tracking radar operators.

Positive command control, or the ability to maintain uplink control without losses of greater than 1.5 seconds in duration, was evaluated on 54 flights between 18 April and 6 September 1974. (Note: Loss of a valid uplink command signal for periods greater than 1.5 seconds would initiate either the failsafe or the LOC orbit destruct sequence.)

On the first maximum range evaluation flight while under MGS control, a 2-second LOC occurred at a range of 25 miles and again at 49 miles. Rather than initiate the LOC orbit, the pilot assumed control and continued with the maximum range evaluation. While under FGS control, LOC occurred at a range of 200 miles and the pilot assumed control for a portion of the return flight. As previously mentioned, it was concluded that the aircraft had gone below the FPS-16 radar line-of-sight due to mountainous terrain.

Significant LOC (greater than 1.5 seconds) were not experienced on the remainder of the flights. However, several LOC-related problems did occur. On one occasion during climbout, the aircraft stopped accepting commands, the LOC tone did not come on, and the safety pilot assumed control. Analysis revealed an intermittent simulated carrier switch. The problem was eliminated by removal and replacement of the switch. It was noted that the failure would not have influenced a PQM-102 flight since this circuit is by-passed by NULLO switches.

During an LOC test with the airspeed-on-pitch command selected the aircraft pitched over to attain desired airspeed. The system disconnected at −2g and the pilot assumed control. The system worked as designed and no corrective action was taken. If LOC occurred on a PQM-102 under these circumstances, since the g-disconnect is disabled, drone recovery would depend on reestablishment of carrier due to the change in aircraft position and the FGS controller's ability.

Altitude hold problems were experienced during an LOC test performed while the aircraft was transonic. This can be expected in this region due to air pressure variations.

The ability to send all and only desired commands, and the abiltiy to send simultaneous commands, was evaluated during this period. No record was kept as to the maximum simultaneous commands sent but six to eight were observed on several occasions. By design the system should accept all 52 commands simultaneously. No known problems were experienced concerning activation of simultaneous commands; however, the following command-related problems were experienced during several missions:

- One console of the FGS caused the aircraft to fly with one wing low on a mission. Adjustment of the accociated FGS format converter corrected the problem.

- While under either FGS or MGS control, when the aircraft speed brakes were closed, the LOC command was received (repeated several times). The mission was aborted on the runway. An aircraft/FCSS grounding problem was identified and corrected.

- The nonpriority discrete commands (from FGS or MGS) were inoperative when the forward telemetry system was selected during pre-flight checks. The mission was flown using the aft telemetry system only. A defective decoder was found to have caused the problem.

- The FGS could not command the speed brakes on the forward telemetry system. The problem could not be identified or duplicated during subsequent ground checks.

- The FGS had difficulty latching on the landing/takeoff command and the forward telemetry system was inoperative during this flight. The problem could not be duplicated.

- The FGS was unable to command Mach-on-throttle from the primary console. A short circuit and defective diode were found and repaired.

- During one flight the MGS wings level command was inoperative and pitch-stick-out was used to execute a wings level attitude. The problem could not be identified.

- When under control of the MGS backup radar, the forward telemetry system would not accept the altitude hold command on two occasions. The problem was identified as transmitter/receiver feed-through in the aircraft transponder and was corrected.

- The aircraft afterburner lit during the landing approach. The problem was identified as an undersized noise spike or voltage created by operation of the speed brakes. The spike initiated maneuver complete action including automatic takeoff. The problem was eliminated by addition of a relay and re-routing of the associated wiring. According to the prime contractor, all aircraft have had this modification incorporated. However, on 9 October 1974, a similar problem occurred on a different aircraft when the afterburner lit (uncommanded) during a touch-and-go. The problem was never identified or duplicated.

With the exception of the afterburner problem in the preceding paragraph, no inflight undesired response related to commands were identified. Several undesired downlink telemetry responses were received but actual occurrence of the events was not confirmed. This is discussed in a subsequent paragraph concerning the downlink system.

The aforementioned problems indicate a resistance of the system to accept all selected commands. However, significant mission impacts were avoided through the experience of the ground controllers and by the system redundancies. The accuracy of the commands as to the resulting flight maneuvers is covered in the data analysis section. Judging mission performance, it appears that a sufficient number of commands were available to achieve the desired missions and that the desired confidence level was attained.

(3) Downlink Adequacy. Downlink adequacy, described as the ability to maintain accurate aircraft telemetry information, includes the information needed by the ground controller to maintain positive command control of the aircraft and the recorded information required for analysis of aircraft performance to insure compliance with the SOW.

Evaluation of the recorded telemetry is covered in paragraph 2.b.(6). The following numerous downlink telemetry problems were experienced on several occasions:

- The most significant problem was the inability of the MGS to obtain downlink telemetry when the aircraft was in the local pattern and FPS-16 radar R-123 was radiating (track or control mode). Radar 123 was a 3-mega-watt unit with a klystron/magnetron as opposed to radar 122 which radiated 1 mega-watt with a magnetron. The only solution was with radar 123 completely passive during this period of the mission. The exact cause of the problem was not determined.

- The FGS experienced significant downlink data losses. During most of these periods data was lost on both consoles and for periods up to 30 seconds. Figure 46, a data loss summary for the record flights, shows the average and maximum durations of downlink data losses.

- Fluctuating or intermittent indications were observed on the altitude, fuel quantity, airspeed, Mach reference, and g indicators. Offsets between FGS/MGS telemetry and aircraft indicators were also experienced. Readjustment of the aircraft transponder AGC level corrected the offset problem.

- Temporary destruct arm telemetry indications were received. No means were available to confirm that this event actually took place. It was suspected that lack of isolation of the White Sands Missile Range missile flights safety destruct box (FGS console) caused the problem.

- The HEFU telemetry (a temporary modification) was very noisy making analysis of the destruct qualifications impossible. Improvement of the modification corrected this problem.

- The FGS primary console attitude indicator was upside down until the aircraft was above the lower altitude telemetry range (7500 feet). The problem was traced to a telemetry patching problem between the FGS and White Sands Missile Range strip chart recorders.

- It was also discovered that downlink data losses were more prevalent when the FPS-16 radars had their skin track local oscillators on. The local oscillators enhance tracking in the event the transponder reply is lost. Correction of the weakness was procedural by using a third FPS-16 radar on skin track slaved to R-122 and R-123 which operate with their local oscillators off.

In summary, downlink adequacy appeared to be the weakest link but the losses did not significantly affect mission success.

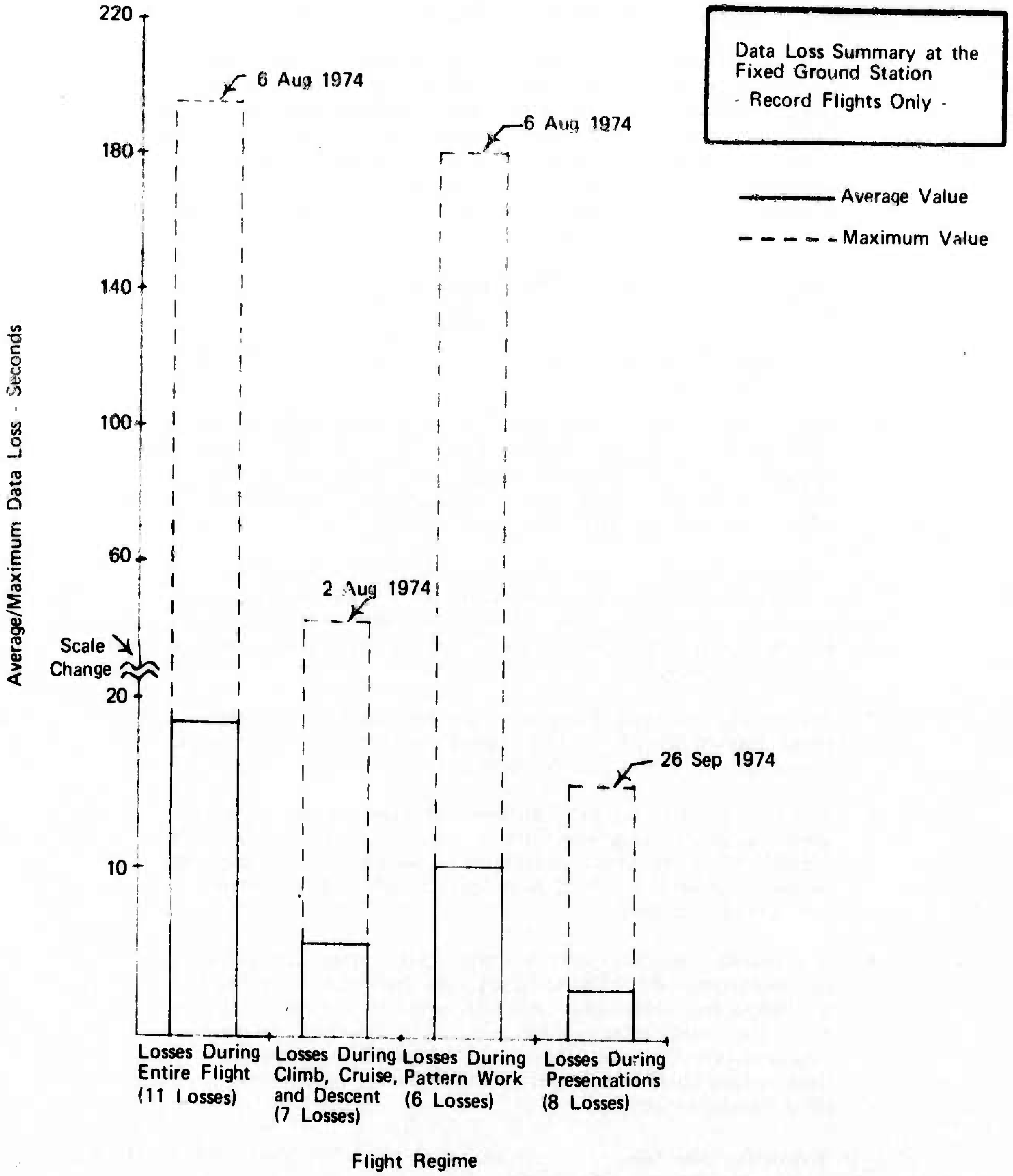


Figure 46. Data Loss Summary

(4) MGS/FGS Operations. Rather than a detailed description of operations occurring at the FGS and MGS, the following is a listing of the various problems that were experienced, along with what was done to improve efficiency and reliability of operations:

Problems were experienced during pre-flight command/telemetry checks between the FGS and the aircraft. In most cases, the probable cause was listed as multi-path or reception by the aircraft of multiple signals (reflections) from the FPS-16. However, in only a few cases was the problem actually traced to multi-path. The problem diminished, most likely as a result of improved operational techniques and improved transponder certification procedures.

Radar 123 was in the control mode and track mode simultaneously (theoretically impossible) during pre-flight checks. The problem was corrected by resoldering several connections in the FGS format converter.

For a period of time interference was experienced between the MGS UHF radio and its backup radar. Relocation of the antennas apparently eliminated the problem.

Problems were experienced at least twice with the FGS/White Sands Missile Range telemetry interface (strip charts) but were resolved prior to aircraft takeoff.

An abnormally high number of FGS problems were experienced but their occurrence during missions was greatly reduced by the initiation of a weekly preventive maintenance ground check utilizing R-122 and R-123.

(5) System Redundancy. The redundancy designed into the command control/telemetry system to insure a high degree of mission reliability was broadly evaluated to confirm its adequacy. The following is a brief description of the redundant subsystems that were evaluated:

The aircraft antennas (two for the aft telemetry system and one for the forward telemetry system) were designed to provide a continuous signal to their respective transponders for various aircraft flight attitudes.

Two transponder/encoder/decoder combinations provided further redundancy for the command control/telemetry system. In the event of a loss of downlink telemetry due to component failure or a weak downlink signal, the alternate system could be selected by command. In the event of a loss of uplink carrier the system could automatically switch to the alternate system. Downlink telemetry indicated which downlink system was selected and indicated the reception of an uplink carrier by either or both of the aircraft transponders. In addition, the system was equipped with a PRF generator. This unit, when activated by the decoder as a result of LOC on both aft telemetry and forward telemetry permitted the encoder to output telemetry data in the normal sequence. Should the LOC be temporary, the controller would be able to maintain a status on the aircraft functions.

Redundancy at the FGS consisted of two independent consoles and two separate FPS-16 radars. Either console could be connected to either of the radar for command control while the remaining console was used only to monitor downlink telemetry received by the other radar operating in the track mode. A single radar could not be simultaneously connected to both consoles. Redundant power supplies were used for the FGS consoles but neither the FGS nor the FPS-16 commercial power was redundant.

Redundancy at the MGS consisted of two consoles operated either singly or in the split mode (as previously described). Either the primary (50-mile range) or backup (10-mile range) radar could be selected for use. The data from a single radar fed both MGS consoles. Redundant gasoline-driven generators were used for electrical power.

No serious deficiencies were found concerning the redundancy of the above and typical problems encountered were listed in earlier paragraphs. In summary, while no specific requirements were listed in the SOW, an apparently adequate level of redundancy existed and operation of all systems appeared to be satisfactory.

(6) Data Recording/Reduction. The ultimate source of all downlink data is serial binary information which is output from a modulator/de-modulator (MODEM). This information is catalogued and checked for parity by the format converted which subsequently sends the information to digital-to-analog converters and to a government furnished tape recorder located at the fixed site. The output of the digital-to-analog converters drives strip chart recorders and may also be recorded on magnetic tape if desired. Consequently, the three possible sources of data for a specific test flight are a magnetic tape containing digital information, strip chart recordings containing analog information, and an optional magnetic tape containing analog information.

Magnetic Tape: Digital Information. The primary source of downlink flight data is digital data recorded on a government furnished magnetic tape recorder. This source is referred to as digital tape. In addition, it contains uplink command information and inter-range instrumentation group (IRIG) B timing on separate channels. The uplink and downlink data available from the digital tape are shown in Tables 6 and 7. Proportional data channels contain 10 bits of information (accuracy 0.3 percent root mean square), and the impact of this on data analysis is discussed in Appendix B.

Prior to May 1974, the digital data for test flights was not available due to hardware problems. Specifically, a continuous stream of digital data was not provided by the format converter and this problem persisted until a compressor was provided by a subcontractor. After the deficiences were removed from the compressor it proved to be very reliable and made the digital data an excellent source of flight information throughout the test program.

Strip Chart Recordings. Selected uplink and downlink information from the primary FGS console was recorded on strip chart recording channels at a rate of 0.5 cm/sec. This data was accurate within 5 percent and was used as a quick-look evaluation of flight performance following a mission. The strip chart recorders were the most reliable source of information in the flight test program and proved to be invaluable during many early missions when other data sources were inoperative.

Magnetic Tape: Analog Information. A backup source of downlink flight data was analog data recorded on magnetic tape. This source was referred to as the analog tape or van tape since the recording was made outside the King I complex in a large mobile van. Only 16 channels of information were available using this procedure and the data was required to be transmitted from the primary FGS console. This analog tape was intended to replace the digital tape data for analysis if necessary and was accurate within 3 percent. Since the digital magnetic tape proved to be very reliable during the test program, the requirement for the analog tape was deleted after NULLO No. 2 on 27 August 1974.

Evaluation of the overall results of test and record flights indicated that the command control and telemetry systems provided: (1) satisfactory operation and that the MGS/FGS could operate on the same frequency, and transfer between stations could be accomplished without interruption of positive flight control; (2) satisfactory uplink and downlink of data; (3) positive control capability for the MGS and FGS at 50 and 200 nautical miles, respectively; and (4) compliance with the requirements outlined in the SOW.

c. Aerospace Ground Equipment (AGE)

All QF/PQM-102 peculiar AGE items listed below were evaluated and utilized at Holloman Air Force Base:

System Test Bench (STB)
Premission Test Stand (PMTS)
Engine Control Unit (ECU)
Brake Control Test Set
Radar Simulator
Target Group Simulator

(1) System Test Bench (STB). The STB, Serial No. 001, was used extensively during the early portion of the program for engineering development and troubleshooting of the QF/PQM-102 line replaceable units. A second bench, Serial No. 002, was received at Holloman Air Force Base in June 1974. Subsequently, both system test benches were utilized to a much greater extent to perform routine testing and troubleshooting of the interface coupler (IFC), flight reference computer (FRC), air data computer (ADC), both the high and low altitude maneuver programmers, and the MD-1 attitude gyro. The procedures, average test times, and patchboard requirements are shown in Table 8.

TABLE 8. SYSTEM TEST BENCH DEMONSTRATED TEST CAPABILITIES

Unit	Procedure No.	Average Time (Hours)	Patchboard	Present Capability
FRC	5320-10742	24	FRC	Full
IFC	5320-10744	12	IFC	Full
High Altitude Maneuver Programmer	5320-10745	20	ADC	*
Low Altitude Maneuver Programmer	5320-10746	24	ADC	*
ADC	5320-10747	10	ADC	Full if TTU-205 available
MD-1 Attitude Gyro	IT 43550-1	2	SYS	Full
System Test	Not Available	Unknown	SYS	Limited

*Full capability if a storage oscilloscope, strip chart recorder, or X–Y plotter is available.

Operation of the STB required an assortment of precision test equipment. A list of this peripheral test equipment and where it was used is shown in Table 9.

There were only three hardware problems associated with the STB after June 1974. Two resulted in design changes and the third was a ±15-volt direct current internal reference power supply failure in STB Serial No. 002.

In the future to increase the STB productivity, a full complement of precision test equipment should be assigned to each bench. This should include each item in Table 9 except the Tektronix 211 oscilloscope and X–Y plotter. These items should be replaced with a dual-trace storage-oscilloscope for each bench. Also, the top shelf on the STB is not deep enough to safely hold most of the test equipment that is used. The shelf should be modified or the equipment should be mounted in an equipment rack alongside the STB.

(2) Premission Test Stand (PMTS). The PMTS was used to evaluate QF/PQM-102 aircraft systems prior to flight. It consisted of a mobile (trailer-mounted) unit to house all the equipment and was electrically connected to the aircraft by five 40-foot cable assemblies. After the PMTS was connected to the aircraft under test, a comprehensive test procedure was utilized to evaluate each of the aircraft subsystems. Operator controls for application of electrical stimuli and measurement of resulting electrical responses were provided on six panels. These panels were the command panel, data panel, system test panel, indicator panel, engine control panel, and brake control test set. In addition, there was an intercom panel to provide operating personnel with communications.

The command panel provided the means for operator selection and control of discrete and proportional command inputs to the QF/PQM-102 aircraft. It was identical to the command panel used in the FGS and MGS.

The data panel provided readout of the aircraft telemetry data and was equivalent to the cockpit instruments. It was also identical to the data panel used in the FGS and MGS.

The system test panel provided test point monitoring, an AC voltage stimulus source, and two DC voltage stimulus sources. It also provided lamps to indicate discrete commands that were sent to the aircraft and lamps to indicate the discrete command response from the aircraft.

The indicator panel was connected to telemetry data points picked up from the pallet assembly junction box prior to routing to the airborne telemetry system. These functions were monitored on a built-in precision digital multimeter (Fluke Model 8110A) for precise measurement and routed to and displayed on the data panel. The data panel readouts were then directly compared to the raw sensor data that was being measured on the system test panel. Aircraft vertical gyro and directional gyro functions were measured on an attitude position indicator as well as simulated by the indicator panel. The indicator panel also provided switching to monitor the analog command signals on the digital voltmeter to evalute the aircraft surface response versus the command input. Static response to discrete commands were either read directly from the data panel or by the digital voltmeter. Responses were monitored from many points in the system, from the initial input to the final output.

The engine control panel and brake control test set are discussed in paragraphs 2.a.(3) and 2.a.(4).

TABLE 9. SYSTEM TEST BENCH TEST EQUIPMENT REQUIREMENTS

Precision Test Equipment	On Hand from Contractor		Required for Test						Remarks
	001	002	FRC	IFC	ADC	*MP	SYS	**MD-1	
Oscilloscope Tektronix 211	1	1	1				1		Shared with PMTS
DVM HP 3440A	1	1	1		1	1	1	1	
API Model 8525	1	1	1		1	1	1	1	
Invertron Model 751A	0	1	1	1			1		
X–Y Plotter HP 7005A and HP 17108A	1	0	1			1	1		Inoperative
Multimeter Simpson 260/Weston 440	1	1		1		1	1	1	Shared with PMTS
Function Gen. HP 202A	0	1		1			1		
Timer/Counter/ DVM HP 5326B	0	1		1		1	1		
Decade Resistance Box Model EUW-30	1	1	1	1	1	1			
Air Data TS TTU-205	0	0			1		1		Borrowed from PMTS
Precision PS TRYGO DL40-1	2	2	2	2	2	2	2		1 for ± 15 volts DC 1 for ± 5 volts DC

*MP: Maneuver Programmer
**MD-1: MD-1 Attitude Gyro

Both PMTS Serial No. 3090001 and 30100002 were used extensively during the early portion of the program for engineering evaluation and troubleshooting of the FCSS and aircraft electrical systems, and for the development and verification of premission test procedures. Also, the PMTS was the primary tool for performing post PMQ-102 conversion ground checks. All three PMTS (a third unit, Serial No. 4090003, was received in September 1974), were, to a greater extent, utilized to perform routine premission testing of QF/PQM-102 aircraft.

The major PMTS deficiency was the lack of appropriate test equipment for testing the FCSS via the command telemetry system RF section. The method currently used to perform a system test of this nature is to use the MGS to generate the commands and monitor the responses while the PMTS is being used simultaneously to evaluate the system performance. However, this ties up a valuable piece of operational ground equipment and does not provide a means to attenuate the signal to simulate range because the MGS radars can only be operated at full power.

Maintenance of the PMTS, with the exception of the 40-foot electrical cable assemblies, was minimal. The largest maintenance item during the DT&E program was modification, both as a result of changes to aircraft systems and due to improvements made to the PMTS. There was a 57 percent reduction in the number of modifications during the second 5 months of the program as compared to the first 5 months (Table 10). Also, there was a significant decrease in the complexity of modifications.

The only major maintenance problem associated with the PMTS was bent, broken, and recessed pins in the connectors on the 40-foot cable assemblies which connect to the aircraft under test. The cables assigned to PMTS Serial No. 3090001 had 24 recorded pin failures and PMTS Serial No. 30100002 had 16 recorded pin failures. It was noted that during the early part of the program pin failures were not always recorded. A failure of this nature was either corrected with a quick-fix (the pin was not replaced) which frequently resulted in the pin failing again at a later date, or the PMTS was taken out of service; there were no spare cables while the cable was repaired.

In summary, the PMTS was used successfully to premission test four PMQ-102 and one QF-102 aircraft prior to a total of 23 drone missions. With the addition of the capability to test the FCSS via the command telemetry system, the PMTS will be suitable for operational use.

It is recommended that test equipment be added to the PMTS to facilitate testing the QF/PQM-102 FCSS via the command telemetry system RF section. Also, a spare set of 40-foot PMTS cables should be procured to allow timely correction of cable problems without affecting aircraft maintenance activities.

(3) Engine Control Unit (ECU). The ECU is a portable test set which, in conjunction with the MD-3 power cart and MC-11 air compressor, provides the capability of starting the QF/PQM-102 aircraft engine and evaluating its performance to ensure proper operation prior to a flight. The functional charcteristics of the ECU consist of engine performance monitoring, start control, ignition control, throttle control, AC/DC power monitoring, failure warning indication, and auxiliary control elements. No external power is required for the ECU as all power used is derived from the aircraft.

There were four engine control panels assigned to the program at Holloman Air Force Base, one installed in its own case and classified as an ECU, and the other three installed in premission test stands. The three units installed in premission test stands were used to checkout wiring associated with aircraft engine functions during the premission test. These units were interchangeable with the engine control panels in the ECU.

TABLE 10. PMTS MAINTENANCE*

Units	Modifications		Repairs		Maintenance Actions Per Unit
	Period 1 (1)	Period 2 (2)	Period 1 (1)	Period 2 (2)	
PMTS (minus panels)	8	2	4	3	17
Command Panel	14	6	6	7	33
Data Panel	10	4	7	5	26
Test Panel	10	4	2	5	21
Indicator Panel	8	4	4	2	18
Intercom Panel	2	2	0	0	4
Maintenance Actions/Period	52	22	23	22	Total 119

*All figures are for 2 each of the units listed.

Note: (1) Period 1 is 1 January 1974 through 31 May 1974
(2) Period 2 is 1 June 1974 through 31 October 1974

Maintenance of the engine control panel was required because of modifications, either as a result of design changes to correct the unit's operation, changes made to the aircraft, or internal failures. Repair of the engine control panels was generally in response to random internal failures or damage caused by aircraft problems reflected into the engine control panel affecting its circuits. Also, there were apparent failures as a result of aircraft problems. In these cases, the engine control panels were checked out in the components test lab then verified operational on another aircraft. A listing of the number of maintenance actions on each engine control panel is shown in Table 11.

Operations involving the engine control panels have evolved from completely unsatisfactory to very satisfactory during the DT&E program. ECU operation was without fault in support of all unmanned flights.

It is recommended that a test fixture be developed to facilitate testing the engine control panels in support of a periodic inspection. This would also eliminate the need to verify the engine control panels' operation on another aircraft when an apparent failure is suspected of being an aircraft problem.

Also, an additional exhaust gauge temperature indicator should be installed with a range that starts at 100 degrees Centigrade. This would facilitate more efficient monitoring of the remote engine start and give a better indication of engine ignition.

(4) Brake Control Test Set. Both brake control test sets (Serial No. 101 and 102) provided continuous service during premission testing; however, during the QF inspection of test set No. 102, wiring was found which did not meet MIL-SPEC-2597539-1 requirements.

There was only one recorded failure against the brake control test set. On 7 October 1974, an IN961B diode failed in unit No. 102. Operation of the brake control test set was satisfactory thereafter and all test objectives were met.

(5) Radar Simulator. The two radar simulators (Serial No. 154 and 143) were successfully operated by prime and subcontractor personnel in performing the following functions:

- Weekly maintenance inspections and troubleshooting of the MGS.
- White Sands Missile Range pre-flight transponder check. This test was scheduled within 24 hours of each PQM-102 flight.
- Troubleshooting of the command and telemetry system in the QF/PQM-102 aircraft.
- Bench check and troubleshooting the command and telemetry system in the RF lab.

Procedures designed specifically for using the radar simulator to checkout the MGS and airborne command and telemetry system have not been developed. Rather, a manual (Reference 1) which contained a general description of the unit, its theory of operation, operating procedures, and maintenance instructions was used. This, in addition to the complexity of the unit and the systems it was used to test, required operating personnel with a high level of expertise in the field of RF propagation and digital systems.

Reference

1. Handbook of Instructions for Model 616C-4 Radar Simulator, Vega Precision Laboratories, Inc., Vienna, Virginia.

TABLE 11. ENGINE CONTROL PANEL MAINTENANCE

Engine Control Panel No. 309000X	1(1)	2	3	4(2)
Location	PMTS No. 1	ECU	PMTS No. 2	PMTS No. 3
Modifications	3	10	10	0
Repairs	2	12	0	0
Total Maintenance Actions per Unit	5	22	19	0

Note: (1) Engine control panel No. 3090001 was returned to the prime contractor for testing and evaluation. The engine control panel was upgraded to a Modification B before being returned to Holloman Air Force Base; consequently, there are no maintenance records prior to July 1974 available.
(2) Engine control panel No. 3090004 arrived at Holloman Air Force Base in October 1974.

There was only one radar simulator failure recorded during the program. On 1 October 1974, simulator No. 143 was found to have low power output from its transmitter. The unit was returned to the subcontractor for repair.

It is recommended that reference be made to the applicable operating procedures in the manual (Reference 1) in the QF/PQM-102 Mobile Ground Station Weekly Checkout Procedures.

(6) Target Group Simulator. The target group simulator (Serial No. 0011) was successfully operated by prime and subcontractor personnel to troubleshoot and perform weekly inspections on the MGS. Procedures designed specifically for using the target simulator to checkout the MGS have not been developed and a manual (Reference 1) was used. There were no failures recorded against the target group simulator during the program.

It is recommended that reference be made to the target group simulator in the QF/PQM-102 Mobile Ground Station Weekly Checkout Procedures where it is used. This should include hookup instructions and reference to applicable operating procedures in Section 3 of the manual (Reference 1).

Evaluation of the overall AGE performance indicated the AGE supported the test program in a satisfactory and timely manner and complied with the requirements outlined in the SOW.

d. Miscellaneous

(1) Backup Power Systems (FGS/MGS/PQM-102). The FGS is powered by several electrical power sources. Each console contains several power supplies dependent upon commercial 115-volt AC, 60-cycle power. In addition, two government furnished 28-volt DC and 115-volt, 400-cycle power sources are required. A switchover circuit allows operation of both consoles from a single 28-volt to 115-volt supply in the event of one failure. All of the above are dependent upon commercial power for which there is no backup or redundant system. Tests conducted to evaluate the switchover circuits and the ability to maintain positive command control of the aircraft indicated satisfactory operation.

The MGS contains two independent gasoline-powered generator systems (6.5 kilowatts) which provide 115-volt AC, 60-cycle power, 115-volt AC, 400-cycle power, and 28-volt DC power. Automatic/manual switchover is provided. The ability to provide adequate power for 30 minutes continuous operation of all critical command control equipment necessary for safe recovery of the QF/PQM-102 was evaluated and operation was satisfactory.

The PQM-102 contains two government furnished lead-acid 24-volt, 36 ampere hour batteries in addition to the basic F-102 backup power systems. The ability to provide DC essential busload and power for all essential flight functions in the event of DC generator failure and the ability to provide a warning signal to the FGS to indicate an AC or DC generator failure was evaluated. Ground tests and in-flight failures experienced indicated satsifactory performance.

(2) DIGIDOPS. System problems were identified early in the evaluation program which contributed to establishment of an artificial dead zone (35-foot radius around each antenna). The first problem was the physical separation between antennas. Actual antenna separation on the aircraft is 39 feet which could create a cross talk situation. The second problem was due to the size of the F-102 and the large number of inspection panels causing excessive noise to be generated. This problem was significantly alleviated by placing tape over loose panels and hinge plates in the immediate vicinity of the scoring antennas. One sortie was flown during the latter portion of the test program which provided for a reduced dead zone to 15 feet using a different scoring technique. This technique was further evaluated during OT&E of the target system. Actual scores are computed within the dead zone by mathematical computation utilizing missile velocity and time within the zone.

Evaluation of system accuracy was accomplished by comparing DIGIDOPS miss distances to cinetheodolite optic data obtained during a series of High Velocity Air-Launched Rockets (HVAR) and AIM series missile firings. The precise comparison of scoring data was complicated by the different reference points used: (1) DIGIDOPS distance is referenced to the antenna closest to the incoming missile; (2) optical data references to the center of the engine exhaust or the nose of the PQM-102 aircraft, depending on which is requested by the user; and (3) missile references are the missile plume or the nose cone for optical data and the missile reflected RF energy for DIGIDOPS data.

Score comparisons from a series of HVAR and AIM missiles launched at the PQM-102 aircraft at Holloman Air Force Base between September and December 1974 are shown in Tables 12 and 13.

It should be noted in connection with the scores shown in Tables 12 and 13, particularly those within 35 feet, that the delta between the optics and DIGIDOPS final miss distances was converging because data reduction techniques were improving over the evaluation time span. Therefore, it is possible that an error of −1.5 feet to +2.5 feet existed between the two miss distances. However, both could be correct due to the different reference points used.

TABLE 12. HIGH VELOCITY AIR-LAUNCHED ROCKET (HVAR) MISS DISTANCES (FEET)

DIGIDOPS	OPTICS
140	238
*	172
*	100
140	137

*Failure to score on two HVAR firings is undetermined. However, the slow closing velocity of the HVAR is one suspected cause.

TABLE 13. AIM MISS DISTANCES (FEET)

DIGIDOPS	OPTICS
15	13
11	9
10	9
28	31
33	33
92	89
33	23
13	18
49	48
31	31
6	6
10	10
33	33
100	101
3.5	3.5

(3) Anti-Skid Brake System. In order to obtain satisfactory braking action on the PQM-102 aircraft, the basic F-102 brake system had to be modified. Additions included wheel speed transducers, solenoid shut-off valves, brake relay valves, a servo valve, and a control box containing electronic circuitry. Braking action is accomplished by the initiation of the brakes on command via the normal command system. The brake system applies the wheel brakes in a manner which slows the aircraft at a constant rate of deceleration while continually compensating for any erratic rates of deceleration (skids) after touchdown. Stopping distances utilizing this system are typically shorter than that obtained by manual braking action. While each wheel individually senses changes in deceleration rates, a composite command is sent to both brakes to provide proper braking. The system does not compensate for small variations in braking effectiveness of the individual brakes and minor steering corrections (via command system) are required to maintain a constant heading.

Initially, problems were experienced with this system which required several minor design changes. Subsequently, the system worked very effectively and design objectives were met. The effectiveness of the system for landings on wet runway was not evaluated during the DT&E at Holloman Air force Base.

(4) Smoke System. A smoke generating system was installed on the QF/PQM-102 aircraft. The system consisted of an oil storage tank (tank assembly), cradle assembly, hydraulic pump, shut-off valves, vent valves, check valves, drain valves, nozzle assemblies, associated plumbing and an electrical system (Figure 10).

A 28-volt DC control voltage from the nose wheel door-closed relay closes the tank vent valve. The voltage to open and close the oil supply valve is controlled by the smoke relay. A 28-volt DC control voltage from the pallet operates the smoke relay and starts a timer. The time controls the application of control voltage to the pump control valve, which is open for 2 seconds and closed for 5 seconds. Oil from the tank flows to the inlet side of the hydraulic pump and the oil is then pumped to the nozzle selector valve. The control voltage for the nozzle selector valve is dependent upon the afterburner control relay. If the drone is operating in the afterburner, the nozzle selector valve directs the oil to the afterburner nozzle assembly. Here the oil is mixed with engine bleed air before being sprayed into the afterburner exhaust stream. If the target is not operating in the afterburner, the oil is directed to the primary nozzle. This nozzle is positioned to direct the oil stream to impinge on the engine exhaust gasses producing the smoke trail.

The Smoke System was tested on 11 April 1974 and it functioned as designed. The acquisition of the drone was greatly enhanced and it seemed superior to the system used in the BQM-34A and equivalent to that used in the QF-104. The pilot reported no degradation in either the cockpit air conditioning system nor the drone's subsonic performance. During this test it was observed that the smoke trail had weaker visibility in the afterburner at high altitude or at low speeds below 250 KIAS. A second test was conducted on 16 April 1974 and the smoke generation in military power at all airspeeds and altitudes was very good. The system operation in afterburner was again not as effective as in military power mode but was considered adequate from a visual enhancement point of view. On subsequent AIM tests the system worked effectively in and out of the afterburner. Comments from the airborne shooter pilot indicated that the smoke was quite dense, indicating a need to discontinue the smoke prior to missile release to insure adequate visibility by the shooter.

(5) Destruct System. A ground evaluation of the explosive destruct system was conducted on 29 August 1974 by the government at Kirtland Air Force Base, New Mexico. The test proved conclusively that the MK-48 warhead used in the system would sever the aircraft, causing subsequent termination of flight. Significant debris from the explosion was found at a distance of 235 feet from the aircraft itself. A description of the debris, weight location, distance, and size is shown in Table 14.

TABLE 14. DESTRUCT SYSTEM DEBRIS SCATTER

Description	Weight (lb)	Angle (deg)	Fore	Aft	Distance(1) (feet)	Size
Armament gear door, right	20	10		X	83.5	8 in by 4 ft
Armament displacement gear	5	0			59.5	6 in by 8 in
Missile bay doors	---	0			40.0	8 ft by 2 ft
Fuselage section	15	0			40.0	3 ft by 4 ft
Armament gear door	20	60	X		56.0	8 in by 4 ft
Small structural member	5	60	X		34.0	1 ft by 2 ft
Transformer	10	0			29.5	4 in by 5 in
Armament gear door	5	0			155.0	6 in by 2 ft
Rack	2	40	X		122.0	4 in by 4 in
Hook	1	0			235.0	3 in by 3 in
Hinge from bay door	5	0			14.0	3 in by 3 in

Note: (1) Distances are measured with respect to the rear missile bay. Angles are measured from aircraft longitudinal axis.

To evaluate the overall reliability of the explosives train, a series of test firings under various ambient conditions were conducted at the subcontractor's facilities on 20 May 1974. The reliability test was conducted to verify the capability of the explosives train to initiate the Mark 48 warhead booster with a 0.95 reliability at 90 percent confidence. The following number of test items were fired:

	Units	Ambient Temperature
	25 Units	Ambient Temperature
	10 Units	160 Degrees Fahrenheit
	10 Units	65 Degrees Fahrenheit
Total	45 Units	

All of the 45 assemblies were functionally operated successfully at various levels of environmental conditions commensurate with the PQM-102 Target System environment.

A single ground evaluation of the maneuver destruct system conducted on 8 October 1974 confirmed movement of the elevons from the takeoff trim position to full down (8 degrees from streamline) upon execution of the maneuver destruct sequence. The elevons remained down after execution of the commands. No problems were experienced.

Destruct System-Airborne Tests. After the individual components of the PQM-102 destruct system were qualified to White Sands Missile Range flight surveillance specifications, a series of test flights were initiated to verify the reliability of the system as a whole while airborne. The tests were conducted with manned QF-102 aircraft with dummy electrical loads installed in place of the actual EBW. Noisy HEFU telemetry precluded analysis on several flights and low destruct battery voltage telemetry indications were observed. The noise problem was corrected and an improved battery charging procedure was developed. The UHF destruct system was also evaluated, independently of White Sands Missile Range flight safety requirements, and significant problems were not experienced. Satisfaction of all destruct system qualifications was accomplished prior to the first unmanned flight on 13 August 1974. Subsequent to this flight, two significant problems occurred. One problem occurred during T-24-hour destruct system checks and was identified as a HEFU failure. The unit was returned for failure analysis and a faulty component was identified. On 1 October 1974, during pre-launch checks, the destruct system was intermittent and the problem could not be identified. The mission was aborted prior to takeoff. Further analysis revealed the problem to be a defective circuit in the UHF transmitter box. In an attempt to prevent recurrence of the problem, the UHF destruct receiver, WOG relay, key switch, and HEFU were removed and replaced.

In summary, the destruct systems proved to be reliable and satisfactory.

3. MAINTENANCE

During the course of the DT&E, AFSWC observed various aspects of the contractor maintenance operation. Because this operation was the responsibility of the Air Force Contract Management Office (in particular, the F-102 peculiar maintenance operation), this report only considers the target system maintenance portion of the program.

a. QF/PQM-102 Premission Test

Premission testing of the QF/PQM-102 Target System was accomplished in accordance with the prime contractor's specification IT5320-10740, entitled, "Premission Test Procedure for the PQM-102 Target System." These procedures evolved from lengthy, awkward, and frequently erroneous ground tets procedures (which were used during the early months of the DT&E program) into an outstanding premission test document.

The premission test document contained a test scope, an instrumentation and test equipment list, a document list, a section on safety, a general information section, a test setup section, a test requirement section consisting of 115 tests (Table 15 contains a list of these tests), a data recording section, and a section defining re-test requirements. The primary test fixtures for performing the premission test were the PMTS and the MGS. In addition, many items of standard aircraft AGE were required. These items are listed in Table 16.

TABLE 15. LIST OF PREMISSION TESTS

Test No.	Test Title	Test No.	Test Title
1	Test Setup	27	Roll Gyro Synchronizer
2	Initial Power On	28	Roll Stick Gain
3	Air Data Computer	29	Roll Stick Gain in Landing/Takeoff
4	Primary and Backup MD-1	30	Roll Rate
5	J4 Compass System	31	Roll Rate in Landing/Takeoff
6	Normal Accelerometer	32	Roll Rate with 0 Greater than 70 Degrees
7	MC-1 Rate Gyro	33	Skid Command into Roll
8	Primary MD-1 and Backup MD-1 Telemetry	34	Yaw Rate Gain (Series Servo)
9	Heading Telemetry	35	Yaw Rate Gain (Parallel Servo)
10	Elevons, Servos and HEP Valves	36	Heading into Rudder
11	Pitch Attitude	37	Nosewheel Steering
12	Pitch Scheduling from Airspeed	38	Skid Command Integrator
13	Pitch Rate Gyro Gain	39	Skid Command Lag
14	Normal Accelerometer Gain	40	Heading Gyro Synchronizer
15	Altitude Hold Gain	41	Roll Rate Crossfeed
16	Altitude Hold Integrator	42	Roll Rate Crossfeed Airspeed Scheduling
17	Altitude Rate	43	Roll Rate Crossfeed Washout
18	Airspeed on Pitch	44	Roll Command Crossfeed
19	Airspeed Integrator	45	Roll Command Crossfeed Airspeed Scheduling
20	Mach Hold on Pitch	46	Direct Throttle
21	Mach Integrator	47	Speed Hold Throttle
22	Pitch Gyro Synchronizer	48	Mach Hold Throttle
23	Angle of Attack	49	Pitch Crossfeed Throttle
24	Roll Attitude below 30,000 Feet Altitude and Heading Hold Roll	50	Maneuver Programmer g Follow-Up
25	Roll Attitude above 30,000 Feet Altitude and Heading Hold Roll	51	Maneuver Programmer g Limiter
26	Roll Attitude Non-Heading Hold Roll	52	Alpha g Limiter

TABLE 15. LIST OF PREMISSION TESTS (CONTINUED)

Test No.	Test Title	Test No.	Test Title
53	Recovery Mode	79	Pneumatic Pressure-Low Warning
54 55	Maneuver Programmer Test Setup (Tests 55 through 59)	80	Primary Hydraulic Pressure Test
55	Maneuver Programmer Roll Axis	81	Secondary Hydraulic Pressure Test
56	Maneuver Programmer-g Command plus Airspeed on Throttle Modes	82	Hydraulic Oil Hot Warning
57	Maneuver Programmer Altitude Hold also Pitch Axis Lift Compensation	83	Fuel Low Warning
58	G-Error Integrator	84	Fuel Tank Warning
59	Maneuver Programmer Time	85	Engine Fuel Pump Warning
60	Backup Throttle	86	Fire and Overheat Detector
61	Backup Yaw	87	Oil Low-Pressure Warning
62	Backup Pitch Attitude	88	Anti-Ice Warning
63	Backup Pitch Attitude Command for LOC	89	Altitude Hold Mode Interlocks
64	Backup Pitch Stick	90	Speed Hold Elevator Mode Interlocks
65	Backup Pitch Rate Feedback	91	Mach Hold Elevator Mode Interlocks
66	Backup Roll Stick	92	Speed Hold on Throttle Mode Interlocks
67	Backup Roll Attitude	93	Mach Hold on Throttle Mode Interlocks
68	Backup Roll Rate Test	94	Maneuver Programmer Mode Interlocks
69	Speed-Brakes	95	Wings Level Mode Interlock
70	Drag Chute	96	Heading Hold Roll Mode Interlocks
71	Arresting Hook	97	Landing/Takeoff Mode Interlocks
72	Boost Pumps	98	Automatic Takeoff Mode Interlocks
73	Aircraft Power Control	99	Takeoff Abort Mode Function Check
74	Transmit-Receive Monitor	100	Automatic Takeoff Mode Function Test
75	Fuel Quantity T. M.	101	Afterburner
76	Engine Pressure Ratio	102	Airstart Ignition
77	Engine RPM	103	Smoke
78	Exhaust Temperature Indicating System	104	Explosive Destruct

TABLE 15. LIST OF PREMISSION TESTS (CONCLUDED)

Test No.	Test Title	Test No.	Test Title
105	Orbit Destruct	111	Beacons System
106	LOC Fast Destruct	112	Brakes Control System
107	Loss of Power Fast Destruct	113	Landing Grea Control
108	Command Destruct Recivere	114	Command and Data Test
109	Maneuver Destruct	115	QF-102 Aircraft Functions
110	DIGIDOPS System	116	Shut-Down

TABLE 16. PREMISSION TEST EQUIPMENT

Equipment	Characteristics
Aircraft Electrical Ground Ground Power Unit	+28, ±2-volt DC, 100 ampere minimum. 115-volt AC 400 Hz WYE, 30 amperes per leg minimum.
Hydraulic Cart	MK-3 or equivalent
High-Pressure Air Compressor	MC-11 or equivalent
Air Data Test Set	TTU-93, TTU-205 or equivalent
Aircraft Jacks (2 each)	10 ton
EBW Simulator/Pulse Evaluator Test Set	TE-114 or equivalent
Maintenance Stand	As required
Safety Markers	As required
Safety Locks	As required
Nose Wheel Turntable or Greased Plate	As required
Tachometer Indicator-Generator Test Set	TTU-27/E or equivalent
Engine Thermocouple Tester	BH112JA-11G1T9 or equivalent
Rudder Protractor	As required
Pneumatic Pressure Gage (2 each)	0 to 1500 psi

Premission tests were completed on four PQM-102 aircraft, three of which flew five successful drone record missions. The average time for the initial premission test on these aircraft was 46 hours. There was no record of the times to perform the initial premission test on the QF-102 aircraft. Subsequent to July 1974, five premission tests were completed on QF-102 aircraft in an average time of 26 hours; subsequent to August 1974, four premission tests, other than the initial one, were performed on PQM-102 aircraft in an average time of 22 hours. Although two complete premission tests, one on a QF-102 and the other on a PQM-102, were performed in 19 hours, it is felt that 22 hours is a more realistic time for a premission test involving no major troubleshooting effort.

Numerous failures, wiring errors, and design problems were uncovered in the FCSS and aircraft during early premission testing. In an effort to determine how effective the premission test was at identifying in-flight problems, airborne squawks and subsequent premission testing efforts were closely monitored on QF-102 FAD 601 and FAD 602 for 2 months. A total of 38 problems were logged against these aircraft with 23 of them being premission test verified on the ground. Of the 13 problems which could not be reproduced on the ground, 11 involved flight dynamics (i. e., automatic takeoff rotation error on takeoff, only 3.6g maneuver with 4g programmed, and aircraft heading-error when coming out of LOC), one was an MGS problem and the last was an intermittent switch on the AFSC panel in the cockpit. Including the flight dynamics write-ups, the premission test was able to detect 62 percent of the in-flight problems. Excluding flight dynamics problems, the premission test was able to detect 96 percent of the airborne failures, all of which were corrected by maintenance action. This study points out the one shortcoming of test philosophy for testing non-pilot-rated aircraft: the inability to detect problems involving aircraft dynamics.

b. Maintenance Technical Data (PQM-102)

Thorough evaluation of the adequacy of PMQ-102 peculiar maintenance technical data and test procedures was not accomplished by the AFSWC. However, a qualitative appraisal was made during routine evaluation of test operations. Due to the continuing nature of the design changes required during the DT&E phase, current maintenance technical data and test procedures were not completed by the contractor. Test operations were normally conducted by experienced personnel using available engineering drawings and the basic equipment operating manuals. The basic series of F-102 Technical Orders were updated to include PQM-102 peculiar items, and some of the required data and procedures have been developed. With the possible transfer of experienced personnel and the subsequent hiring of inexperienced personnel, it was imperative that continuing attention be given to the completion of essential data and procedures. Complete inspection, fault isolation, repair, calibration, and test data/procedures were needed to increase the efficiency of operations.

c. Logistics (PQM-102)

Logistic supportability of PQM-102 peculiar requirements was investigated by a team from AFLC, Kelly Air Force Base, Texas, and their findings were submitted to the PQM-102 SPO. Included in the review was maintainability, current maintenance data, reliability, level of repair, special storage or transportation requirements, DATAC technical data, and reprocurement rights. No serious deficiencies were noted except for those relating to reprocurement requirements. Since the prime contractor claimed proprietary rights to 47 of 80 contractor-furnished documents, it was felt that the Air Force's ability to provide follow-on support through competitive reprocurement might be seriously impaired. Resolution of this was left to the PQM-102 SPO. Observations of the AFSWC test director, relating to test procedures and technical data during the DT&E phase at Holloman Air Force Base, are covered in paragraph 3.b., above.

d. Failure Analysis

The failure analysis cycle as maintained by the contractor was evaluated for adequacy. The cycle started with the failure of a component and the initiation of a Reliability and Maintainability (R&M) form. If the part was a prime contractor provided part, the R&M report and part were returned to the prime contractor's plant for a failure analysis. The findings were sent to Holloman Air Force Base and a tabulation or record of all failures was maintained in the prime contractor's Reliability and Maintainability Allocations, Assessment and Analysis Report. For vendor provided parts a debit notice form was prepared. The form and part were returned for analysis and repair or replacement. On some items, a government representative was required at the vendor's facility for final approval during the repair cycle. The findings of the analysis were then sent to Holloman Air Force Base.

It appeared that the failure analysis cycle was adequate and worked satisfactorily. No significant deficiences were noted.

e. Contractor Maintenance Operations

The manner in which the prime contractor and associated subcontractors conducted their maintenance operations was broadly evaluated during the OT&E at Holloman Air Force Base. Initially, coordination was lacking between the prime contractor and the subcontractor responsible for the aircraft maintenance. After establishment of a maintenance control section coordinations greatly improved, resulting in more efficient operations.

Problems were experienced in the documentation and follow-up of the various types of problems experienced. Initiation of separate discrepancy logs for the MGS, FGS, and FCSS improved matters somewhat. However, two serious deficiencies existed in this system. First, a large number of the significant problems, especially those discussed during mission debriefings, were not entered in the logs. The items should have been entered in the logs during the debriefings. Second, the corrective actions listed for many problems were technically unsound and did not conform to established procedures outlined in Air Force Manual 66-1. It was deemed that a tighter and more accurate quality control of maintenance efforts, including documentation, was necessary. Consequently, through coordination and resolution, a very high level of cooperation between the Air Force and associated contractors was accomplished.

f. Interchangeability

Although there were no special tests performed to demonstrate interchangeability, several FCSS components were flown in pallets other than their own. All LRU were tested to the same test specifications on the STB after maintenance action or prior to integration into a new system. Also, in June 1974, the pallet from PQM-102 FAD 605 was flight evaluated in QF-102 FAD 602 with no indication of any interchangeability problems.

g. PQM-102 Conversion

After arriving from Crestview, where F-102 aircraft are configured to PMQ-102 Target Systems, the aircraft were prepared for unmanned flights. This conversion effort consisted of 55 aircraft modifications which took 403.3 manhours to perform. After the conversion was completed, an extensive ground test was performed in accordance with the prime contractor's document EB 5320-10702. The ground test took approximately 12 work days, and consisted of a test and calibration sequence, a premission test with the FCSS pallet electrically connected to the aircraft, a premission test with the pallet installed, and an aircraft taxi test.

Based on the success of the three drones flown during the DT&E, the conversion procedure adequately prepared the PQM-102 for flight. Drones FAD 604 and FAD 605 were flown in an unmanned configuration after being on the ground for over 6 months. The only problem encountered was the failure of the primary FCSS on NULLO No. 1. This problem, which was due to a defective trim switch, could not be duplicated on a normal premission test. However, premission test procedures had been incorporated to detect this type of malfunction.

Evaluation of the contractor maintenance operation indicated the following:

- Premission testing was satisfactory and in accordance with specified documentation and procedures.
- Basic F-102 Technical Orders had been verified and were acceptable with recommended changes. A corrective action program had been implemented by the contractor that would be monitored to a successful conclusion by the PQM-102 SPO.
- Logistics support by AFLC and the contractor was acceptable for the R&D program.
- Failure reporting was satisfactory and complied with the procedures established by the contractor and the PQM-102 SPO.
- Maintenance operations were satisfactory upon establishment of a maintenance control section.
- Interchangeability requirements were demonstrated successfully when some FCSS components and a pallet were flown in aircraft other than their own.
- The PQM-102 conversion program was demonstrated as very successful with accomplishment of the programmed reliability (hands-off) and QF/PQM-102 record flights.

4. OPERATIONS

As previously mentioned, the QF/PQM-102 Target System was conceived to be an all-contractor operation. The contractor was therefore tasked to demonstrate this philosophy during the DT&E. To accomplish this, the contractor was required to handle all routine aspects of the operation except White Sands Missile Range scheduling and documentation and the Air Force UHF destruct function in the Holloman Air Force Base area. All initial planning was accomplished by the PQM-102 SPO, AFSWC test director, and the Air Force Contract Management Division.

a. Procedures

With the exception of the destruct procedures discussed in Appendix C, the contractor was tasked with writing and implementing all system procedures.

(1) Flight Procedures.

Description. Two sets of flight procedures were developed by the contractor. The first, in response to the requirements of Air Force Regulation 55-22 and Air Force Systems Command Supplement 1 thereto, defined how contractor flight operations would be conducted during the Holloman Air Force Base operation. These procedures required approval by the Holloman Air Force Base government flight representative and were subject to semiannual review. The second set of procedures defined specific operating procedures in checklist form for use during manned and unmanned operations.

Development/Update. The Air Force Systems Command Supplement 1 to Air Force Regulation 55-22 specified what procedures were to be included in the Holloman Air Force Base Operating Procedures Manual. The procedures were based on Air Force Regulation 60-1; Air Force Manual 60-16; other Air Force publications; experience of the contractor's controllers; and local Holloman Air Force Base regulations. After the approval of the prime contractor's chief pilot and the Holloman Air Force Base government flight representative, the Holloman Air Force Base Operating Procedures Manual became the official document governing flight operations during the test program. Changes to these procedures were incorporated with the approval of the prime contractor's field operations supervisor and the government flight representative.

The prime contractor's procedures were developed and updated in the same manner as the Emergency Procedures [paragraph 4.a.(3)].

Operational Use. A copy of the prime contractor's flight operations procedures for the Holloman Air Force Base Operating Procedures Manual was maintained in the contractor's operations area and was used as part of the aircrew information file. Each contractor pilot was responsible for knowing and complying with the provisions of the manual and each flight, manner or unmanned, was governed by the procedures contained in the manual.

The prime contractor's checklists were available at each ground station and at the launch control vehicle. Designated individuals read each step while other specifically identified crew members performed the task. Some pre-launch checks were omitted on QF-102 missions, but the entire checklist was followed on PQM-102 flights.

Evaluation. The Holloman Air Force Base Operating Procedures Manual was reviewed by Air Force Contract Management personnel prior to approval by the government flight representative. Subsequently, it was evaluated during two Air Force Systems Command Standard Evaluation visits by members of the Standard Evaluation Team. The criteria used by the evaluators were Air Force Regulation 55-22 and Air Force Systems Command Supplement 1 thereto.

The procedures were found to be excellent. The Standard Evaluation Teams made specific reference to the excellence of the contractor's flight operations and his operating procedures. When minor changes were suggested they were immediately incorporated.

To evaluate the PQM-102 Target Manual, qualified Air Force personnel observed each step of the procedures on each unmanned flight and on many manned flights. As deficiencies were noted, the procedures were corrected by the contractor. The criteria used by the Air Force evaluators were adequacy, completeness, utility, and contractor's ability to execute the procedures properly. The PQM-102 Target Manual procedures were judged satisfactory and acceptable.

Both the prime contractor's flight operating procedures for Holloman Air Force Base and the PQM-102 Target Manual checklist procedures pertained specifically to the operation as it developed at Holloman Air Force Base. Therefore, for other operating locations, the procedures would have to be revised to suit local operating conditions. In the case of the checklist procedures, such revisions would require thorough evaluation with QF-102 aircraft before attempting any unmanned operations.

(2) Ground Procedures. PQM-102 pre-launch and recovery operations were performed in accordance with the prime contractor's flight manual (Reference 2). These procedures were exceptionally well organized and followed a technical order format. The ground operation consisted of aircraft towing, engine starts and checkouts, MGS and FGS functional checks of the aircraft, destruct system check, gyro torque test, destruct package upload and arming, aircraft launch, and aircraft recovery. These functions, except for launch and recovery, were performed on two PQM-102 aircraft while a second drone was prepared for flight in the event of a ground abort with the primary drone.

Ground operations were very smooth during the PQM-102 missions flown. The only area requiring improvement was communications. There were three communication systems required to support the mission. First, there was an ARC-27 UHF radio (provided by AFSWC and installed in the AFSWC furnished launch control vehicle) used to communicate with the FGS and MGS. Second, there was an intercom system (also installed in the launch control vehicle) which was used by personnel performing aircraft engine starts and pre-launch checks. This intercom was provided by a modified aircraft AIC-10 system tied into the UHF radio allowing the launch control supervisor to communicate with both his crew and MGS/FGS personnel. Last, there was a VHF maintenance set. The primary problem with communications was the noisy and poor quality signals associated with the intercom system. Also, there were failures in both the intercom system and UHF radio which caused a breakdown in communication.

(3) Emergency Procedures.

<u>Description</u>. An emergency operation manual (Reference 3) was prepared by the prime contractor for use by ground controllers in responding to ground and airborne emergency conditions in the QF/PQM-102 aircraft and with command and control equipment. Each procedure with critical initial steps contained bold face items to be accomplished without reference to the checklist. The checklist was then referred to for procedure completion, warnings/cautions, and additional information. The following classes of emergency procedures are listed in the manual (the number in parenthesis indicates procedures per class):

Ground Operations, QF/PQM-102 (2)

Takeoff, QF/PQM-102 (10)

Inflight, QF/PQM-102 (18)

Landing, QF/PMQ-102 (7)

Command and Control, FGS/MGS (13)

References
2. <u>Flight Manual QF-102A and PQM-102A</u>, Sperry Flight Systems, Phoenix, Arizona.
3. <u>Emergency Operation, PQM-102A Target System</u>, SFTP 5320-10743, April 1974, Sperry Flight Systems, Phoenix, Arizona.

Procedures were developed based on F-102 Technical Orders, failure analysis of the airborne and ground equipment, and experience of the contractor's controllers. These procedures were prepared by a contractor project pilot and approved by the contractor program manager and the government flight representative.

Any contractor or government individual could recommend changes to the emergency procedures manual by submitting a change approval to the contractor chief pilot. Approvals were given by the PQM-102 field operations supervisor and the government flight representative before the change was incorporated.

During missions, a minimum of one copy of the emergency procedures manual was immediately available to each ground station used during each mission. It was standard procedure for the back-up or secondary controller position to read the checklist, while the primary, in control, position performed the required steps.

The contractor identified and the government flight representative approved a listing of possible equipment malfunctions which would serve as criteria for aborting scheduled or on-going missions.

Testing of Procedures. The two basic categories, airborne and command/control equipment, had emergency procedures tested in planned and orderly test programs:

- Airborne Equipment

Method: Of the 47 identified emergency conditions associated with the airborne equipment, the most probable to be expected were subjectively identified for simulation during the flight. The contractor also selected the most expected items from the abort criteria listing. These 20 conditions were included in four dedicated emergency procedure training flights (4 June, 6 June, 1 July, and 7 August 1974).

Results: In every case for every emergency, the controllers correctly identified the abnormal condition and used the proper corrective procecure.

- Command and Control Equipment

Method: A plan for simulating the remote control command and telemetry emergencies was prepared by the government flight representative (with contractor input and approval), and performed during the period 30 May through 11 July 1974. Emergencies were simulated without the prior knowledge of the ground controllers.

Results: Fourteen simulated emergencies were conducted covering the various abnormalities listed in the ground controllers' procedures. In all cases but one, the controllers quickly and correctly identified the malfunction and used the correct procedure. The one exception was a simulated loss of radio communications between FGS and MGS. Concurrent with the simulated emergency, an abnormal aircraft condition caused a wing rocking, the signal to transfer control between controllers. The emergency condition was simulated 5 days later (4 June 1974) and controller action was successful and correct.

Throughout the program, eight emergency situations, covered by prepared procedures, actually occurred. In all cases, proper use of the checklists was observed. The eight emergency situations were as follows:

- Fire Wing Light on Start, Aircraft FAD 603, Ground Abort, 7 March 1974
- Fire Wing Light in Flight, Aircraft FAD 608, Air Abort, 11 April 1974

• Hydro Oil Hot, Aircraft FAD 601, Ground Abort, 19 April 1974

• Hydro Oil Hot, Aircraft FAD 602, Air Abort, 16 May 1974

• Hydro Oil Hot, Aircraft FAD 602, Ground Abort, 23 May 1974

• High Pressure Pneumatic System Low, Aircraft FAD 602, Air Abort, 7 June 1974

• Primary AC Generator Failure, Aircraft FAD 602, Air Abort, 31 July 1974

• Primary AC Generator Failure, Aircraft FAD 602, Air Abort, 1 August 1974

Evaluation. The criteria used by the evaluator were adequacy, completeness, utility, and confidence in the contractor's ability to recognize and cope with emergency conditions.

Using these criteria, the emergency procedures, both written and demonstrated by the controllers, were satisfactory and acceptable. The attitudes of the controllers and the chief pilot were completely positive, and all personnel involved continued to improve and perfect the emergency procedures throughout the entire testing period.

b. White Sands Missile Range/Holloman Air Force Base Interface

The development and test of a new system, such as the QF/PQM-102, at the White Sands Missile Range/Holloman Air Force Base complex created many unique problems and required unique solutions to these problems. The following is a discussion of the problems, how they were solved, and an evaluation of how their solution affected operations.

(1) White Sands Missile Range Interface. White Sands Missile Range is a highly complex, multi-mission, inland range which serves the needs of all services, as well as NASA. For missions flown by the PQM-102, i. e., air-to-air and ground-to-air missile presentations, the greatest appeal of the White Sands Missile Range was the accuracy of its optical data and the sophistication of its data acquisition system. Its shortcomings were its relatively small size (approximately 35 by 135 miles) and its complexity, both of which affected its ability to support flexible requirements of the PQM-102 Target System. These factors, as they related to the PQM-102 operation, are discussed in the following paragraphs.

Safety. White Sands Missile Range safety was by far the most important and critical factor in the White Sands Missile Range/PQM-102 interface. As discussed in subsequent sections, its influence was felt in practically every aspect of the White Sands Missile Range operation; however, for purposes of this section, only the failsafe destruct system and the range area restrictions will be discussed.

Because the PQM-102 was a DT&E drone, White Sands Missile Range ruled that a failsafe destruct system would be the primary destruct mechanism for range flights [paragraph 2.d.(5)]. Since the PQM-102 was initially designed without a failsafe system, the contractor was required to design and qualify such a system. White Sands Missile Range closely supervised this operation. Attention was also focused on the parts of the destruct train and FCSS which were also a part of the failsafe system, e. g., the HEFU and the IFC.

The failsafe system was used for all NULLO flights throughout the DT&E. White Sands Missile Range would assign a flight area over the range in which the PQM-102 could fly. The boundaries of this area were computed on the basis of timer setting, maximum altitude and maximum true airspeed. The boundaries were referenced to the nearest critical boundary in the White Sands Missile Range area. In general, the nearest critical boundary was the range boundary. However, other boundaries were considered critical such as the White Sands National Monument picnic loop, protected and closed during all NULLO flights; the boundary to the northern range extension, requiring extensive time and cost to close if flown over; and Highway 70 requiring blockage if flown over.

Examples of the resultant flight areas are shown in Figures 47, 48, and 49. Figures 47 and 48 compare the areas for approximately the same altitude/airspeed combinations with different timer settings. Figures 48 and 49 compare different altitudes with the same timer settings and maximum speeds.

In conclusion, White Sands Missile Range safety imposed significant but livable constraints on the PQM-102. All contractual DT&E objectives were achieved while operating under these constraints, e. g., Mach numbers of 1.3 and altitudes over 55,000 feet. In addition, White Sands Missile Range attention to and participation in the explosive train qualification insured a safe, well engineered destruct system in the PQM-102.

<u>Documentation.</u> To support this program, White Sands Missile Range required 10 Operation Requirement documents plus 2 Program Introduction documents. Some of the reasons for this heavy requirement were as follows:

- The newness and uniqueness of the QF/PQM-102 system caused some initial confusion on the hardware involved.

- The addition of the HVAR firings to the PAVE DEUCE documentation.

- The early program requirement to fly captive AIM missiles against record flights (deleted).

- The program requirements to fly the PQM-102 against several different AIM series missiles during early NULLO flights (partially deleted).

Two observations can be made on the subject of documentation. First, White Sands Missile Range did exhibit inertia in supporting new, fast-response requirements. Second, none of the listed problems uniquely involved the PQM-102. They were true of most drone operations over White Sands Missile Range. The PQM-102 documentation requirement in an operational phase is no more complex than a BQM-34A documentation requirement.

It should be noted that despite this rather awkward system, experience tended to streamline the operation. For example, when the need arose for inclusion of the HVAR firings in the first few NULLO flights, the firing took place 19 work days after start of the documentation. This involved revision of the Program Introduction document, including coordination by higher Army Headquarters (TECOM), and the writing and processing of a new Operation Requirement document. The White Sands Missile Range advertized time period for such an operation is 60 work days.

<u>Airspace.</u> Because of the safety constraints mentioned in paragraph 4.b.(1), all NULLO flights were flown in the central range. Altitudes extended from ground level to the mission altitude. This block of airspace was available on a routine basis approximately twice a week.

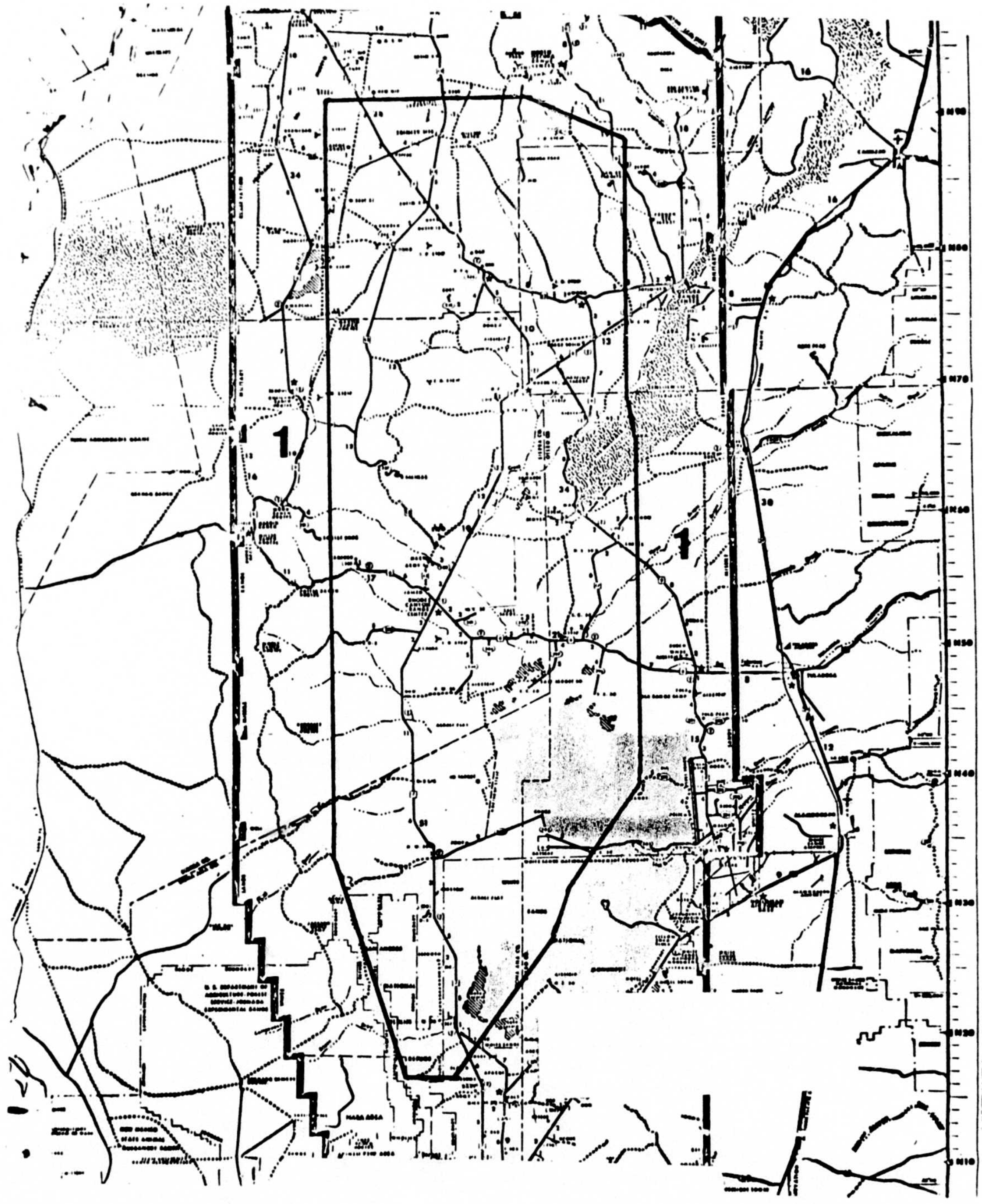


Figure 47. PQM-102 Safety Boundary with Timer Settings of 10 Seconds, Altitude of 20,000 Feet, and Velocity of 625 KTAS

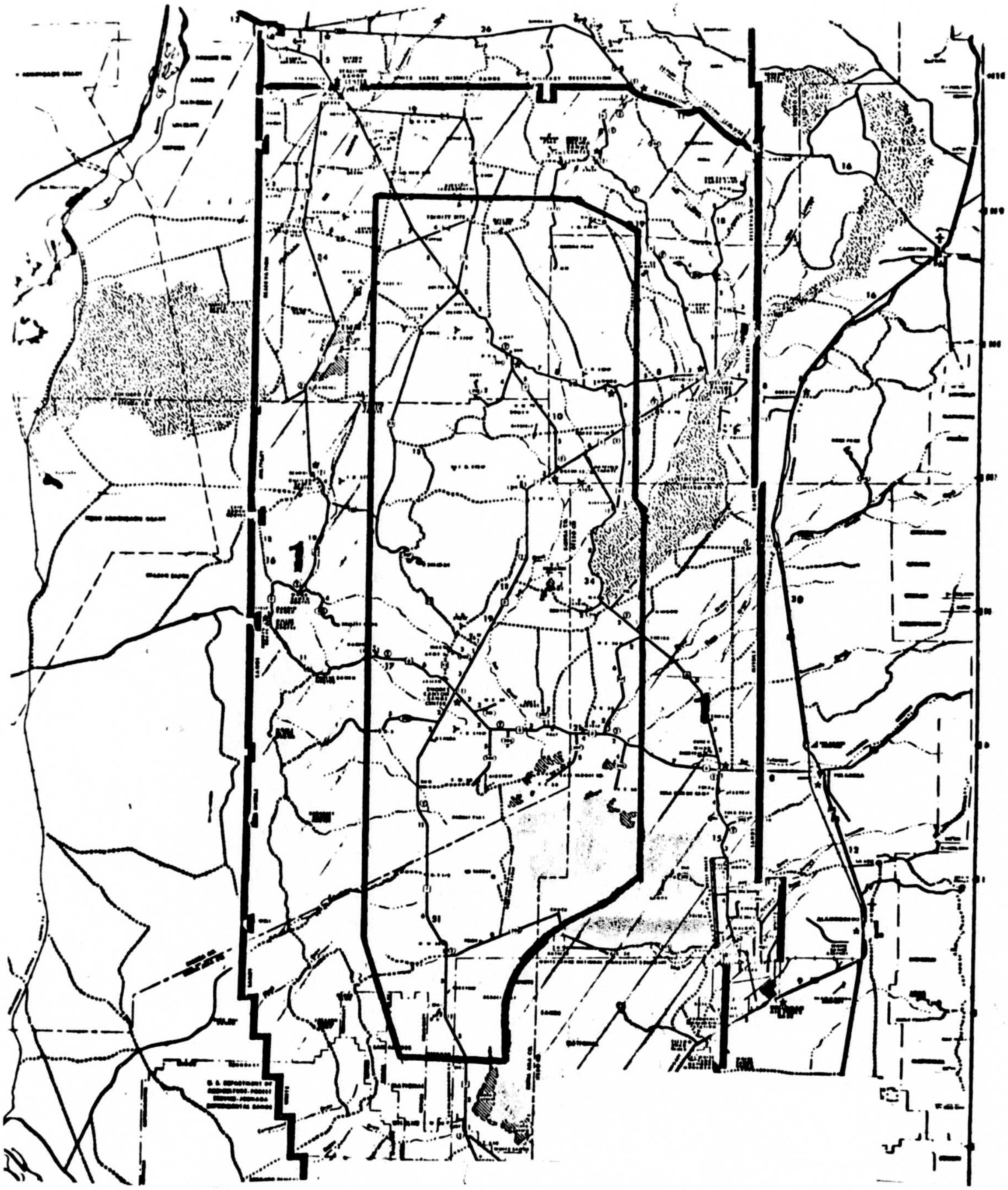


Figure 48. PQM-102 Safety Boundary with Timer Setting of 18 Seconds, Altitude of 17,000 Feet, and Velocity of 575 KTAS

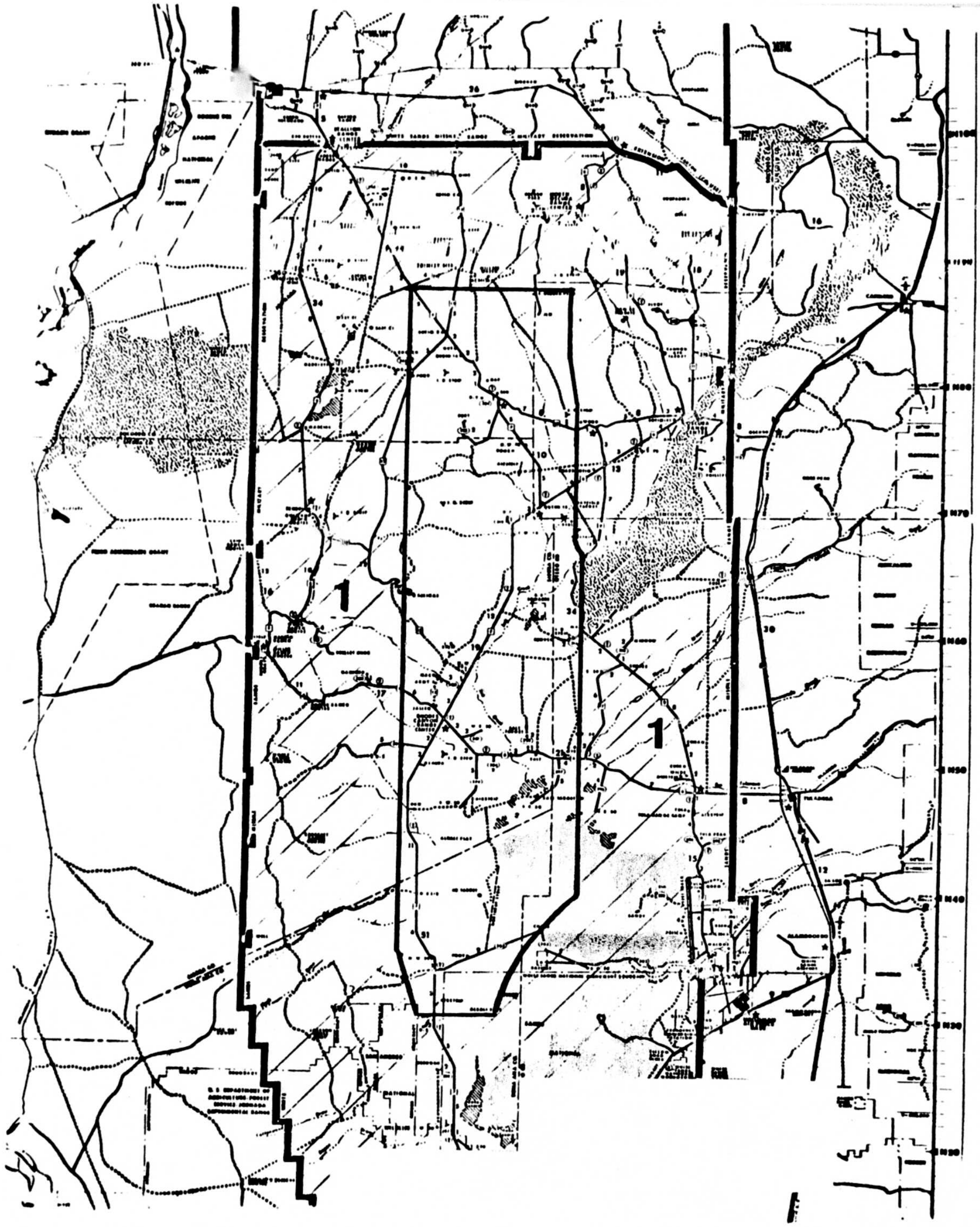


Figure 49. PQM-102 Safety Boundary with Timer Setting of 18 Seconds, Altitude of 57,000 Feet, and Velocity of 575 KTAS

QF-102 flight requirements were different in that there were no safety constraints. On the other hand, the QF-102 required daily access to the range. A backward L-shaped area proved to be the optimum tradeoff between range and program requirements. The flight area boundaries were the M coordinate in the western range, south and east of the Stallion region in the northwestern range and 20,000 feet above the Oscura Bombing Range in the northeastern portion of the range, the north and eastern range boundaries, and Highway 70 in the south.

Airspace constraints presented no significant problems for this program.

Scheduling. Monthly and weekly schedules were obtained from the contractor and submitted to the range scheduling office. No QF/PQM-102 peculiar problems were apparent.

There was some difficulty in the contractor not adhering to his weekly schedule published on the preceding Friday. During the last month of the program, the contractor cancelled or significantly reduced his range requirements six times out of a total of 21 scheduled missions. These numbers were typical of the entire program.

Metric (Optical) Coverage. Several missions were flown and tracked over the 50-mile area to determine any acquisition problems peculiar to the PQM-102. These missions included captive flights at high g, HVAR rocket firings, and AIM-9J missile firings. Two problems peculiar to the PQM-102 became apparent. First, White Sands Missile Range safety imposed constraints on the coverage to include only cameras on the periphery of the 50-mile area. Typical coverage for BQM-34A presentations include cameras within the 50-mile area. Second, because of the aft geometry of the PQM-102, there was no common reference near the afterburner plume from which miss distances could be measured. It was decided to guess at the center of plume and compromise the accuracy of the measurements.

Preliminary data on the AIM-9J firings showed miss distance accuracies on the order of 1.5 feet. This contrasts to the BQM-34A miss distances which yield accuracies on the order of 0.5 foot. Since the PQM-102 exhaust is approximately 4 feet in diameter compared to the 1 foot diameter on a BQM-34A CIR pod, the 1-foot difference in accuracy did not appear to be significant.

Communications. The PAVE DEUCE system required extensive communication support from White Sands Missile Range. These requirements are discussed in paragraph 4.d.(5).

In the White Sands Missile Range areas of responsibility, several serious problems were chronically encountered at King I. For example, on the NULLO flight of 4 October 1974, the King I transmitter failed during the first AIM-9J presentation and during handover when entering the Holloman Air Force Base pattern. At the end of the program, AFSWC requested White Sands Missile Range review this and similar incidents, and remedy the situation. Clearly, PQM-102 requirements severely strained the capability of the King I complex.

Command/Control and Telemetry. The QF/PQM-102 system did not require any standard command/control or telemetry support other than UHF destruct commands, LOC monitor, and DIGIDOPS transmission. All requirements except DIGIDOPS were handled in a satisfactory manner. King I did not have oscillographs of suitable response for DIGIDOPS telemetry. This support was obtained from the 6585th Drone Test and Material Division, Holloman Air Force Base.

Radar Support. As discussed in paragraph 2.b. of this section, the QF/PQM-102 system required two FPS-16 radars. In addition, White Sands Missile Range safety required an additional radar to skin track the drone during NULLO flights. Finally, a fourth radar was required to track the launching aircraft for live firings. Other than those problems already discussed, no problems were encountered in providing this support.

Launch/Recovery Operations. Information concerning launch/recovery operations is discussed in the paragraph entitled Traffic Operations, below, and in Appendix C.

(2) Holloman Air Force Base Interface. The appeal of Holloman Air Force Base for the PQM-102 program was its proximity to White Sands Missile Range, its special drone runway, the support obtainable from the 49th Tactical Fighter Wing for air-to-air operations, and its isolation from populated areas.

Traffic Operations. The QF/PQM-102 was launched and recovered on Runway 21. This runway was not normally used by the 49th Tactical Fighter Wing. Launch was accomplished by transferring to a backup tower frequency, diverting local pattern traffic, and launching the drone. The sequence of subsequent events for launch and recovery are discussed in Appendix E. To recover, all stations transferred to a backup frequency prior to drone entry into the pattern and local traffic was diverted from the area until the drone was landed. Air traffic diversions were carried out in stages, depending on the location of the drone. Local roadblocks were set up from 5 minutes prior to launch until handover, and from 5 minutes prior to recovery until the drone landed. The chase aircraft took off on Runway 21, 2 minutes prior to launch, entered a closed pattern, called for launch approximately 30 seconds out, and arrived abeam of the drone at liftoff. After the recovery, the chase landed normally in accordance with tower instructions.

The operation described worked to the satisfaction of all concerned. Mistakes were minimal and impact on the 49th Tactical Fighter Wing flying schedule (approximately 130 sorties per day) was small.

Maintenance Support. The contractor received certain maintenance support from the 49th Tactical Fighter Wing. Since this operation was administered by the Air Force Contract Management Office, it is not discussed in this report.

Facilities. The facility area for the PAVE DEUCE program was in the western half of Building 901 (Figures 50 and 51). The contractor was provided with 12,000 square feet of hangar space and 2800 square feet of office/shop space. The hangar space was shared with Detachment 6, 43rd Air Rescue and Recovery Squadron (MAC), which used 3600 square feet. The two organizations used a total of 15,600 square feet of floor space for maintenance operations.

In early September 1974, the government vacated its offices on the west side of Building 901, providing 500 more square feet of space for the contractor's quality control office and a larger briefing room.

The above arrangement proved very cramped. The contractor did not have an AGE shop and was forced to do sheet metal work on the hangar floor. The laboratory space was also very cramped. Although some of the requirements were relaxed during the operational phase, e. g., the engineering office, the contractor was not able to expand his capability using the facility.

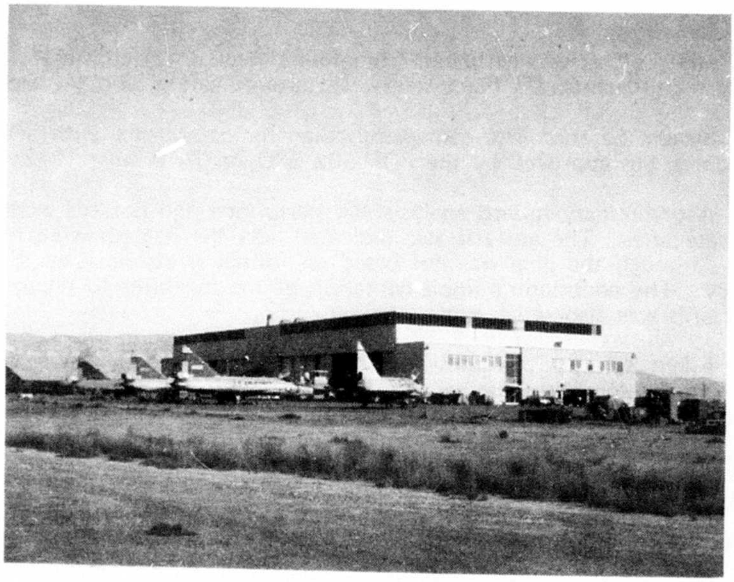


Figure 50. Holloman Air Force Base Building 901

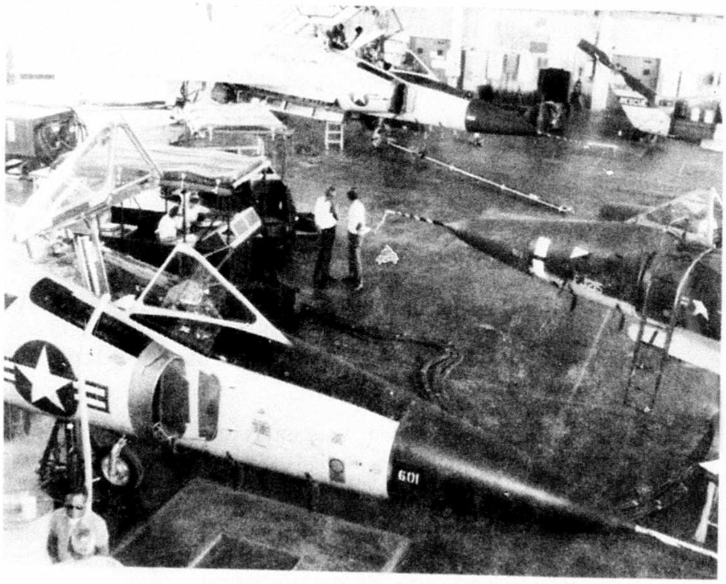


Figure 51. PQM-102 Operations, Building 901

c. Safety

The safety effort was evaluated from four aspects: (1) contractor compliance with system safety requirements, (2) flight safety, (3) ground safety, and (4) range safety.

(1) System Safety. The contractor's plan for compliance with SOW requirements for system safety was approved by the PQM-102 SPO on 24 August 1973.

A preliminary hazard analysis was performed and hazards were identified in appropriate categories. The analysis also indicated how the hazards were to be eliminated or reduced. Although the plan was not based on formal safety analyses it was judged to be satisfactory. The contractor's implementation of the measures to reduce or eliminate identified hazards was also satisfactory.

(2) Flight Safety. The contractor's flight safety program was evaluated by comparison with similar Air Force programs and was found to be satisfactory. Flight safety considerations were stressed in all normal operations and resulted in a strong safety awareness on the part of all contractor personnel. The only deficiency in the program resulted from the failure to perform the system safety tasks during the earlier phases of the program. As a result, when system malfunctions occurred, the analyses and corrective measures were of the hobby-shop, cut-and-try technique. Generally, the first corrections were inadequate and the condition reoccurred during subsequent operations.

(3) Ground Safety. Ground safety was continuously evaluated and was rated very satisfactory. When hazardous conditions were discovered they were quickly corrected and the contractor was quick to respond to guidance from local Air Force safety representatives.

(4) Range Safety. The QF/PQM-102 satisfied all White Sands Missile Range safety constraints. The procedures and restraints imposed by range safety considerations complicated the task of operating and maintaining the PQM-102; however, there were no test requirements which were not met because of range safety.

d. Miscellaneous

(1) Electromagnetic Interference/Compatibility (EMI/EMC). The ability of the FCSS and interface systems to operate without degradation from EMI emanating from other various systems and from any RF sources external to the PQM-102 was evaluated along with evaluations to insure that the FCSS and interface systems did not generate EMI.

To accomplish the evaluation a series of tests were accomplished on 5 June 1974. Systems tested included the FCSS, MGS, FGS, DIGIDOPS, UHF command destruct receiver, radar altimeter, AN/APX-25 IFF, AN/ARC-34 radio LOC tone, F-4 aircraft fire control radar, and the basic F-102 aircraft.

During the testing, each system was exercised and responses were monitored. Additional monitoring equipment, including a strip chart recorder, test boxes, and voltmeters were used in order to thoroughly monitor all responses. Special interest was given to the destruct system, including the UHF destruct system. Effects of the DIGIDOPS and ARC-34 UHF transmitters to the UHF destruct receiver signal strength voltage were monitored.

Three EMI related problems were experienced. A pitch transient (elevon movement) was observed just as the speed brakes became fully closed. Pitch transients were also observed when either the right or left boost pumps were energized. The AN/ARC-34 transmitter caused fluctuation of the g downlink telemetry as observed on the FGS and MGS. No effect to the FCSS or aircraft was observed. In addition, several minor problems were experienced during conduct of the tests. However, none were concluded to be EMI-related. While the three problems were repeatable during the tests, they were not observed on subsequent NULLO flights conducted on 13 August and 20 August 1974 on this aircraft. Transients associated with speed brake closure were observed on other aircraft during pre-flight checks (landing/takeoff command latched ON) and the problem was identified and corrected.

In summary, EMI/EMC evaluation, which also included the series of manned QF flights, indicated a satisfactory level of electromagnetic compatibility, primarily due to the fact that aircraft response (inflight) to the transients had not been observed. The intermittent nature of the problems, including various telemetry fluctuations, was not an area of major concern.

(2) Environmental. An essential evaluation aspect was the determination of environmental effects on the entire PQM-102 Target System. The only identified problem relating to environmental effects was a drift in frequency of a single transponder that was installed in the vertical stabilizer. The drift was found to be caused by the extreme cold temperature in the fin. Subsequently, a factory modification was performed on the transponders and complete environmental checks were performed. No further problems were experienced.

(3) Operational Technical Data. Evaluation in this area was cursory, at best, because of the almost complete absence of operational technical data throughout the development and test phase. In the time period immediately preceeding the first PQM-102 flight, the contractor prepared and submitted checklists for operational use. During the last month of the development and test effort (October 1974) a draft supplement to the F-102A Flight Manual was submitted. The following comments on these two areas constitute the evaluation of operational technical data.

PQM-102A Target Manual. The contractor submitted an operational manual for the PQM-102 on 7 August 1974. This manual was approved by AFSWC and subsequently used on PQM-102 flights. The contractor perfected the operational procedures during the pre-NULLO practices. Consequently, the manual was validated and became a very effective document. Procedures were established for submitting additions, changes, and deletions for the manual to reflect changes in operation (use of ground spare drone, for example), and additional inputs from safety agencies. At the end of the development and test phase, this operational manual adequately and accurately reflected the procedures for normal operation of the PQM-102 Target System.

QF/PQM-102A Flight Manual. This manual supplemented the flight manual for the F-102A and TF-102A, Technical Order 1F-102A-1 Change 1, Sections I through IV. The manual was submitted near the end of the development and test phase. Since it had not been approved by the PQM-102 SPO, it was treated as a draft copy. A review of the manual resulted in the following observations:

- The information in Sections I and IV was clear and straightforward; however, diagrams were rough and required additional art-work prior to final printing.

- Section II contained normal operational procedures; however, there were a large number of differences between these procedures and those actually used for the PQM-102 Target Manual. Identical checklist and flight manual procedures were mandatory.

- The Emergency Procedures in Section III were complete; however, the procedures were not clear and concise because of combining three aircraft (F-102, QF-102, and PQM-102). In addition, Section V (Operational Limitations) and Section VIII (Crew Duties, i. e., ground controllers for PQM-102 operations) of the manual required supplementing.

In summary, any true evaluation of the PQM-102 operational technical data awaited contractor submission and correction, and PQM-102 SPO approval. Suffice to say, no other personnel, other than those employed by the contractor, could operate the system because of the inadequate and unprovided technical data.

(4) Human Engineering.

Method of Test: QF/PQM-102 airborne equipment and AGE were examined for compliance with the requirements of MIL-STD-1472. Consoles and display panels were checked for dimensions and layout. Switches, levers, lights, gauges, and other displays were evaluated for function, orientation, protection, labeling, and color. Environmental protection for maintenance personnel and remote control operators was observed on a daily basis; precise measurements of the environment were not made, but obvious deficiences were noted and are addressed in the following paragraphs.

Results: MIL-STD-1472 requirements were met throughout the system with a few minor exceptions. Seven of the indicator lights on the standard data panels, Panel No. 4015242, were activated by switch position rather than system response. On the same panels, the use of a red light to indicate direct throttle operation violated the color coding of MIL-STD-1472.

The orientation of the X–Y plotting boards used by the remote operators at both the FGS and MGS was marginal. At the FGS the plotting board was too far from the controller and precise control of the ground track was difficult because the controller could not see the display clearly. At the MGS, the location of the plot board (down and to the controller's left) required the controller to look away from the instruments and the direction of approach in order to see the plotting board. While the orientation of the plottings boards was not a significant problem during the test program, new FGS installations should definitely include a better plotting board location. The mobile plotting board orientation would be more difficult to correct and could be a more significant deficiency at operating locations where weather conditions require extensive use of the plotter during launch and recovery.

The environmental protection provided for the remote operators on the MGS was unsatisfactory. The awning provided some protection from rain and sun but was lowered during pattern operation. Furthermore, no thermal protection was provided. During cold weather operation, the environment was severe enough to require arctic clothing and to degrade the operator's performance.

(5) Voice Communications. Several voice communication systems were established and maintained. A UHF system, normally operating on either a Holloman Air Force Base tower frequency or a White Sands Missile Range assigned project frequency of 379.7 MHz provided two-way communications among the operators at the FGS, MGS, maintenance-launch vehicle, chase aircraft, and QF-102 aircraft. Receive-only monitors were provided personnel located in the King I telemetry room, the FPS-16 radar site, the DIGIDOPS telemetry room (Building 902), and the prime contractor's conference room (Building 901). The uplink LOC tone from the QF-102 aircraft was transmitted on the frequency selected

(tower or project), and on PQM-102 aircraft only on the project frequency. A fixed frequency VHF system was also used for FGS/MGS two-way communications. A battery-operated back-up unit was provided for use at the FGS in the event of power failure. An additional VHF system, consisting of three battery-operated portable units, was provided for maintenance flightline/runway operations. An intercom system was provided for communications among the FGS and radar operators and a similar system was used on the MGS. An additional system was used among the launch control vehicle, maintenance personnel, and the QF-102 pilot.

Evaluation of the communication systems could only be done on a qualitative basis. Overall, communications were considered adequate but not highly reliable. Numerous problems were experienced with the UHF and launch control vehicle intercom systems. Despite personnel operating errors, component failures, and careless wiring, no serious mission impacts resulted. The launch control vehicle intercom system definitely requires replacement and consideration should be given to procurement of a more reliable UHF system for this vehicle and the MGS. Of the flights evaluated, at least 12 UHF communication problems were experienced with the FGS, MGS, QF-102, and launch control vehicle.

(6) Reliability. The SOW mission reliability requirement for the QF/PQM-202 Target System was 90 percent. That value required 19 of 21 flights (14 QF-102 and 5 PQM-102) be verified by the PQM-102 SPO/AFSWC as successful. Twenty-two record flights (16 QF-102 and 6 PQM-102) were flown to evaluate the 90 percent reliability requirements. One flight was outside the F-102 performance envelope and was not counted toward mission reliability. The record flights not meeting SOW criteria were QF-102 Record Flight No. 3, 6, 7, 8, 12, and 14, and PQM-102 Record Flight No. 1. An accounting of these flights is as follows:

<u>QF-102 Record Flight No. 3</u>: This flight was considered successful due to the involvement of one and possibly two failures on government furnished equipment. The PQM-102 had the option to re-fly since the mission failure was due to the government furnished equipment in question.

<u>QF-102 Record Flight No. 6, 7, 8, and 12</u>: Failure of these flights was attributed to one failure mode. Under the reliability ground rules and assumptions, the contractor corrected this design deficiency by installing a maneuver programmer roll error integrator. The modification eliminated the steady-state roll offsets previously encountered during presentations. By applying accepted reliability practices, only one failure and three successes were credited to the contractor's record for these four flights.

<u>QF-102 Record Flight No. 14</u>: This flight was established as unsuccessful due to failure of contractor furnished equipment and was credited to the contractor's failure record.

<u>PQM-102 Record Flight No. 1</u>: This NULLO was unsuccessful. The aircraft auto trim followup micro switch (government furnished equipment) malfunctioned causing an air abort. This record flight was reflown with outstanding success.

In summary, of the 12 record reliability flights flown for mission reliability, 2 failures and 19 successes were credited to the contractor's record. Using the following formula for mission reliability the QF/PQM-102 Target System reliability was 90.47 percent:

$$\frac{\text{Number of Successful Record Flights}}{\text{Total Record Flights}}$$

SECTION V

FINDINGS AND RECOMMENDATIONS

1. GENERAL

The QF/PQM-102 Target System adequately filled the urgent Air Force need for a supersonic, afterburning, maneuvering target. Acceptable levels of system performance as well as the de-manrated concept were verified during the DT&E; no major system changes were recommended. Within the scope of the areas addressed in this document, the concept of an all-contractor operation proved to be acceptable.

The following are specific AFSWC findings and where applicable, recommendations for system/concept improvement.

2. FCSS

a. The compressor should be modified so that the parity check currently made with software can be made with hardware. This will save a considerable amount of computer time and would not be difficult to implement. With the modification, data would be updated only when the parity check was valid, and the parity list would not be recorded on magnetic tape.

b. Overall performance of the pitch axis and throttle control modes of the FCSS was excellent. The only potential problem area was altitude hold at high altitudes and high bank angles. In this flight regime, the pitch axis loses much of its stability and may go unstable above 0.8 Mach. Since this characteristic is common to most autopilots, a specific hardware fix is not recommended. Care must be exercised, when exceeding 60 degrees of bank above 35,000 feet since pitch oscillations may result if altitude hold is engaged.

c. The marginal performance of the bank attitude hold function of the FCSS was considerably improved by checking the differential elevon feedback voltage prior to each NULLO flight. The proposed roll integrator modification will improve performance still further, although the change will cause a larger bank overshoot during maneuver presentations.

d. It is evident from the test program that HEP valve lockout was a distinct possibility when the artifical feel system had not been modified by disconnecting the airspeed input. Since lockout may result in unpredictable and severe maneuvering, it is recommended that this modification be made a permanent feature of all NULLO flights. Further efforts should also be made to determine the cause of excessive g loading which occurs during lockout since there remains a small theoretical possibility that lockout may occur even with the modification.

e. Flight procedures which minimize the effects of loss of carrier should be tested and well understood. Specifically, high reference airspeeds during presentations may cause a sudden pitch down if LOC occurs due to the airspeed on pitch mode being set. During transonic flight, LOC may cause severe pitch oscillations if altitude hold is engaged. Low reference airspeeds should be avoided at high altitude to minimize the chance for a compressor stall, although the rate of throttle movement has been reduced to solve this problem.

3. MAINTENANCE

a. A test fixture is needed for the ECU to verify its proper operation and for trouble-shooting purposes. Present techniques of switching ECU around and/or trying on different aircraft are not acceptable.

b. A lower temperature range starting at 100 degrees Centigrade should be used on the ECU exhaust gas temperature indicator to allow more accurate evaluation of the engine condition during ECU starts.

c. Procedures need to be developed for operation/maintenance of the radar simulator and target group simulator.

d. Provisions should be made for the use of commercial power or a portable generator with the MGS since a mission would be aborted if one of the two MGS Onan generators was not operative. No spare Onan generators were available and extensive down time occurred when one was removed for periodic maintenance or repair.

e. Steps should be taken to improve the DIGIDOPS dead zone and to allow determination of which antenna is in operation. This would allow more accurate real time evaluation of miss distances.

f. More accurate and complete procedures for the documentation, corrective action, and follow-up of FCSS, MGS, FGS, and PQM-102 related problems is urgently required.

g. More effective and reliable means of communications are urgently required. Use of modern UHF equipment in the MGS, PQM-102, and launch control vehicle would greatly enhance reliability of operations. An improved intercom system is also needed for the launch control vehicle.

h. The PQM-102 conversion and subsequent premission testing proved to be adequate tools in support of the de-manrated concept. Its one shortcoming was the premission testing inability to detect problems involving aircraft dynamics. This is an inherent problem and cannot be improved by refined procedures.

i. Further evaluation of the MGS control range needs to be accomplished since full 360-degree coverage (azimuth) was not investigated and suspected dead zones exist.

4. OPERATIONS

a. Future users of the QF/PQM-102 Target System should officially request White Sands Missile Range assistance in the following areas:

(1) A procedure for streamlining air-to-air White Sands Missile Range documentation requirements should be considered. A possible solution would be an all-inclusive Program Introduction/Statement of Compliance and a series of Operation Requirements for each AIM type missile prepared ahead of any specific requirement.

(2) The White Sands Missile Range decision to close the White Sands Monument during launch operations imposed a severe scheduling constraint on XRAY (short notice) type scheduling requests. In view of the high expenditures involved in keeping an air-to-air operation staged at Holloman Air Force Base, the Air Force should request relief from the constraint at the highest level necessary.

(3) The King I complex, while very convenient to Holloman Air Force Base operation, was severely taxed by the PQM-102 operation. White Sands Missile Range should be requested to improve King I capabilities in such areas as communications, vertical plot capability, power requirements, and floor space (already completed in an unused addition to the King I building).

b. Facilities in Building 901 were very cramped during the DT&E operation. The con tractor demonstrated an excellent ability to estimate facilities requirements to support his operations. Any Operation and Maintenance operation should seriously consider the contractor's estimate of his requirements.

c. Contractor operational technical data was incomplete. This data should be completed prior to any redeployment, rehiring of new personnel, or redirection of mission.

d. Various items in the area of human engineering do not conform to MIL-STD-1472A. In the interest of safety, proper modification to the equipment should be considered.

5. SUMMARY - PQM-102 CONCEPT

The PQM-102 was the culmination of a three year development effort to provide the Air Force with a full size, afterburning, supersonic target. The aircraft was unmanned and controlled from takeoff to landing by means of remote control terminals on the ground. Its speed and maneuverability permitted simulation of high performance maneuvers, a long needed capability for testing an increasingly complex array of air armament. The PQM-102 performed maneuvers up to 8g, flew in excess of 1.2 Mach, and operated effectively between 200 and 55,000 feet altitude.

The reduced program costs for the PQM-102 were as follows:

- Use of the director aircraft previously used for control of the drone to and from the range was eliminated.
- Procurement of expensive range control radars was eliminated by utilizing existing FPS-16 radars.

a. Elimination of Director Aircraft

Previously converted drone programs, such as the QF-104, utilized two DT-33 director aircraft per mission. This meant the director aircraft controlled the drone during takeoff and controlled it to the range where the fixed site assumed control. Following the range mission, the director aircraft resumed control until the MGS assumed control on final approach. The second director aircraft acted as a backup to the director aircraft in control. Additionally, the second aircraft performed the takeoff and was necessary due to imcompatibility between the F-104 and T-33. At least two pilots and two ground controllers, plus two airborne controllers, were required on a mission on the AF-104 program. These functions were eliminated by providing the MGS with total dual redundant operation, tracking radar, and extended control capability. The cost saving was significant due to reduced fixed cost reductions as noted below:

Fixed Cost Savings

- No requirements for two T-33 aircraft
- No modification required for conversion of T-33 to DT-33
- No airborne control equipment costs

Monthly Cost Savings

- No proficiency requirements for at least four pilots/controllers
- No maintenance or petroleum, oil, and lubricant costs on T-33 aircraft
- Mission support and/or proficiency support
- No maintenance cost on airborne control equipment
- Reduced operational cost as a result of no checkout on director aircraft

b. Elimination of Separate Range Control Radar

The target control system was developed to interface with the existing FPS-16 radars and thus eliminated the costs which would have been incurred if separate C-Band range radar systems were used.

c. De-Manrated Concept

The de-manrated concept represented a unique approach to the converted drone target which ultimately eliminated the costs associated with the manned capability of previous drone targets. For example, the electronics pallet assembly which contained the majority of the electronics necessary for remote control of the aircraft. This had potential cost savings in that the ejection seat did not have to be maintained and the installation of the electrical junction box and elevon electronic boxes could be made by merely sliding the electronics pallet assembly down the seat rails.

(1) The following three areas resulted in cost savings for the Research and Development program:

- Reduced FCSS hardware and aircraft modification cost in the PQM-102 (remote command and data panel, control stick, radio altimeter indicator, Mach/airspeed indicator eliminated).

- Reduced maintenance costs as a result of no life support systems to maintain and support, such as the oxygen system, ejection system, RAT, pneumatic force feel system, ILS, panel instruments, and air conditioning systems.

- Reduced maintenance costs as a result of reduced inspection requirements associated with an unmanned aircraft. For example, an often overlooked but important advantage of the PQM-102 was tolerance to overstress. A manned overstressed target would have to be subjected to a vigorous safety inspection after each overstress incident. Over a period of years a considerable amount of money could be saved by reduced maintenance resulting from this factor and others that do not have to be performed.

(2) The PQM-102 concept, in contrast to previous drone targets, did not allow evaluation of the remote drone control system via inflight evaluation of the system by the airborne pilot. Consequently, a more elaborate method of premission testing was necessary to provide the level of confidence to insure a successful target mission. This was done by means of a PMTS that is electrically connected to the drone control electronics. This provided a means for the flightline technician to stimulate, test, and exercise all facets of the drone control system. For the present PQM-102 program, this is a lengthy process. Future programs employing a totally unmanned concept should consider adding semiautomated test capability to the PMTS. One other disadvantage would be evident if there were a referryability requirement, since the PQM-102 target would have to be re-manrated.

(3) In the future, the de-manrated concept can potentially offer even greater cost savings when the following occurs:

- Reduction of QF-102 missions, thus reducing number of pilots, and thus reducing number of proficiency flights.
- Elimination of requirements to have current F-102 pilots as controllers at the FGS and MGS, thus reducing the number of proficiency flights.
- Reduction in premission test procedure requirements to greatly reduce check-out time.

(4) Manrated Versus De-Manrated Concept. The manrated versus de-manrated concept can be evaluated by comparing estimated initial procurement costs and monthly operation costs.

The QF-102 target is estimated to cost about 10 percent more than a PQM-102 target due to additional hardware and higher airframe modification costs.

If the QF-102 has the full capability of the ground controller, then monthly operating cost differences can be estimated by considering the reduction in maintenance due to not having to maintain manned systems, and the increase in maintenance due to the additional check-out time required. Based on 24 flights per month, with a breakdown of 8 NULLO, 8 QF-122, and 8 F-102 flights, it is estimated that there was a cost savings of at least $10,000 per month. Obviously, much greater savings can be made if QF-102 flights and F or TF proficiency flights can be reduced.

d. If a direct comparison of the manpower using the PQM-102 concept on the existing PQM-102 program was made with the manpower used on the previous QF-104 program, it would be found that a greater number of NULLO flights could be conducted with one-third less manpower.

e. The PQM-102 concept has proven to be successful. At this point in time, 23 successful NULLO flights have been made utilizing four PQM-102 aircraft, and one de-manrated QF-102. During these flights, the performance and reliability were fully demonstrated. The PQM-102 was chased by modern jet fighters and air-to-air missiles, and was labeled by many Air Force fighter pilots as an invaluable asset for the realistic evaluation of modern weapons.

LIST OF ABBREVIATIONS AND ANCRONYMS

ADC	air data computer
AGC	automatic gain control
AGE	aerospace ground equipment
AGL	above ground level
DIGIDOPS	digital-doppler scoring system
EBW	exploding bridgewire
ECU	engine control unit
EGT	exhaust gauge temperature
EMC	electromagnetic compatibility
EMI	electromagnetic interference
FCSS	flight control stabilization system
FGS	fixed ground station
FRC	flight reference computer
HEP	hydraulic elevon package
HEFU	high energy firing unit
HVAR	high velocity air-launched rocket
IFC	interface coupler
ILS	instrument landing system
IRIG	inter-range instrumentation group
KCAS	knots calibrated airspeed
KIAS	knots indicated airspeed
KTAS	knots true airspeed
LAMP	low altitude maneuver programmer
LOC	loss-of-carrier
LOS	line-of-sight

LIST OF ABBREVIATIONS AND ANCRONYMS (CONCLUDED)

LRU	line replaceable unit
MGS	mobile ground station
MODEM	modular/de-modular
MSL	mean sea level
nmi	nautical mile
NULLO	unmanned flight (PQM-102)
PMTS	premission test stand
PRF	pulse repetition frequency
RAT	ram air turbine
STB	system test bench
WOG	weight-on-gear

APPENDIX A

MISSION LOG

The development flights flown during the Holloman Air Force Base phase are listed in this appendix. All flights are listed in Table A-1 except those flown to fulfill pilot requirements of Air Force Regulation 60-1. Detailed analyses are presented on all record flights and a summary of maneuver programmer performance follows QF-102 Record Flight No. 16.

The various types of flights are as follows:

Training: Flights for checkout of new pilots/controllers on the QF/PQM-102 system.

Development, Test and Engineering (DT&E): Flights for demonstrating the various capabilities required under the SOW (Appendix D).

Engineering Evaluation: Engineering flights by the contractor to develop and troubleshoot the system prior to DT&E demonstration.

Antenna Evaluation: Flights used for reconfiguring the forward telemetry system.

DIGIDOPS: Flights for checkout of the DIGIDOPS.

Smoke System Development: Flights for checkout of the smoke system.

Emergency Training: Flights flown to demonstrate and practice emergency procedures.

IR Tests: Special flights dedicated to an ADTC study of the IR characteristics of the QF/PQM-102.

Record Flights: Flights flown to officially demonstrate system performance, safety, and reliability.

Reliability Flights: Flights flown to demonstrate an acceptable level of system confidence prior to the first NULLO flight.

White Sands Missile Range Qualification Flights: Flights flown for White Sands Missile Range to demonstrate the reliability of the destruct system.

TABLE A-1. FLIGHT LOG

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
1	10 Jan 1974	602	Training
2	11 Jan 1974	602	Training
3	14 Jan 1974	602	Training
4	21 Jan 1974	601	Training
5	22 Jan 1974	601	Training
6	24 Jan 1974	601	Training
7	25 Jan 1974	601	DT&E
8	29 Jan 1974	601	DT&E
9	31 Jan 1974	601	DT&E
10	20 Feb 1974	601	DT&E
11	21 Feb 1974	601	Training
12	21 Feb 1974	601	Training
13	22 Feb 1974	601	DT&E
14	25 Feb 1974	601	DT&E
15	25 Feb 1974	601	Training
16	26 Feb 1974	601	DT&E
17	27 Feb 1974	602	DT&E
18	2 Mar 1974	603	Engineering Evaluation
19	4 Mar 1974	603	Engineering Evaluation
20	4 Mar 1974	603	Engineering Evaluation
21	6 Mar 1974	601	DT&E
22	6 Mar 1974	603	Engineering Evaluation
23	7 Mar 1974	602	DT&E
24	8 Mar 1974	601	DT&E
25	8 Mar 1974	603	Engineering Evaluation
26	11 Mar 1974	601	DT&E
27	12 Mar 1974	601	DT&E
28	13 Mar 1974	602	Engineering Evaluation
29	14 Mar 1974	603	Engineering Evaluation
30	14 Mar 1974	603	Engineering Evaluation
31	15 Mar 1974	602	Antenna Evaluation
32	18 Mar 1974	603	Engineering Evaluation
33	18 Mar 1974	602	Antenna Evaluation
34	18 Mar 1974	603	Engineering Evaluation

TABLE A-1. FLIGHT LOG (CONTINUED)

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
35	18 Mar 1974	602	Antenna Evaluation
36	19 Mar 1974	602	Antenna Evaluation
37	21 Mar 1974	603	Engineering Evaluation
38	21 Mar 1974	603	Engineering Evaluation
39	22 Mar 1974	603	Engineering Evaluation
40	22 Mar 1974	601/606	DT&E/DIGIDOPS
41	25 Mar 1974	601	DT&E
42	26 Mar 1974	602	DT&E
43	27 Mar 1974	603	DT&E
44	29 Mar 1974	602	Antenna Evaluation
45	5 Apr 1974	606	DIGIDOPS
46	5 Apr 1974	602	Antenna Evaluation
47	5 Apr 1974	606	DIGIDOPS
48	9 Apr 1974	606	DIGIDOPS
49	9 Apr 1974	602	Antenna Evaluation
50	10 Apr 1974	603	Engineering Evaluation
51	10 Apr 1974	606	DIGIDOPS
52	11 Apr 1974	603	Engineering Evaluation
53	11 Apr 1974	608	Smoke Development
54	16 Apr 1974	606	DIGIDOPS
55	16 Apr 1974	608	Smoke Development
56	17 Apr 1974	601	Engineering Evaluation
57	18 Apr 1974	601	DT&E
58	22 Apr 1974	601	DT&E
59	23 Apr 1974	606	DIGIDOPS
60	23 Apr 1974	603	Engineering Evaluation
61	25 Apr 1974	606	DIGIDOPS
62	26 Apr 1974	606	IR Test
63	26 Apr 1974	608	IR Test
64	30 Apr 1974	608	IR Test
65	2 May 1974	608	IR Test
66	4 May 1974	602	Engineering Evaluation
67	6 May 1974	602	DT&E
68	10 May 1974	606	DIGIDOPS

TABLE A-1. FLIGHT LOG (CONTINUED)

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
69	14 May 1974	602	DT&E
70	15 May 1974	601	DT&E
71	16 May 1974	601	DT&E
72	16 May 1974	602	DT&E
73	17 May 1974	602	DT&E
74	30 May 1974	602	DT&E
75	30 May 1974	602	DT&E
76	31 May 1974	602	DT&E
77	4 Jun 1974	602	Emergency Training
78	4 Jun 1974	602	DT&E
79	6 Jun 1974	602	Emergency Training
80	7 Jun 1974	602	DT&E
81	10 Jun 1974	602	DT&E
82	11 Jun 1974	602	DT&E
83	12 Jun 1974	602	DT&E
84	13 Jun 1974	602	Training
85	18 Jun 1974	601	DT&E
86	21 Jun 1974	601	DT&E
87	21 Jun 1974	606	DIGIDOPS
88	24 Jun 1974	601	Training
89	24 Jun 1974	601	Training
90	25 Jun 1974	601	DT&E
91	26 Jun 1974	601	DT&E
92	28 Jun 1974	602	DT&E
93	29 Jun 1974	603	Engineering Evaluation
94	29 Jun 1974	601	Engineering Evaluation
95	1 Jul 1974	601	Emergency Training
96	1 Jul 1974	603	Engineering Evaluation
97	2 Jul 1974	601	DT&E/Reliability
98	2 Jul 1974	601	DT&E/Reliability/White Sands Missile Range Qualification
99	3 Jul 1974	601	DT&E/Reliability/White Sands Missile Range Qualification
100	8 Jul 1974	601	DT&E/Reliability/White Sands Missile Range Qualification

TABLE A-1. FLIGHT LOG (CONTINUED)

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
101	9 Jul 1974	601	DT&E/Reliability/White Sands Missile Range
102	10 Jul 1974	601	DT&E/Reliability/White Sands Missile Range
103	10 Jul 1974	601	DT&E
104	11 Jul 1974	602	DT&E/Reliability/White Sands Missile Range
105	12 Jul 1974	602	Engineering Evaluation
106	15 Jul 1974	602	Engineering Evaluation
107	16 Jul 1974	602	Engineering Evaluation
108	17 Jul 1974	602	Engineering Evaluation
109	17 Jul 1974	603	Engineering Evaluation
110	18 Jul 1974	601	Engineering Evaluation
111	22 Jul 1974	601	Engineering Evaluation
112	23 Jul 1974	603	Engineering Evaluation
113	26 Jul 1974	601	Engineering Evaluation
114	26 Jul 1974	602	Engineering Evaluation
115	29 Jul 1974	602	QF-102 Record Flight No. 1/Reliability
116	30 Jul 1974	603	Engineering Evaluation
117	30 Jul 1974	602	Reliability/White Sands Missile Range Qualification
118	31 Jul 1974	602	QF-102 Record Flight (Incomplete)/Reliability
119	1 Aug 1974	601	Engineering Evaluation
120	1 Aug 1974	602	QF-102 Record Flight (Incomplete)/Reliability
121	2 Aug 1974	601	QF-102 Record Flight No. 2/Reliability
122	2 Aug 1974	601	Reliability/White Sands Missile Range Qualification
123	3 Aug 1974	601	QF-102 Record Flight No. 3/Reliability/White Sands Missile Range Qualification
124	3 Aug 1974	602	Engineering Evaluation
125	5 Aug 1974	601	QF-102 Record Flight No. 4/Reliability
126	6 Aug 1974	601	QF-102 Record Flight No. 5/Reliability/White Sands Missile Range Qualification

TABLE A-1. FLIGHT LOG (CONTINUED)

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
127	7 Aug 1974	601	Emergency Procedures
128	7 Aug 1974	602	Engineering Evaluation
129	8 Aug 1974	602	Engineering Evaluation
130	8 Aug 1974	602	QF-102 Record Flight No. 6/ White Sands Missile Range Qualification
131	10 Aug 1974	602	QF-102 Record Flight No. 7/ White Sands Missile Range Qualification
132	12 Aug 1974	602	Pre-NULLO
133	13 Aug 1974	605	PQM-102 Record Flight No. 1 (NULLO No. 1)
134	14 Aug 1974	602	QF-102 Record Flight No. 8
135	15 Aug 1974	602	QF-102 Record Flight No. 9
136	16 Aug 1974	601	Engineering Evaluation
137	19 Aug 1974	603	Engineering Evaluation
138	22 Aug 1974	605	PQM-102 Record Flight No. 1 Re-fly (NULLO No. 2)
139	26 Aug 1974	601	Pre-NULLO
140	27 Aug 1974	605	PQM-102 Record Flight No. 2 (NULLO No. 3)
141	28 Aug 1974	601	Pre-NULLO
142	3 Sep 1974	602	Engineering Evaluation
143	3 Sep 1974	602	QF-102 Record Flight No. 10
144	4 Sep 1974	605	PQM-102 Record Flight No. 3 (NULLO No. 4)
145	5 Sep 1974	602	Engineering Evaluation
146	5 Sep 1974	602	QF-102 Record Flight No. 11/ Pre-NULLO
147	6 Sep 1974	602	QF-102 Record Flight No. 12
148	10 Sep 1974	604	PQM-102 Record Flight No. 4 (NULLO No. 5)
149	12 Sep 1974	602	Engineering Evaluation
150	12 Sep 1974	602	Engineering Evaluation
151	13 Sep 1974	602	Engineering Evaluation
152	16 Sep 1974	602	Engineering Evaluation
153	17 Sep 1974	602	Engineering Evaluation

TABLE A-1. FLIGHT LOG (CONTINUED)

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
154	19 Sep 1974	602	Engineering Evaluation
155	20 Sep 1974	602	Engineering Evaluation
156	23 Sep 1974	602	Engineering Evaluation
157	25 Sep 1974	602	Pre-NULLO
158(1)	26 Sep 1974	606	PMQ-102 Record Flight No. 5 (NULLO No. 6)
159	27 Sep 1974	603	Engineering Evaluation
160	28 Sep 1974	603	Engineering Evaluation
161	30 Sep 1074	603	Engineering Evaluation
162	30 Sep 1974	603	Pre-NULLO
163	3 Oct 1974	603	Engineering Evaluation
164	4 Oct 1974	604	NULLO No. 7
165	7 Oct 1974	603	Engineering Evaluation
166	8 Oct 1974	606	NULLO No. 8
167	9 Oct 1974	603	QF-102 Record Flight No. 13
168	10 Oct 1974	603	Engineering Evaluation
169	10 Oct 1974	602	QF-102 Record Flight (Incomplete)
170	11 Oct 1974	602	QF-102 Record Flight No. 14
171	11 Oct 1974	602	QF-102 Record Flight No. 14 Re-fly No. 1
172	12 Oct 1974	603	Engineering Evaluation
173	18 Oct 1974	602	Engineering Evaluation
174	18 Oct 1974	602	Engineering Evaluation
175	23 Oct 1974	602	Engineering Evaluation/Training
176	25 Oct 1974	601	Engineering Evaluation
177	30 Oct 1974	601	Pre-NULLO
178	30 Oct 1974	601	Engineering Evaluation
179	1 Nov 1974	606	NULLO No. 9
180	4 Nov 1974	601	Engineering Evaluation
181	5 Nov 1974	601	QF-102 Record Flight No. 15
182	6 Nov 1974	606	NULLO No. 10
183(2)	7 Nov 1974	601	QF-102 Record Flight No. 16
184	12 Nov 1974	605	NULLO No. 11
185	15 Nov 1974	602	IR Test

TABLE A-1. FLIGHT LOG (CONCLUDED)

Flight No.	Date	Aircraft/Drone FAD No.	Type of Flight
186	18 Nov 1974	602	IR Test
187	19 Nov 1974	602	IR Test
188	20 Nov 1974	606	NULLO No. 12
189	20 Nov 1974	601	IR Test
190	21 Nov 1974	601	IR Test
191	22 Nov 1974	605	NULLO No. 13
192	22 Nov 1974	602	IR Test
193	22 Nov 1974	602	IR Test
194	3 Dec 1974	602	AIM/Captive
195	7 Dec 1974	606	NULLO No. 14
196	9 Dec 1974	601	AIM/Captive
197	11 Dec 1974	606	NULLO No. 15
198	12 Dec 1974	603	LAMP Demonstration (R&D)
199	17 Dec 1974	604	NULLO No. 16
200	6 Jan 1975	603	Engineering Evaluation
201	7 Jan 1975	603	Engineering Evaluation
202	8 Jan 1975	603	Engineering Evaluation
203	13 Jan 1975	602	Engineering Evaluation
204	14 Jan 1975	603	AIM/Captive
205	15 Jan 1975	605	NULLO No. 17
206	16 Jan 1975	603	AIM/Captive
207	21 Jan 1975	601	NULLO No. 18
208	23 Jan 1975	603	AIM/Captive/Engineering
209	27 Jan 1975	601	NULLO No. 19
210	28 Jan 1975	601	NULLO No. 20
211	28 Jan 1975	603	AIM/Captive
212	30 Jan 1975	601	NULLO No. 21
212	31 Jan 1975	607	NULLO No. 22
214	31 Jan 1975	601	NULLO No. 23

Notes: (1) PQM-102 record flights complete.
(2) DT&E complete.

QF-102 RECORD FLIGHT NO. 1

Mission: FG
Profile: QF2-I-9
Date: 29 July 1974

Zulu Time at Brake Release: 16:10:47
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

All data points called for in the 48-Hour Plan (Appendix F) were flown within specification tolerances. The strip-chart recorders and PCM digital tape were operational for this mission. There was no unplanned data loss for this flight and the safety pilot never took control of the aircraft. Radar 123 was put in the passive mode during pattern work to eliminate the interference that caused much of the data loss in previous flights. The afterburner did not ignite for the programmed maneuver, but this did not adversely affect maneuver performance.

Two minutes before takeoff the air data indicator on the primary console indicated a pitch angle that varied between −10 and −15 degrees. This indicated pitch down persisted through takeoff and initial climb, and approximately 5 minutes into the flight, the air data indicator rolled, inverted (the aircraft was not inverted), and control was transferred to the secondary console. It was later noticed that the air data indicator would indicate inverted flight whenever the altitude was in the high scale range above 7500 feet. This problem did not affect mission completion and was later traced to a wiring problem in the display console.

A total of 35 destruct commands were easily identified by the downlink data. No problems were noted with the failsafe arm or destruct command channels. The FGS controller had a minor problem in maintaining a desired ground track to the maneuver initiate point, but the point was successfully reached at the desired time. No serious problems were uncovered during this flight, and the minor problems have been identified and corrected.

The digital PCM tape was operational for this flight. Data taken just prior to brake release indicates that the data accuracy is 0.27 percent root mean square (rms) of fullscale value. This figure, if validated in future flights, yields the following accuracies:

Altitude (low scale)	20.3 feet rms
Airspeed	1.76 knots rms
Mach	0.0038 Mach rms
g	0.038g rms
Trigonometry Functions (roll, pitch, heading)	0.006 sin or cos rms
Example: roll 45 degrees, cosine 0.707	0.5 degree rms

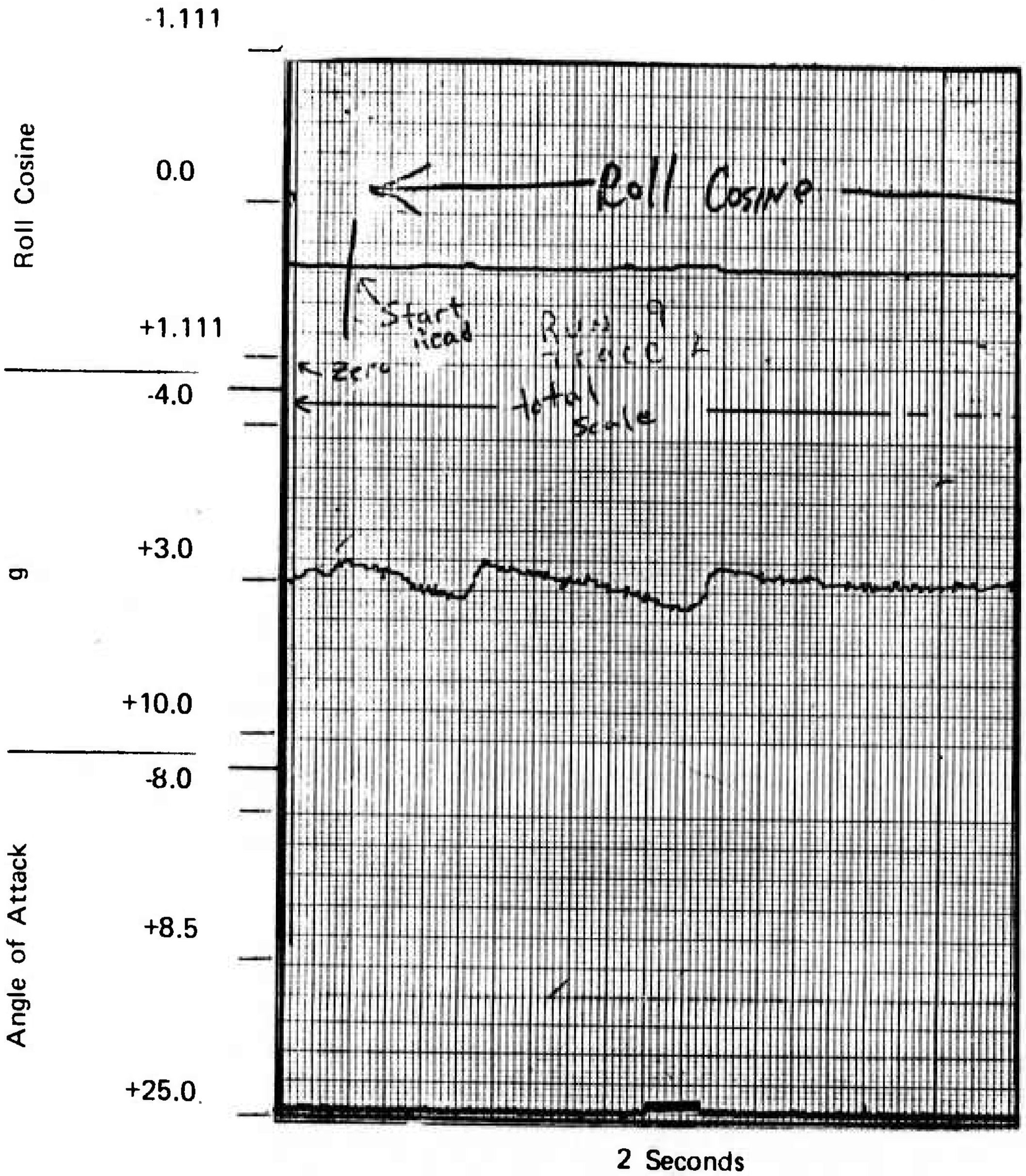


Figure A-1. Presentation Performance During Event 8: Scheduled Bank: 60 degrees; Altitude Hold On; Altitude: 25,000 feet MSL; Entry Airspeed: 0.60T Mach

QF-102 RECORD FLIGHT NO. 2

Mission: FF
Profile: QF1-I-10
Date: 2 August 1974

Zulu Time at Brake Release: 15:00:15
Data Sources: FGS Controller, Analyst Notes, Strip Charts, Van Tape, and PCM Tape

This was an excellent record flight and all events were flown as scheduled. No problems were noted during the flight or during the quick-look strip chart analysis.

An attempt was made to acquire the drone on an optical pass through the 50-mile area. The results were unsatisfactory due to a haze problem. No QF/PQM-102 peculiar problems were evident in acquiring the drone.

Data Loss Intervals:

15:29:28 for 18 seconds (26,000 feet in 60-degree right bank)
15:29:50 for 10 seconds (26,000 feet in 60-degree right bank)
15:30:15 for 12 seco (26,000 feet in 60-degree right bank)
15:31:30 for 3 second following LOC demonstration)
15:44:12 for 2 seconds (3 minutes prior to touchdown)

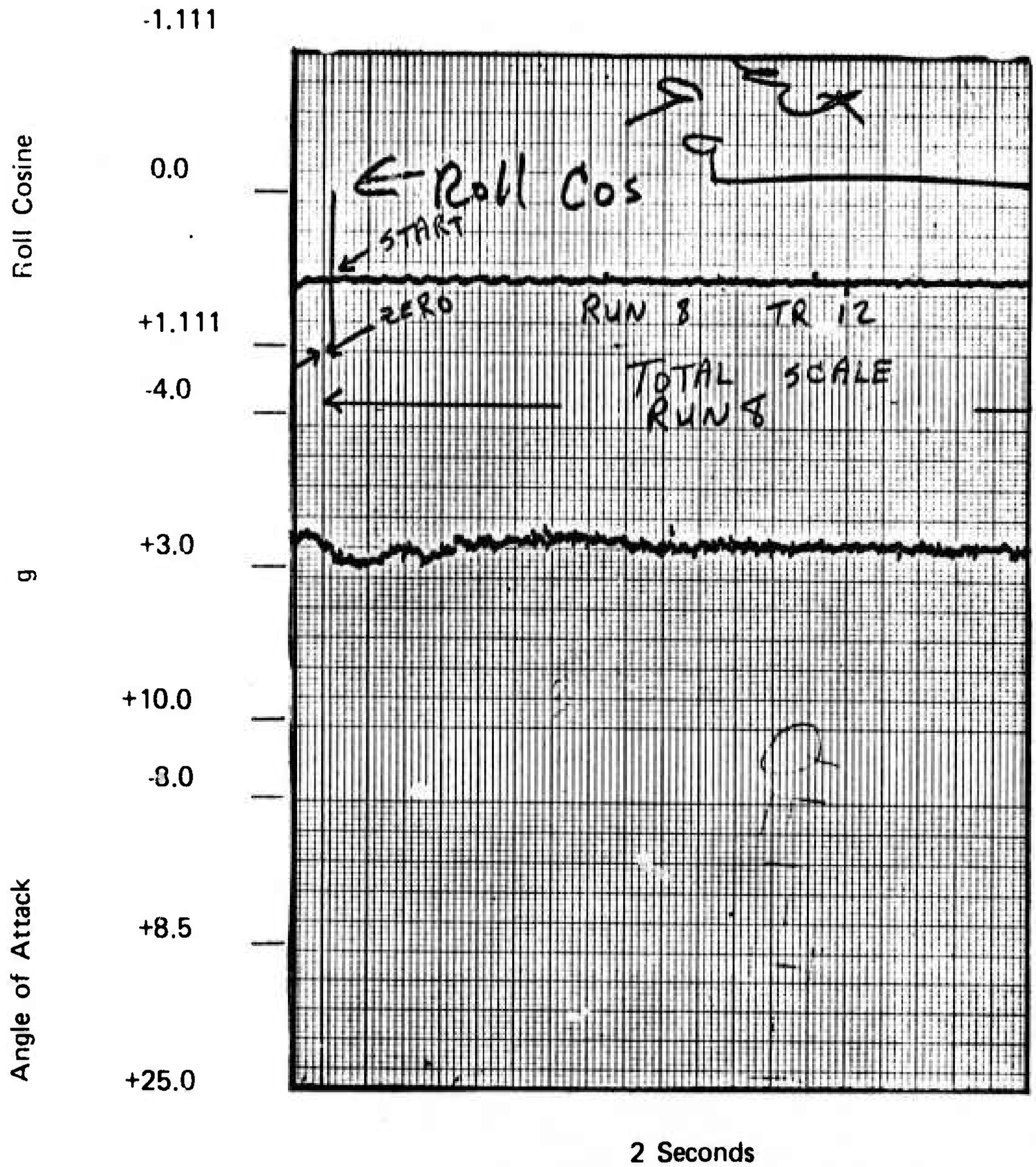


Figure A-2. Presentation Performance During Event 8; Scheduled Bank: 72 degrees, right; Scheduled g: 3g; Altitude: 25,000 feet MSL; Entry Airspeed: 0.87T Mach

QF-102 RECORD FLIGHT NO. 3

Mission: AA
Profile: 2-I-11
Date: 3 August 1974

Zulu Time at Brake Release: 16:31:15
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

Although this record flight was accomplished safely and as scheduled, it must be considered marginal due to aircraft performance during the programmed maneuver. All other data points were within specification tolerances.

After a nearly flawless approach to the maneuver initiate point, the bank angle overshot the scheduled value of 75 degrees by 8 degrees and subsequently oscillated between 75 degrees and 82 degrees. The plot (Figure A-3) illustrates aircraft performance during this time interval. The slow buildup in g can be attributed to the low density at the maneuver initiate altitude of 35,000 feet and the g washout at the end of the maneuver is due to the angle of attack limiter taking effect. It was difficult to determine both the nominal bank angle and the nominal g loading, and it is significant to note that the bank angle is slightly out of tolerances no matter how the nominal is chosen from the plot. A contributing factor to the g-washout was the failure of the afterburner to perform throughout the programmed maneuver, causing the airspeed to decrease from 338 KIAS to 145 KIAS.

During this flight the familiar ±1 degree oscillation in pitch, roll, and heading at a 2 to 5 per second rate was observed. A noticeable altitude fluctuation occurred during event 9a when altitude hold was engaged at 0.95 Mach and 60 degrees of bank. This may be typical of altitude hold performance at high airspeeds, bank, and altitude.

At the end of the flight a simulated FGS display console failure was presented to the ground controllers. This simulated emergency was handled swiftly and expertly by transferring control to the MGS.

Data Loss Intervals:

16:50:00 for 12 seconds (35,000 feet in 50-degree right bank)
16:52:28 for 6 seconds (35,000 feet in 60-degree right bank)
16:57:10 for 2 seconds (35,000 feet level)
16:46:45 for 6 seconds (35,000 feet level)
17:02:00 for 4 seconds (35,000 feet in 60-degree right bank)

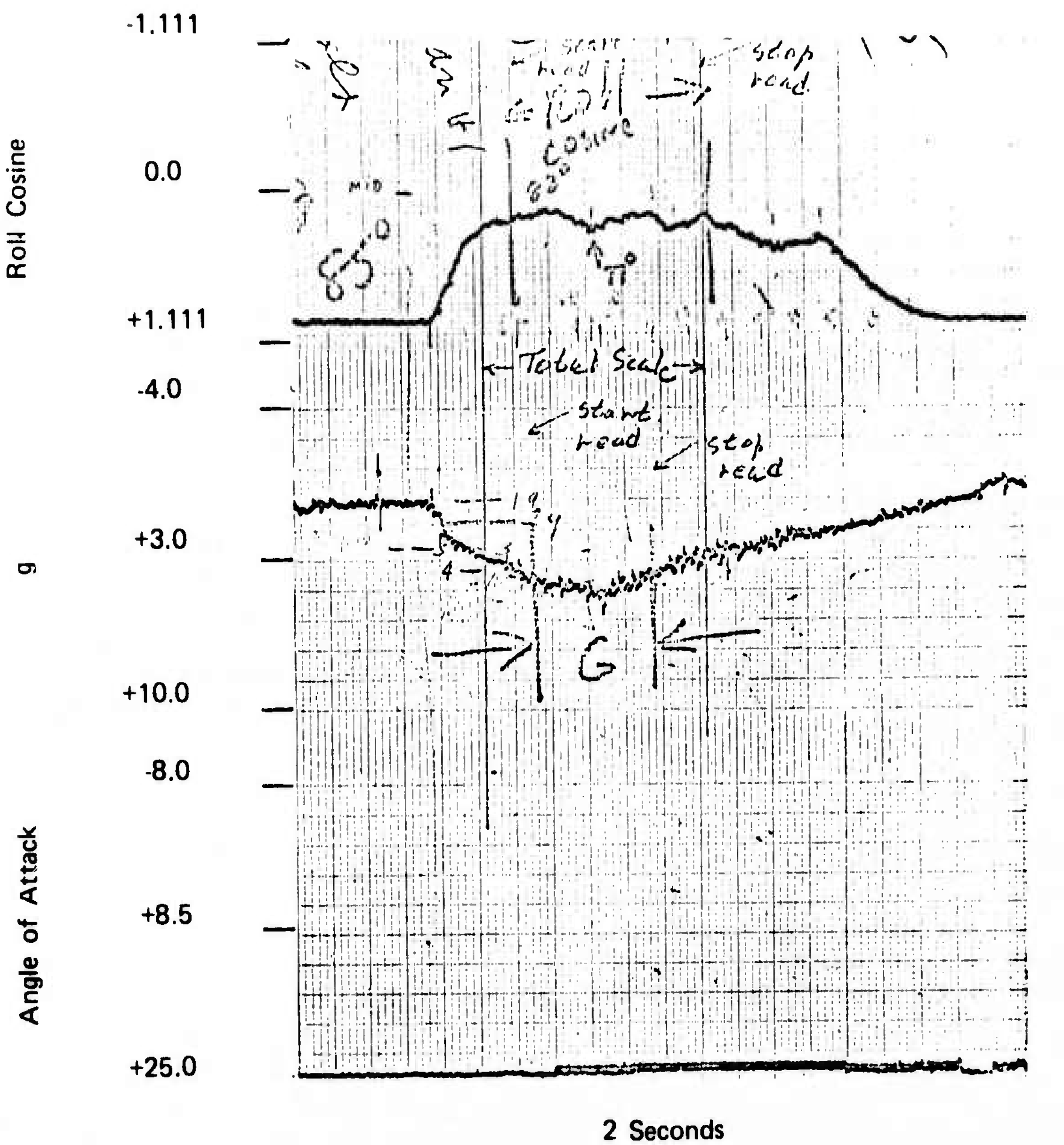


Figure A-3. Presentation Performance During Event 8; Scheduled Bank: 75 degrees, right; Scheduled g: 4.0; Altitude: 35,0000 feet MSL; Entry Airspeed: 0.96T Mach

QF-102 RECORD FLIGHT NO. 4

Mission: AC
Profile: I-IV-7
Date: 5 August 1974

Zulu Time at Brake Release: 17:29:30
Data Sources: FGS Controller, Analyst Notes, Strip Charts, Van Tape, and PCM Tape

This flight was marred by the recovery sequence in the maneuver programmer. All events were flown as scheduled by the 48-Hour Plan (Appendix F) and aircraft control using the backup FCS was successfully demonstrated.

The maneuver program (Event 10) called for an 85-degree right bank at 4g for 15 seconds. The maneuver was initiated at 18:00:40 GMT with the aircraft at 35,000 feet holding 1.08 Mach. Although g buildup time was excessive (6.0 seconds), the maneuver appeared successful for 14 seconds. Immediately following the maneuver, the g loading increased to 6.0 at 18:00:57 as bank decreased through 60 degrees. At this time the FGS controller commanded wings level but the pitch continued to increase to +29 at 18:01:14 GMT. This occurred despite a positive nose-down command from the FGS controller. Finally, at 18:01:20 GMT, the controller rolled the aircraft inverted to affect recovery. Airspeed on the display console indicated well below 100 KIAS at this time although the safety pilot reported that it did not drop below 120 KIAS in the aircraft.

Post flight analysis indicates that the excessive elevator deflection required during this maneuver retracted the lockout pistons in the left HEP valve, and this caused subsequent electrical commands to the control surface to be ignored. When the electrical command to rollout was obeyed by the right HEP value only, a resulting pitch moment was generated causing the 6g pullout. Moreover, since the electrical pitch trim can only operate at 1 degree per second, the FGS controller could not quickly unload the excessive g that were encountered.

It can be concluded that any prolonged high altitude, high g maneuver may cause a repeat of the events described in this report. Chances for a successful presentation and recovery can be maximized by entering the maneuver at a high airspeed with afterburner on and by shortening the presentation time to less than 15 seconds. The adverse effects of retracting the lockout piston in the HEP valve can also be minimized by selecting the backup FCS during recovery. The backup control system actuates the HEP valve mechanically, and the original purpose of retracting the lockout piston was to transfer control to mecnanical inputs. Hence, the FGS controller should have positive control available for recovery if the backup system is selected.

Data Loss Interval:

17:37:35 for 4 seconds
17:37:51 for 3 seconds (intermittent)
17:46:56 for 4 seconds (afterburner climb through 30,000 feet)
17:59:56 for 12 seconds (1.08 Mach descent to 35,000 feet)
18:14:38 for 5 seconds (touch-and-go landing)

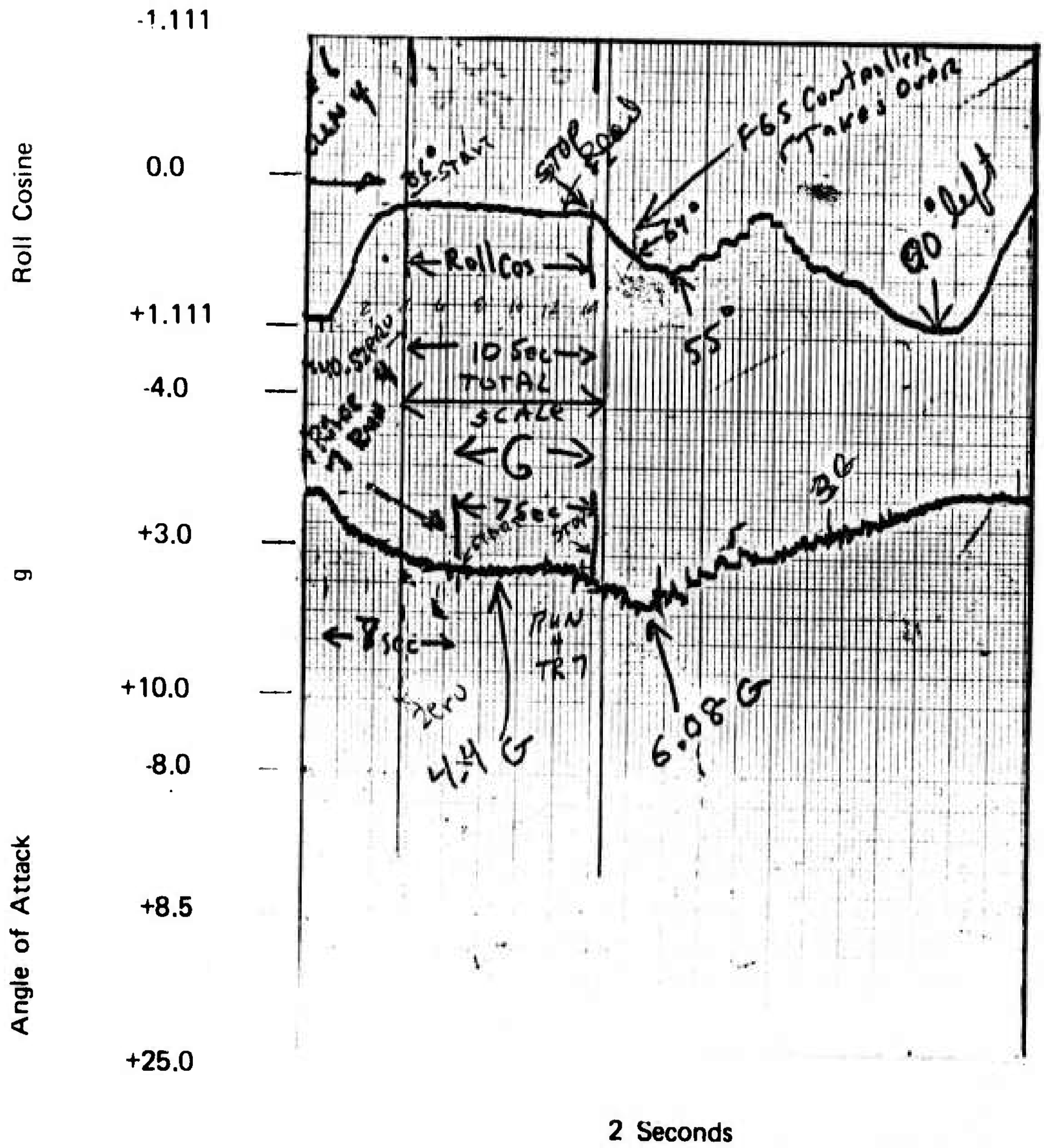


Figure A-4. Presentation Performance During Event 10; Scheduled Bank: 85 degrees, right; Scheduled g: 4g; Altitude: 35,000 feet MSL; Entry Airspeed: 1.13T Mach

QF-102 RECORD FLIGHT NO. 5

Mission: FG
Profile: QF1-IV-8
Date: 6 August 1974

Zulu Time at Brake Release: 20:40:58
Data Sources: FGS Controller, Analyst Notes, Strip Charts, Van Tape, and PCM Tape

This was a successful record flight with all events flown as scheduled. Two problems of a minor nature occurred, but both may be attributed to operator technique. The first involved a data loss of 114 seconds just prior to the programmed maneuver. The forward telemetry antenna system was selected throughout the data loss interval, and when the aft telemetry was finally selected, the data loss disappeared completely. The second problem area concerned the excessive pitch oscillations encountered during the recovery sequence from the programmed maneuver. Approximately 30 seconds after the scheduled completion time of the programmed maneuver, the pitch attitude reached 32 degrees and the FGS controller took control for recovery. This condition was caused by the altitude hold function being set in the transonic airspeed regime during the recovery sequence. Careful attention to airspeed during presentation recovery should avoid a recurrence of this nature.

Data Loss Intervals:

20:41:02 for 18 seconds (intermittent at takeoff)
20:46:30 for 4 seconds (intermittent during climb)
21:09:10 for 114 seconds (approachnig maneuver initiate point)
21:12:56 for 10 seconds (intermittent at end of program maneuver)
21:27:12 for 6 seconds (pattern work)
21:27:50 for 3 seconds (pattern work)
21:30:40 for 40 seconds (pattern work)

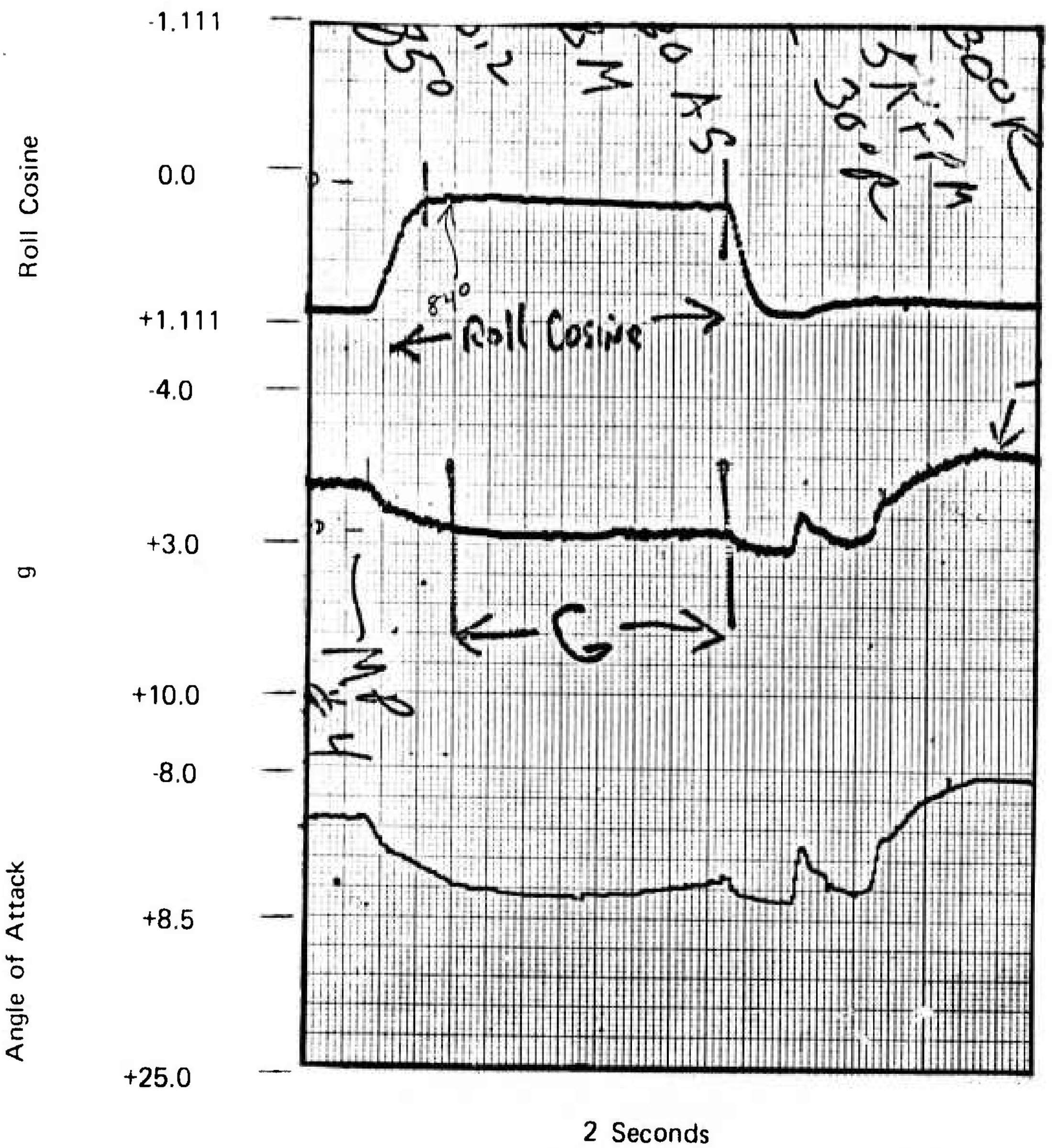


Figure A-5. Presentation Performance During Event 10; Scheduled Bank: 85 degrees, right; Scheduled g: 3g; Altitude: 40,000 feet MSL; Entry Airspeed: 0.94T Mach

QF-102 RECORD FLIGHT NO. 6

Mission: AB
Profile: QF2-II-9
Date: 9 August 1974

Zulu time at Brake Release: 16:02:00
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

Except for certain portions of the programmed maneuver entry sequence, this was a well-executed record flight with negligible data loss. The ground track at maneuver initiation was 4 degrees off reference and maneuver entry airspeed was 60 KIAS low. During the maneuver presentation the bank was very steady at 56 degrees left, indicating a bias error in the dial setting since 60 degrees left bank was scheduled. All other autopilot data points were well within SOW tolerances as shown in Table A-2. It should also be noted that the indicated altitude on the low scale was incorrect when the FGS was in control. This problem seems to recur only on aircraft FAD 602.

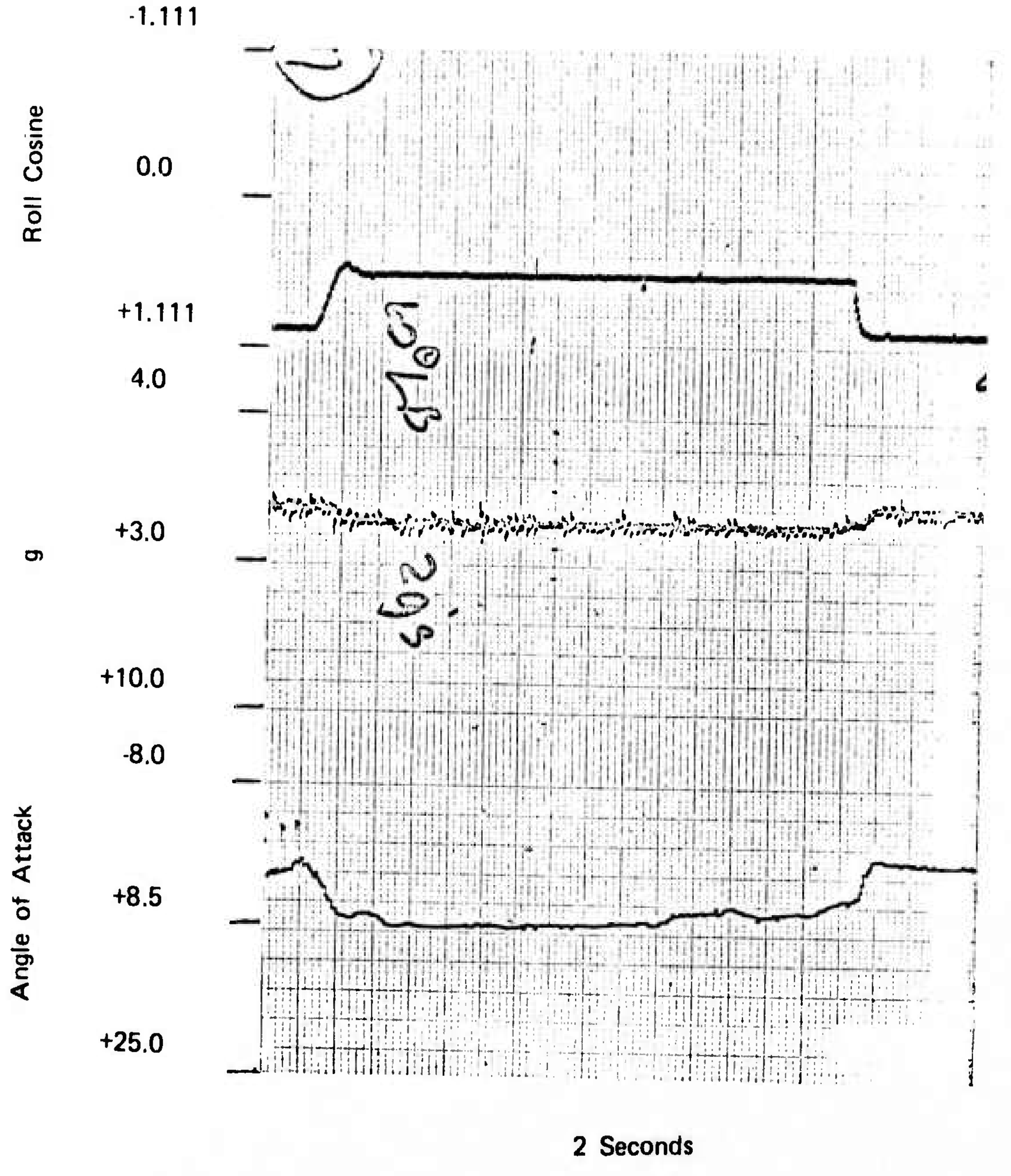


Figure A-6. Presentation Performance During Event 7; Scheduled Bank: 60 degrees, left; Altitude Hold On; Altitude: 10,000 feet MSL; Entry Airspeed: 0.49T Mach

QF-102 RECORD FLIGHT NO. 7

Mission: FF
Profile: QF2-II-10
Date: 10 August 1974

Zulu Time at Brake Release: 15:59:45
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

This was an overall successful record flight with only a few minor difficulties. The programmed maneuver called for 78 degrees left bank with 5.5g and appeared to go well, but digital data subsequently showed the initial bank angle slightly out of tolerance. In addition, the position error at the entry point was 1.2 nmi.

Data Loss Intervals:

16:00:58 for 3 seconds (LOC simulation)
16:01:25 for 4 seconds (LOC simulation)
16:01:40 for 4 seconds (LOC simulation)
16:26:08 for 3 seconds (pattern work with MGS in control)

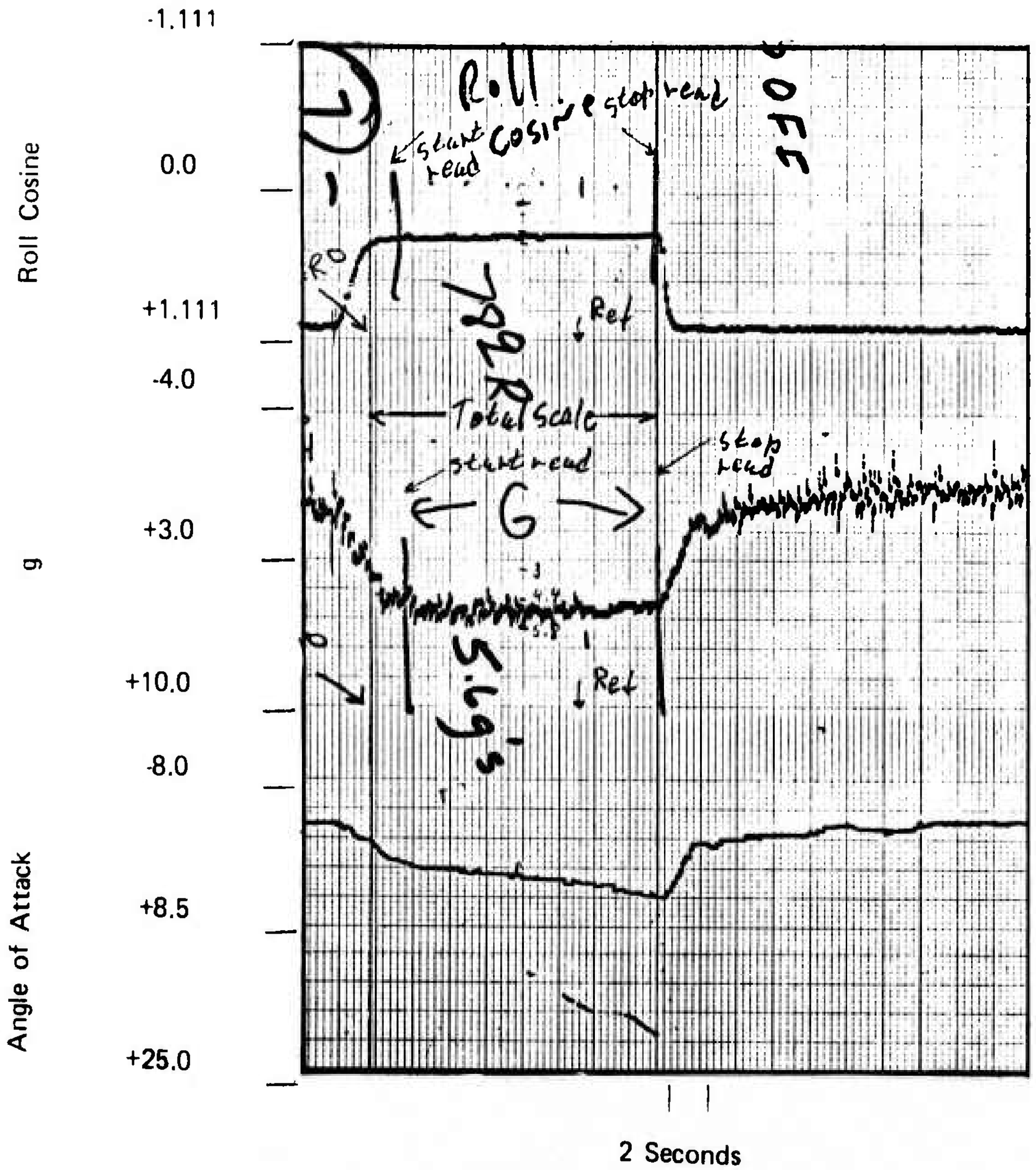


Figure A-7. Presentation Performance During Event 7; Scheduled Bank: −78 degrees; Scheduled g: 5.5g; Altitude: 10,000 feet MSL; Entry Airspeed: 0.88T Mach

PQM-102 RECORD FLIGHT NO. 1, NULLO NO. 1

Mission: AA
Profile: PQM 5-I-1
Date: 13 August 1974

Zulu Time at Brake Release: 13:29:15
Data Sources: FGS Controller, Analyst Notes, and Strip Charts

This flight was significant in that a manned aircraft was converted to a drone and flown following a ground checkout only. Unfortunately, problems with the primary flight control system prevented a maneuver program presentation and the mission must be considered unsuccessful.

After a successful takeoff, the drone would not respond to a wings level command. Roll command authority was erratic throughout the MGS/FGS handover sequence, and within 3 minutes of takeoff it was obvious that a serious control problem existed. Following a reference airspeed increase in the airspeed on throttle mode, the bank increased to 45 degrees right despite left turn commands from the FGS. At 13:34:28 GMT the backup flight control system was selected and the drone began responding properly to all command inputs. After depleting the fuel supply to yield an acceptable landing weight, the ground controllers flew the drone to an uneventful landing at 14:00:15 GMT. Long intervals of data loss during two handoff sequences caused further apprehensions during the flight, but this problem did not occur at any other time.

Special note should be taken of the fact that preflight and post-flight checks using the PMTS did not reveal any discrepancies in the flight control system. The problem could only be duplicated when the artificial feel forces were increased to simulate airspeeds above 200 KIAS. At these airspeeds a pitch down command from the autopilot would not deflect the elevon enough to actuate the automatic pitch trim mechanism. In turn, this caused excessive stick forces to be applied to the HEP valve lockout pistons from the artificial feel system. When this force reached 40 pounds, the lockout pistons retracted and transferred control to mechanical control stick inputs. Since the primary control system produces electrical commands only, full control of the drone was achieved only when the backup system (which produces mechanical inputs) was selected by the controllers. The problem was eventually traced to a maladjusted auto-trim switch that did not activate and allow the trim system to relieve the stick forces from nose-down commands.

The excessive data loss during handover could not be duplicated, but it is very likely that the loss occurred from data being transmitted over the forward telemetry and aft telemetry antenna systems simultaneously. Normally a relay specifically selects the antenna system under primary control to transmit data, but under backup flight control, it is possible that the aft telemetry system selected by the MGS controller and the forward telemetry system selected by the fixed station controller were both transmitting data, thus overloading the system. When both stations selected the forward telemetry system, the data loss completely disappeared and the problem did not reappear. The system has subsequently been modified so that the PRF generator in the forward telemetry system would not transmit data unless specifically selected by the primary controller. The problem has not recurred with this modification.

The results of this flight indicate that the PMTS sequence should be modified to check control authority limits given different sets of artificial feel forces which simulate airspeed changes in flight. This would check flight control authority in a more realistic flight environment. Continuing problems associated with the HEP valve lockout pistons can be expected when a high g loading (above 5g) is scheduled as a maneuver presentation. Chances for a successful presentation are increased by lowering the presentation altitude, increasing the entry airspeed, and shortening the high g loading time interval. These procedures were previously listed in the report on QF Record Flight No. 4, 5 August 1974.

Data Loss Intervals:

13:37:01 for 10 seconds (under FGS control)
13:54:50 for 18 seconds (MGS to FGS hand-off)
13:56:28 for 24 seconds (FGS to MGS hand-off)

QF-102 RECORD FLIGHT NO. 8

Mission: FF
Profile: QF2-III-9
Date: 14 August 1974

Zulu Time at Brake Release: 17:30:25
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

This record flight was marginal due to aircraft roll performance during the two-phase programmed maneuver. During the first presentation the afterburner blew out and the FGS controller discontinued the maneuver due to low airspeed. The entry parameters were evaluated for this initial presentation and the performance parameters were evaluated for a subsequent presentation. The bank was very stable during the two-phase maneuver, but was apparently biased 6 degrees to the right in both cases. The g-loading was also stable until the angle-of-attack limiter caused a slight g washout at the termination of phase two. A planned inverted recovery was observed following the maneuver due to a high pitch angle of 25 degrees.

Data Loss Intervals:

17:41:38 for 4 seconds (35,000 feet at 0.9 Mach)
17:52:49 for 2 seconds (first presentation attempt)
17:55:20 for 10 seconds (recovery from second presentation)
18:10:00 for 5 seconds (MGS in control)

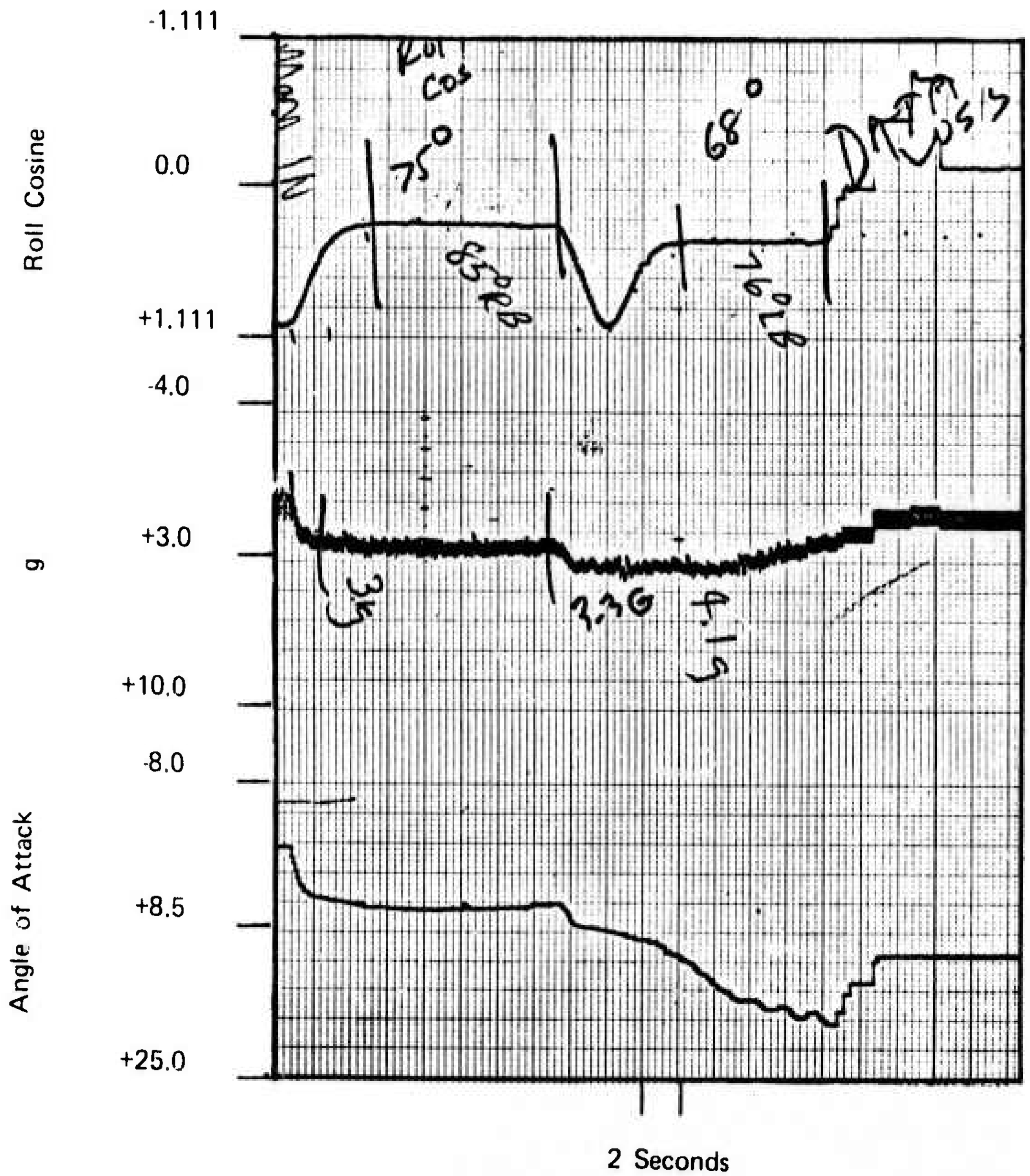


Figure A-8. Presentation Performance During Event 8; Scheduled Bank: +72 and −76 degrees; Scheduled g: +3g and +4g; Altitude: 35,000 feet MSL; Entry Airspeed: 0.85T Mach

QF-102 RECORD FLIGHT NO. 9

Mission: CB
Profile: QF2-III-10
Date: 15 August 1974

Zulu Time at Brake Release: 14:00:30
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

The two-phase programmed maneuver did not perform within specifications during this flight. Phase I of the maneuver was entered at 0.87 Mach near 45,000 feet. The initial bank surpassed the scheduled bank of 85 degrees by 7 degrees and decreased slowly throughout the maneuver. The effects of angle-of-attack limiting were apparent approximately 8 seconds after maneuver initiation and caused a g oscillation during the final part of Phase I and could not be reached within SOW tolerances. The scheduled 4.0g of Phase II could not be reached within SOW tolerances. Most of these discrepancies are caused by the high angle-of-attack resulting from a subsonic maneuver entry airspeed combined with a high entry altitude. It also appears probable that a bias existed in the preset bank angles of the maneuver programmer since a right 8-degree offset existed in both phases of the presentation.

Data Loss Intervals:

14:15:53 for 4 seconds (cruise at 45,000 feet)
14:23:07 for 8 seconds (Phase II of maneuver)
14:36:22 for 14 seconds (mobile control in pattern)

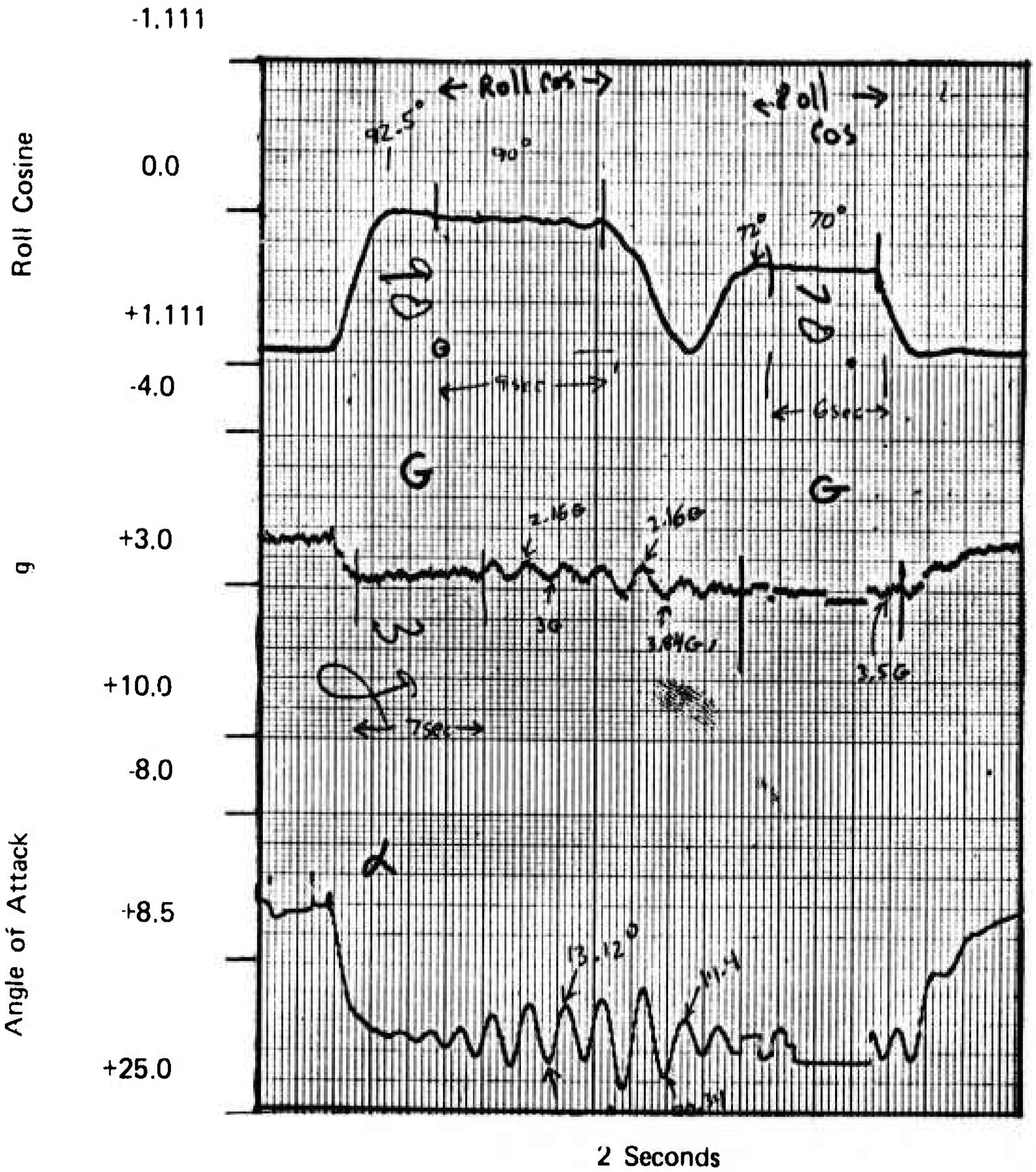


Figure A-9. Presentation Performance During Event 8: Scheduled Bank: +85 and −80 degrees; Scheduled g: +3g and +4g; Altitude: 45,000 feet MSL; Entry Airspeed: 0.88T Mach

PQM-102 RECORD FLIGHT No. 1 (RE-FLY)
NULLO NO. 2

Mission: FF
Profile: PQM5-I-1
Date: 22 August 1974

Zulu Time at Brake Release: 14:30:37
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

This unmanned flight accomplished the original objectives of the PQM-102 NULLO No. 1 flight which was air aborted on 13 August 1974. All events were flown as scheduled and were within established tolerances.

Takeoff was late due to a brake relay failure and a popped chute during the countdown.

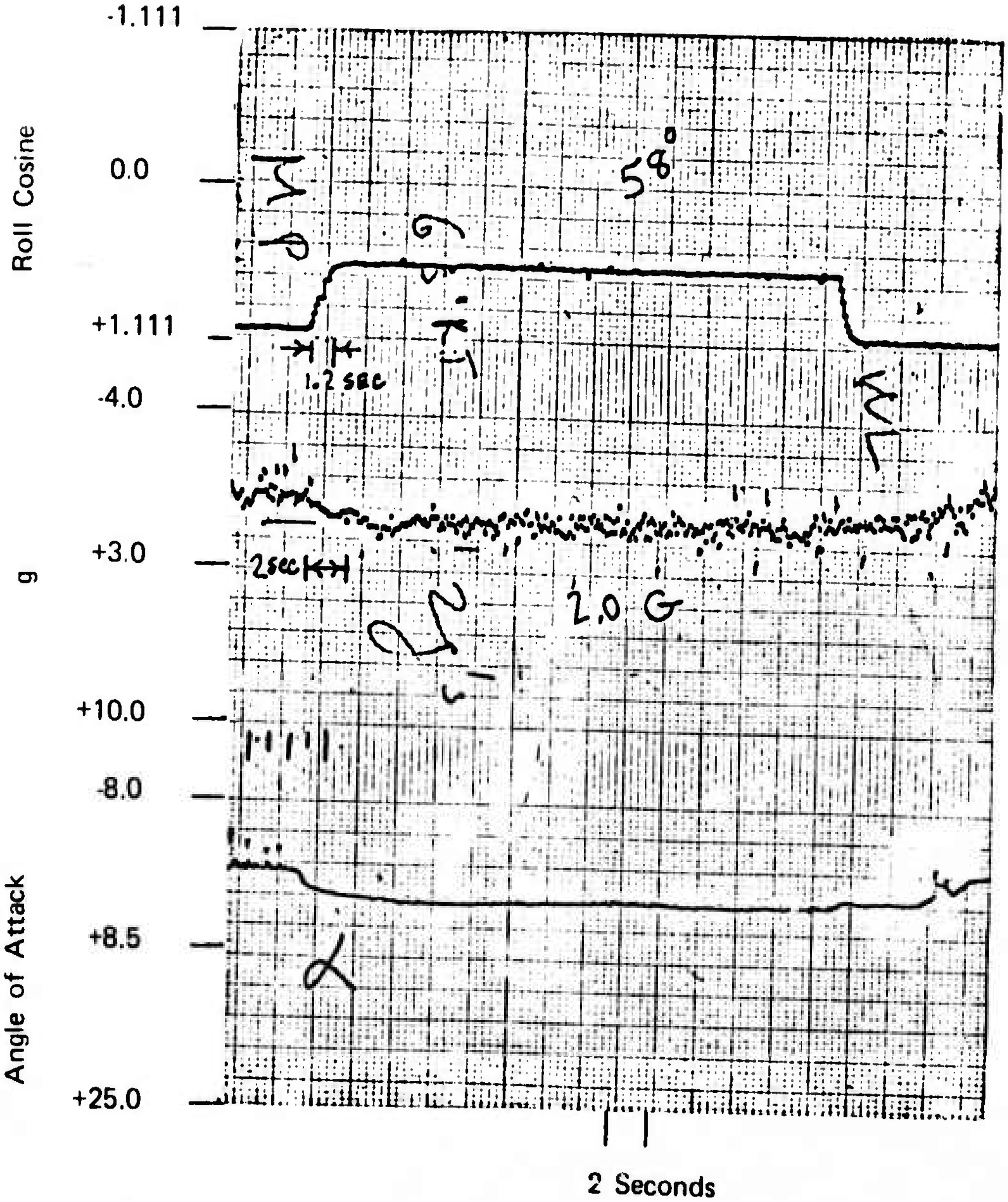


Figure A-10. Presentation Performance During Event 6; Scheduled Bank: 60 degrees; Scheduled g: 2g; Altitude: 25,000 Feet MSL; Entry Airspeed: 0.86T Mach

PQM-102 RECORD FLIGHT NO. 2, NULLO No. 3

Mission: AA
Profile: PQM5-IV-2
Date: 27 August 1974

Zulu Time at Brake Release: 13:13:11
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

This unmanned flight successfully accomplished its objectives despite the prevailing poor weather conditions. The heading indicator froze at 245 degrees after initial handoff to the FGS, and the plotting board was subsequently used to confirm ground track. It is significant to note that if a LOC occurred while the heading indicator was frozen at 245 degrees, the aircraft would have climbed in a constant right 30-degree turn until automatic destruct. Only one maneuver presentation was made because the chase pilot lost visual contact with the drone following the first presentation due to weather conditions. Data loss was negligible for this flight.

Recovery was uneventful except for the barrier engagement when the drone swerved off the runway. The drone was not damaged and the reason for the mishap is undetermined.

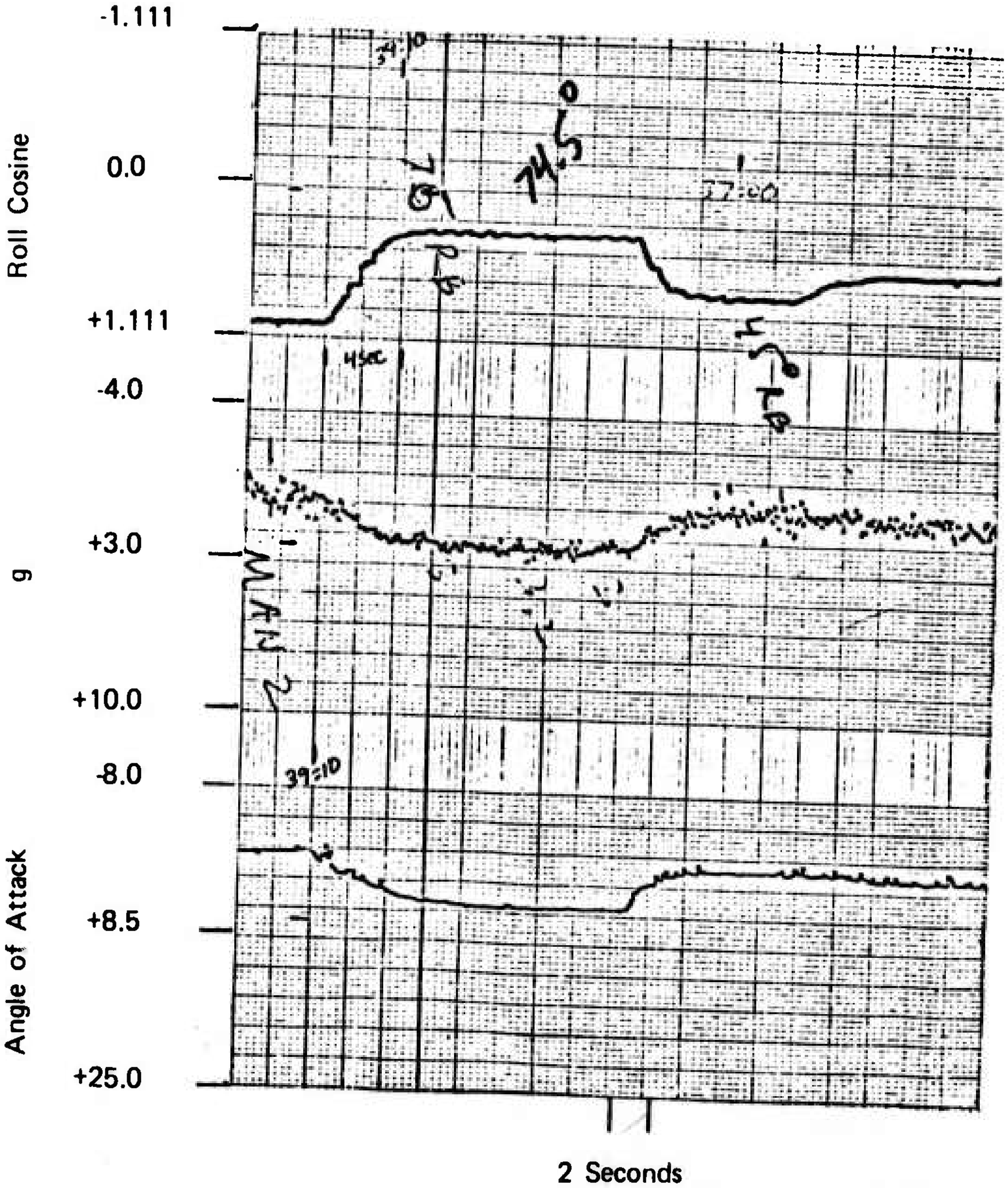


Figure A-11. Presentation Performance During Event 8: Scheduled Bank: 75 degrees; Scheduled g: 3g; Altitude: 30,000 feet MSL; Entry Airspeed: 0.92T Mach

QF-102 RECORD FLIGHT NO. 10

Mission: FH
Profile: QF2-NP-4
Date: 3 September 1974

Zulu Time at Brake Release: 21:12:52
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

The dual purpose of this flight was to demonstrate programmed maneuvers above 4.0g and to test the low altitude command and control ability of the QF-102. Phase II of the high g programmed maneuvers was used to reduce the g-loading on the aircraft while maintaining the original bank angle. This procedure allows time for the trim actuator to follow-up to the new neutral position, and avoids a combined pitch and roll command that might cause the lockout pistons in the HEP value to retract.

Phase I of both presentations went well, but Phase II only lasted a few seconds before the recovery sequence (automatic takeoff) was commanded. Tests with a noise generator after the flight verified that random signals could cause the program timer to reset before the scheduled completion time. The problem is still under investigation.

The low altitude portion of the flight was accomplished near Northrup Strip at an airspeed of 400 KIAS. Contour lines indicate that the ground level in this area is approximately 4000 feet MSL. Since this is very close to the field elevation at Holloman Air Force Base, the difference between the radar altitudes on the runway and the radar altitude during the low-level flight was used to determine height above ground level. With this procedure, the QF-102 indicated controlled flight with no data loss at an altitude of 348 feet above ground level.

During this mission the smoke system did not operate. No explanation is available.

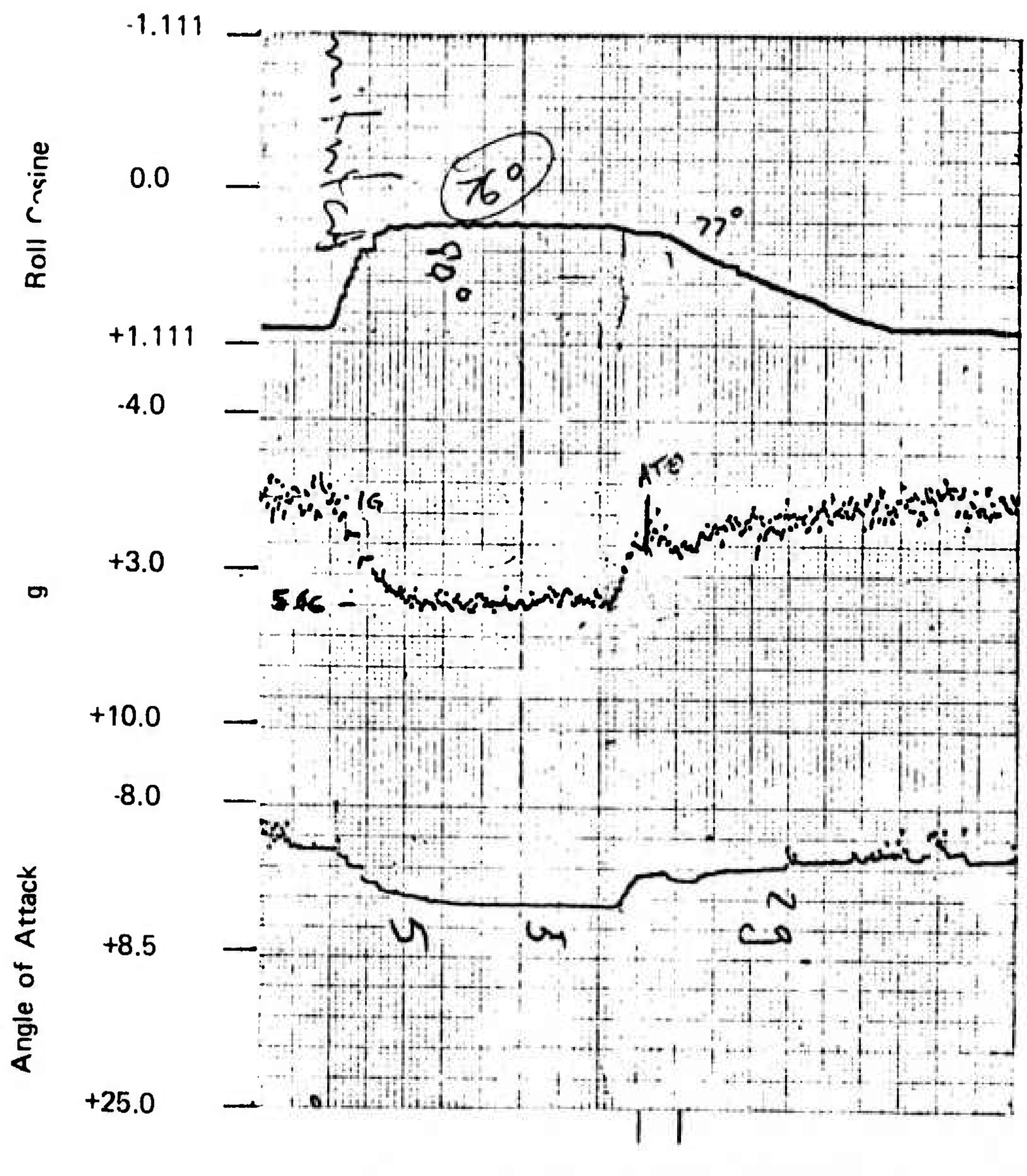


Figure A-12. Presentation Performance During Event 6: Scheduled Bank: 78 degrees, right; Scheduled g: 5g; Altitude: 15,000 feet MSL; Entry Airspeed: 0.94T Mach

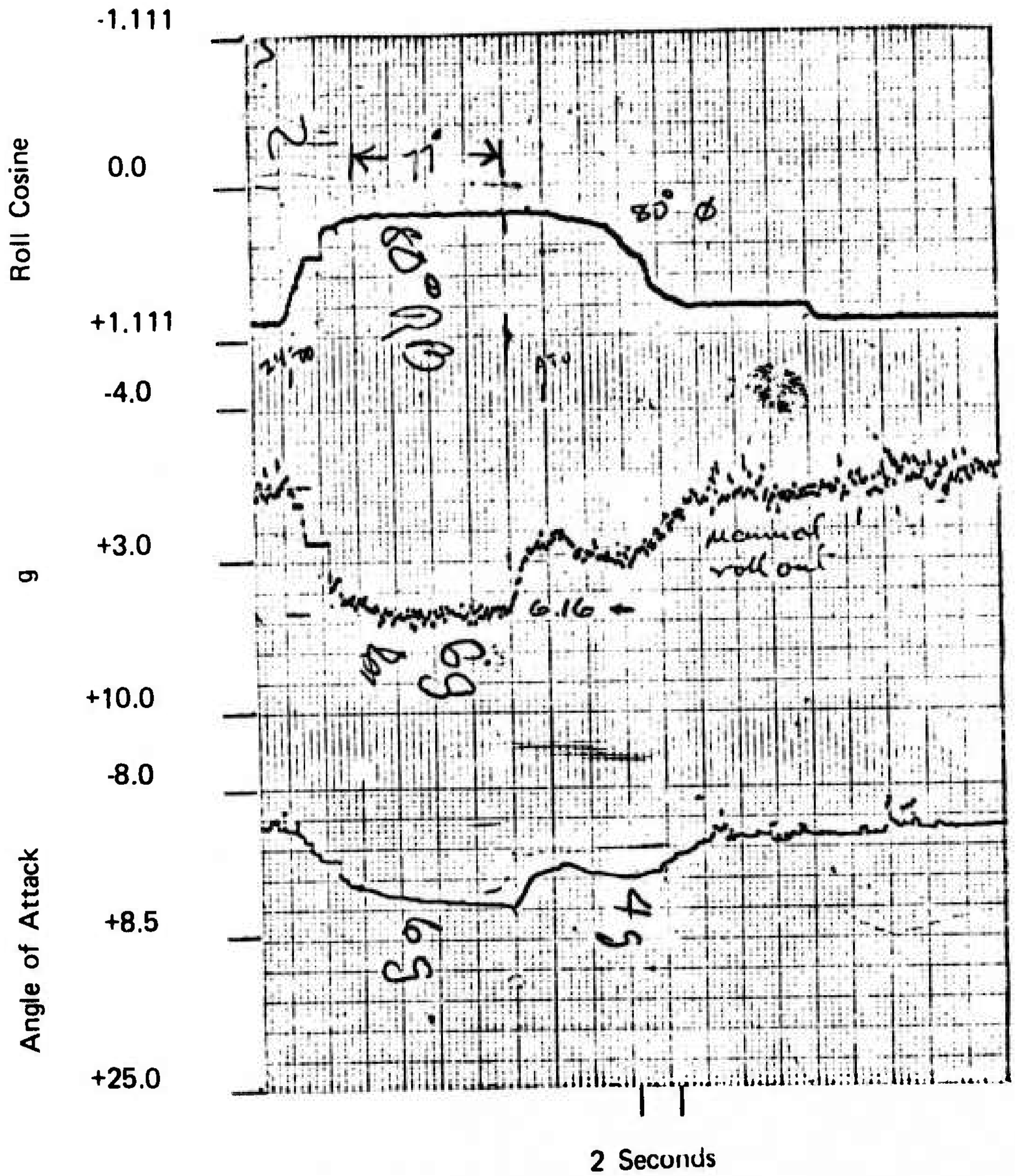


Figure A-13. Presentation Performance During Event 7: Scheduled Bank: 80 degrees, right; Scheduled g: 6g; Altitude: 15,000 feet MSL; Entry Airspeed: 0.94T Mach

PQM-102 RECORD FLIGHT NO. 3, NULLO NO. 4

Mission: AA
Profile: PQM-II-2
Date: 4 September 1974

Zulu Time at Brake Release: 13:46:40
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

The purpose of this unmanned flight was to demonstrate DIGIDOPS, low altitude flight capability, and high-g programmed maneuvers. The scoring system was tested by actual HVAR firings at 13:52:18 GMT. The second HVAR did not leave the rail due to a missile malfunction.

Radar altitude data showed the drone at 392 feet above ground level during the low altitude testing. This figure was obtained by differencing the radar altitude on the runway with the radar altitude during the low-level flight. Contour lines indicate that this procedure introduces negligible error to the altitude figures.

The first programmed maneuver went into recovery (automatic takeoff) 6 seconds after initiation, and the second programmed maneuver went into recovery entering Phase II of the presentation. The bank and g-loading during the maneuvers were within tolerances. This problem occurred during the 3 September 1974 manned flight and is still under investigation. The most probable explanation at present is that random electrical signals are resetting the maneuver timer and causing an inadvertent entry to the recovery sequence.

Data Loss Intervals:

14:01:28 for 2 seconds (first program maneuver)
14:07:30 for 2 seconds (second program maneuver)

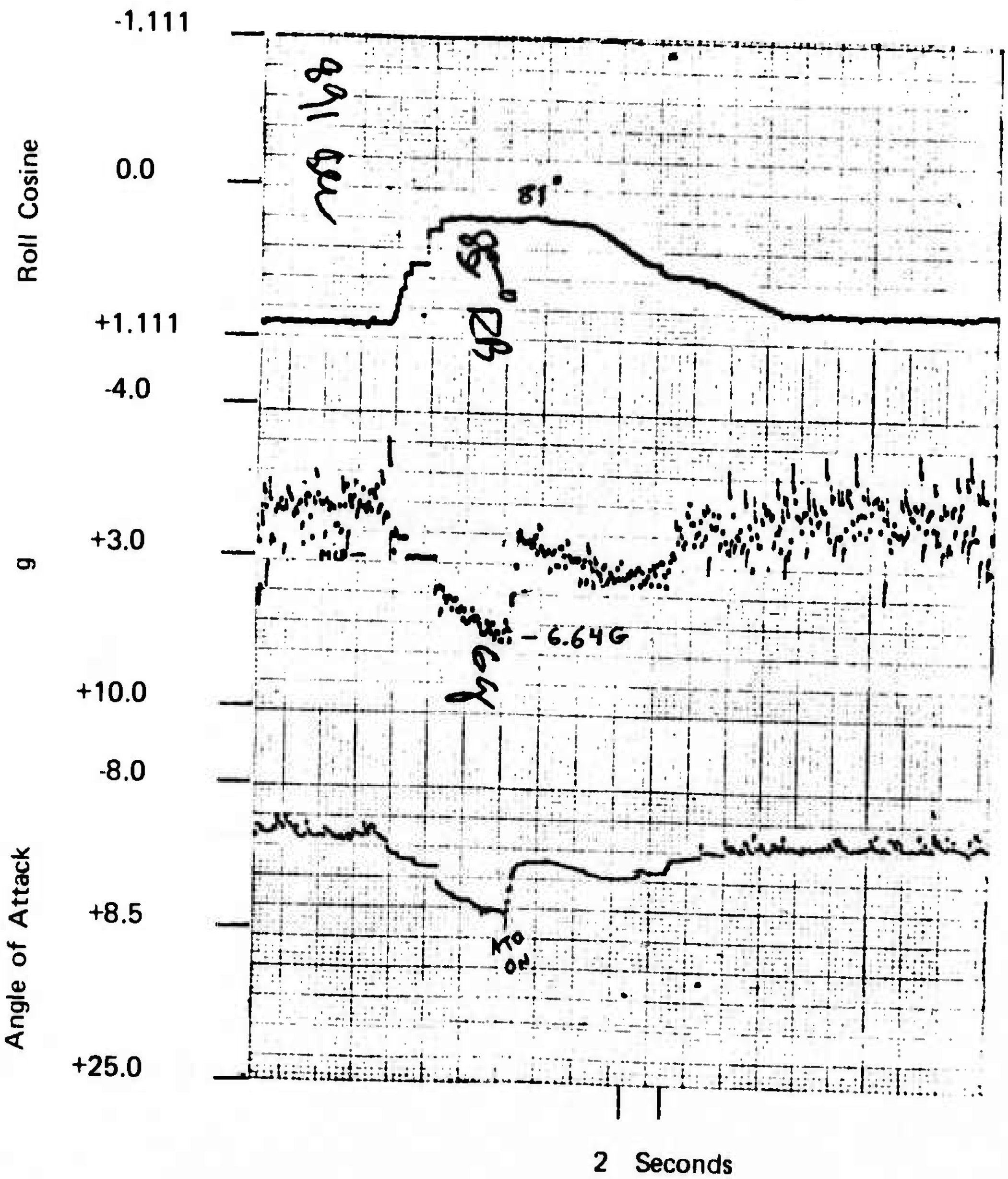


Figure A-14. Presentation Performance During Event 6: Scheduled Bank: 80 degrees, right; Scheduled g: 6g; Altitude: 15,000 feet MSL; Entry Airspeed: 0.92T Mach

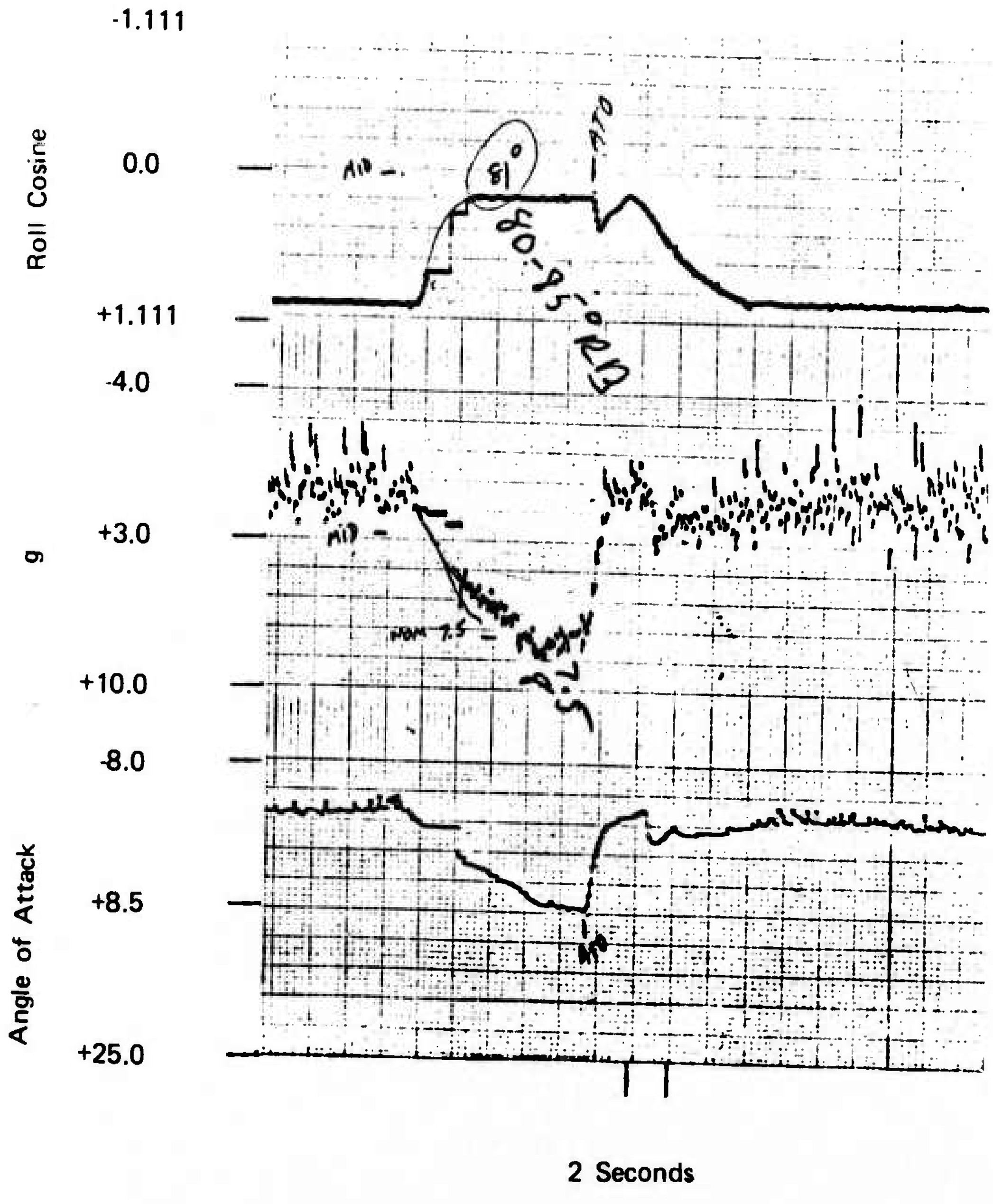


Figure A-15. Presentation Performance During Event 7: Scheduled Bank: 82 degrees, right; Scheduled g: 7g; Altitude: 15,000 feet MSL; Entry Airspeed: 0.92T Mach

QF-102 RECORD FLIGHT NO. 11

Mission: FF
Profile: QF2-NP-5
Date: 5 September 1974

Zulu Time at Brake Release: 21:00:48
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

The goal for this test flight was to prepare for the maximum altitude flight on a subsequent NULLO mission and to demonstrate maximum obtainabile Mach number.

The maximum altitude indicated by PCM tape data was 52,053 feet. The chase aircraft indicated less than 50,000 feet pressure altitude at this time, and the OAT at this altitude was –69.7 degrees Centigrade. Maximum density altitude of the QF-102 was computed to be 51,000 feet.

The maximum Mach number obtained this flight was 1.3 Mach as indicated by PCM data at 21:23:24 GMT. The aircraft was descending at –3350 feet per minute (fpm) through 25,000 feet at the time of maximum speed. The SOW goal for maximum speed is 1.35 Mach; this could not be reached.

A 5.0g maneuver program presentation was accomplished following the maximum speed demonstration. Aircraft performance during the presentation and recovery was satisfactory.

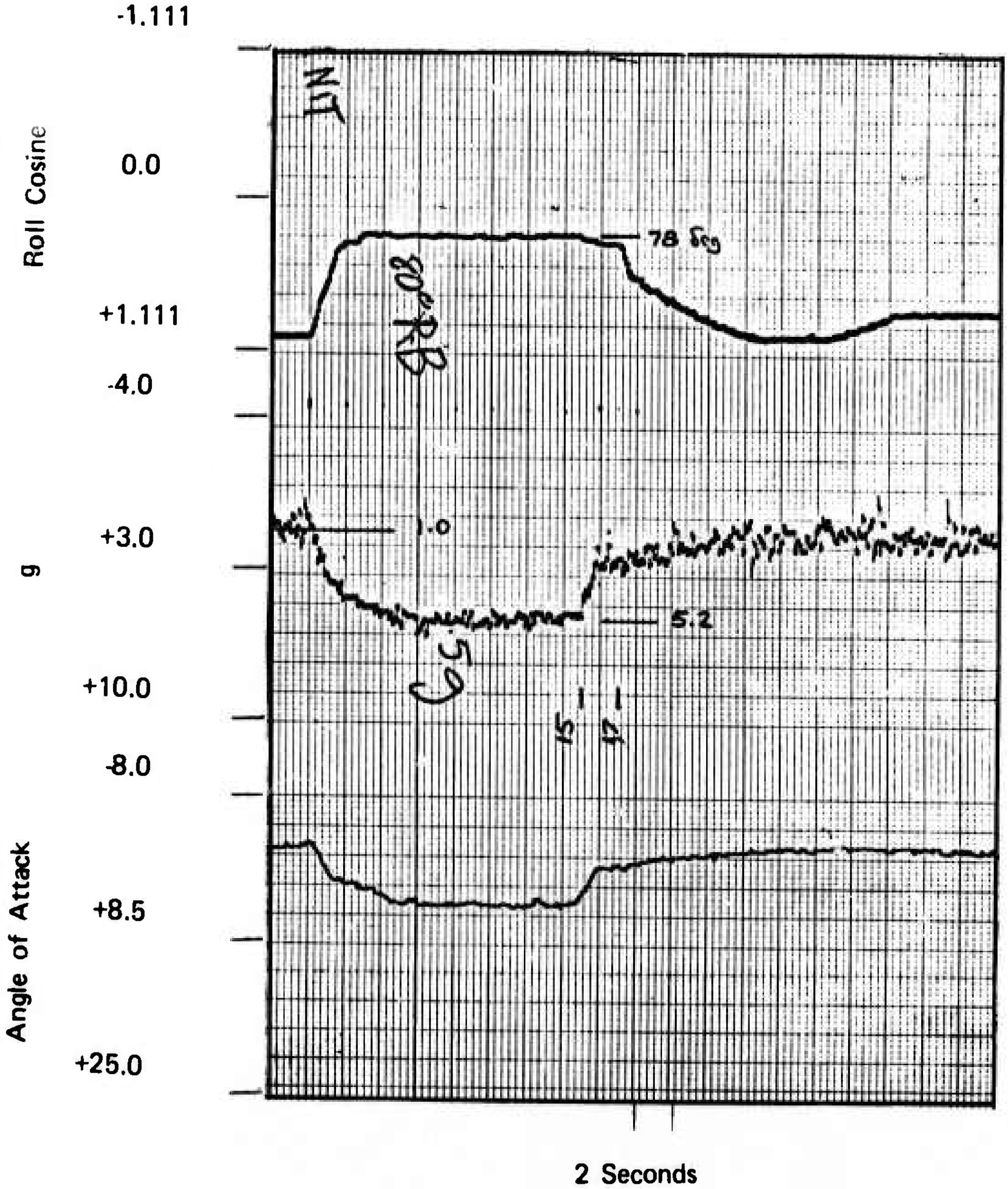


Figure A-16. Presentation Performance During Event 6: Scheduled Bank: 78 degrees; Scheduled g: 5g; Altitude: 20,000 feet MSL; Entry Airspeed: 0.94T Mach

QF-102 RECORD FLIGHT NO. 12

Mission: AA
Profile: QF2-V-5
Date: 6 September 1974

Zulu Time at Brake Release: 23:01:34
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

During this flight the aircraft failed to present a programmed maneuver within SOW tolerances. The actual bank angle was consistently 6 degrees higher than scheduled bank for the maneuver. This bank offset was noticed four separate times during the flight and had been observed during previous flights of aircraft FAD 602 on 14 and 15 August 1974. The evaluation of maneuvers demonstrating 75 degrees of bank with altitude hold on could not be accomplished due to the high resulting bank angle. At 80 degrees of bank the altitude hold was automatically set off and the maneuver was subsequently discontinued. This demonstration will be rescheduled at a later date.

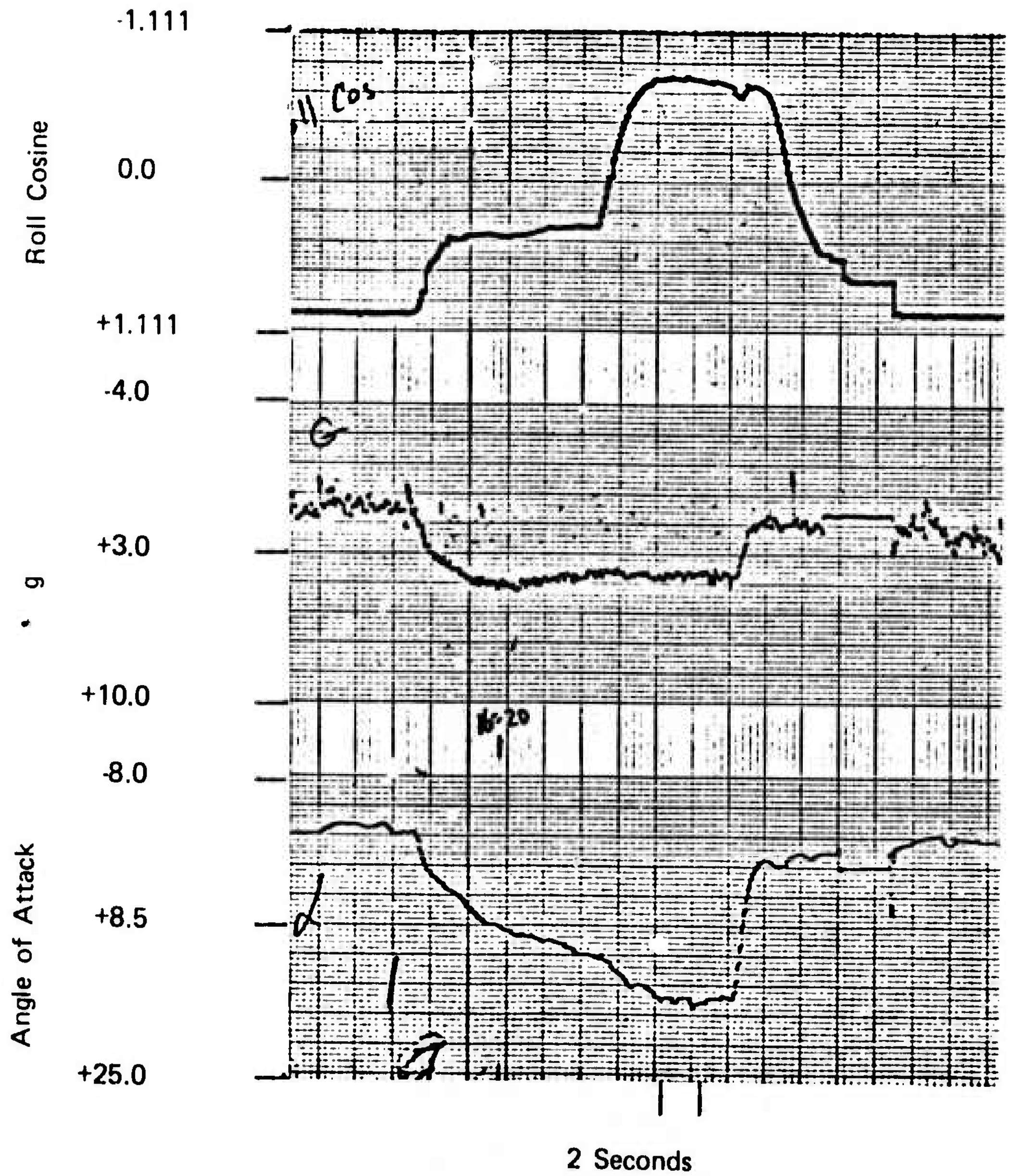


Figure A-17. Presentation Performance During Event 6: Scheduled Bank: 60 and 135 degrees; Scheduled g: 4g; Altitude: 29,400 feet MSL; Entry Airspeed: 0.94T Mach

PQM-102 RECORD FLIGHT NO. 4, NULLO NO. 5

Mission: AA
Profile: PQM4-IV-4
Date: 10 September 1974

Zulu Time at Brake Release: 14:07:16
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

The purpose of this flight was to demonstrate the maximum altitude attainable on a NULLO mission. The maximum altitude indicated by PCM tape data was 56,305 feet MSL and the accuracy of this data is 264 feet rms. The maximum altitude indicated by Radar 122 was 56,800 feet MSL and 56,870 feet MSL by Radar 123. The OAT at this altitude was −68.3 degrees Centigrade, and the maximum density altitude was 56,000 feet MSL.

Two HVAR shots were scheduled for this mission. The second HVAR failued due to a missile malfunction.

In addition to the maximum altitude demonstration, a programmed maneuver was accomplished. Aircraft performance was within SOW specifications throughout the maneuver.

Data Loss Intervals:

14:13:27 for 4 seconds (following handover to FGS)

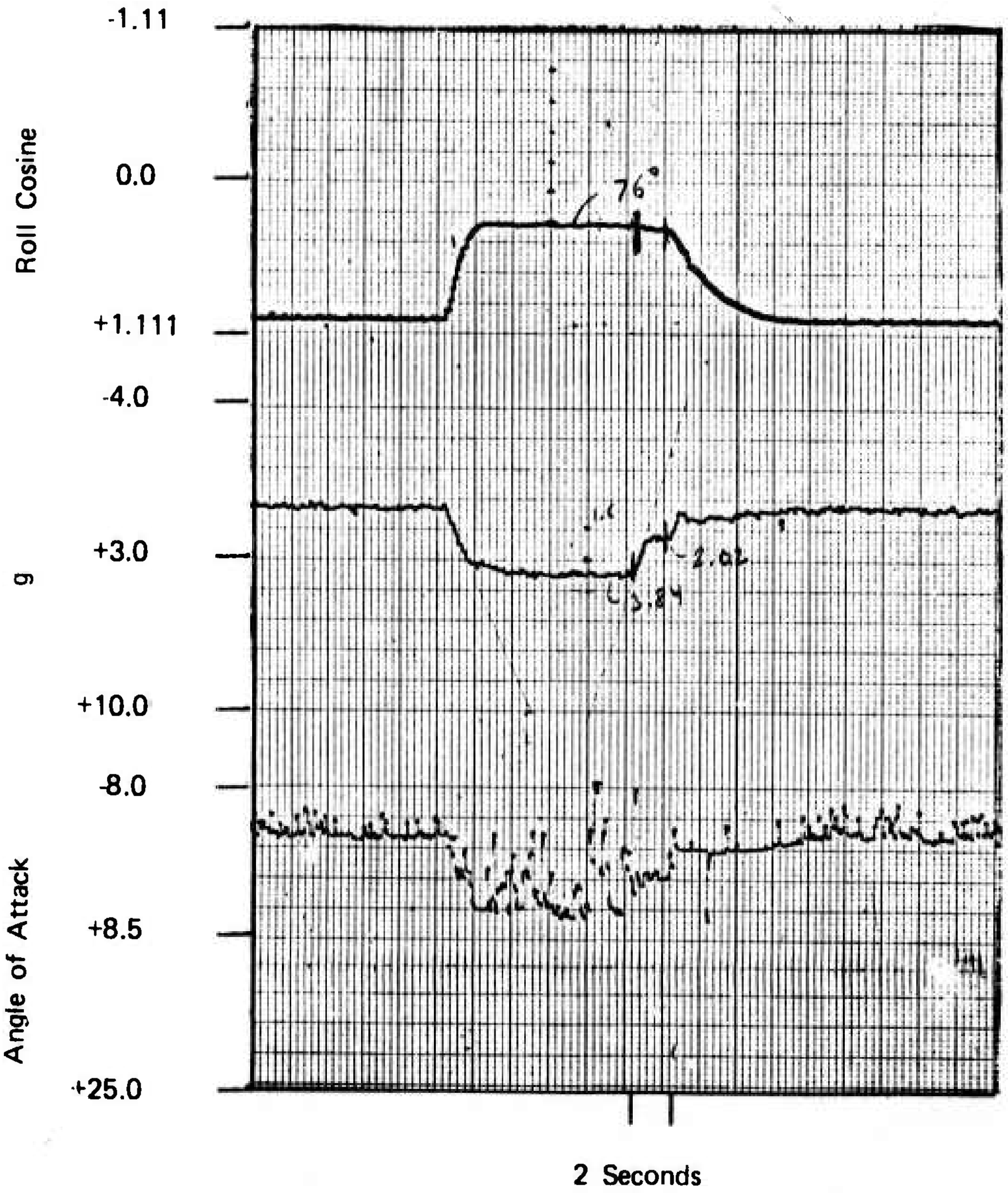


Figure A-18. Presentation Performance During Event 7: Scheduled Bank: 75 degrees; Scheduled g: 4g; Altitude: 25,000 feet MSL; Entry Airspeed: 0.83T Mach

PQM-102 RECORD FLIGHT NO. 5, NULLO NO. 6

Mission: AA
Profile: PQM6-V-5
Date: 26 September 1974

Zulu Time at Brake Release: 14:14:36
Data Sources: FGS Controller, Analyst Notes, Strip Charts, and PCM Tape

This flight included two successful HVAR firings for DIGIDOPS evaluation and two AIM-9J firings. These firings ended the scheduled HVAR firings and began the operational phase of the program.

The programmed maneuvers consisted of two 6g presentations. (A third 6g presentation was cancelled due to low fuel.) During each maneuver the nominal bank was 2 to 3 degrees low. This recurring problem concerning incorrect nominal bank angles (reference QF-102 Record Flight No. 12) is apparently caused by a feedback voltage in the roll attitude circuitry which should be zero when the elevons are aligned. If this voltage is zero when the elevons are misaligned, or if aircraft trim requires slightly misaligned elevons for level flight, an offset in bank will appear during maneuver presentations. The offset does not occur during non-programmed flight because heading hold automatically cancels any feedback voltage which exists. A roll error integrator has been proposed to correct this problem.

The high g maneuvers also showed a definite g-overshoot tendency which lasted for approximately 2 seconds. This was most probably caused by the g-error integrator, which sums the g error over time and generates a command for additional g if needed. During the longer building time for high g maneuvers, this integrator will theoretically generate a large error signal and cause temporary overshoot. A gate which eliminates the integrator from operating until a certain g force is attained has been proposed to solve this problem.

A range computer problem delayed takeoff.

Data Loss Intervals:

14:15:46 for 6 seconds (following takeoff on Radar 123)
14:17:02 for 6 seconds (initial climbout on Radar 123)
14:22:00 for 12 seconds (following HVAR firings on Radar 122)
14:29:22 for 10 seconds (cruise at 18,000 feet)
14:35:22 for 3 seconds (termination of record presentation)

Note: Fixed station altitude data was lost at 14:49:51 GMT and loss persisted until MGS took control at 14:51:36 GMT.

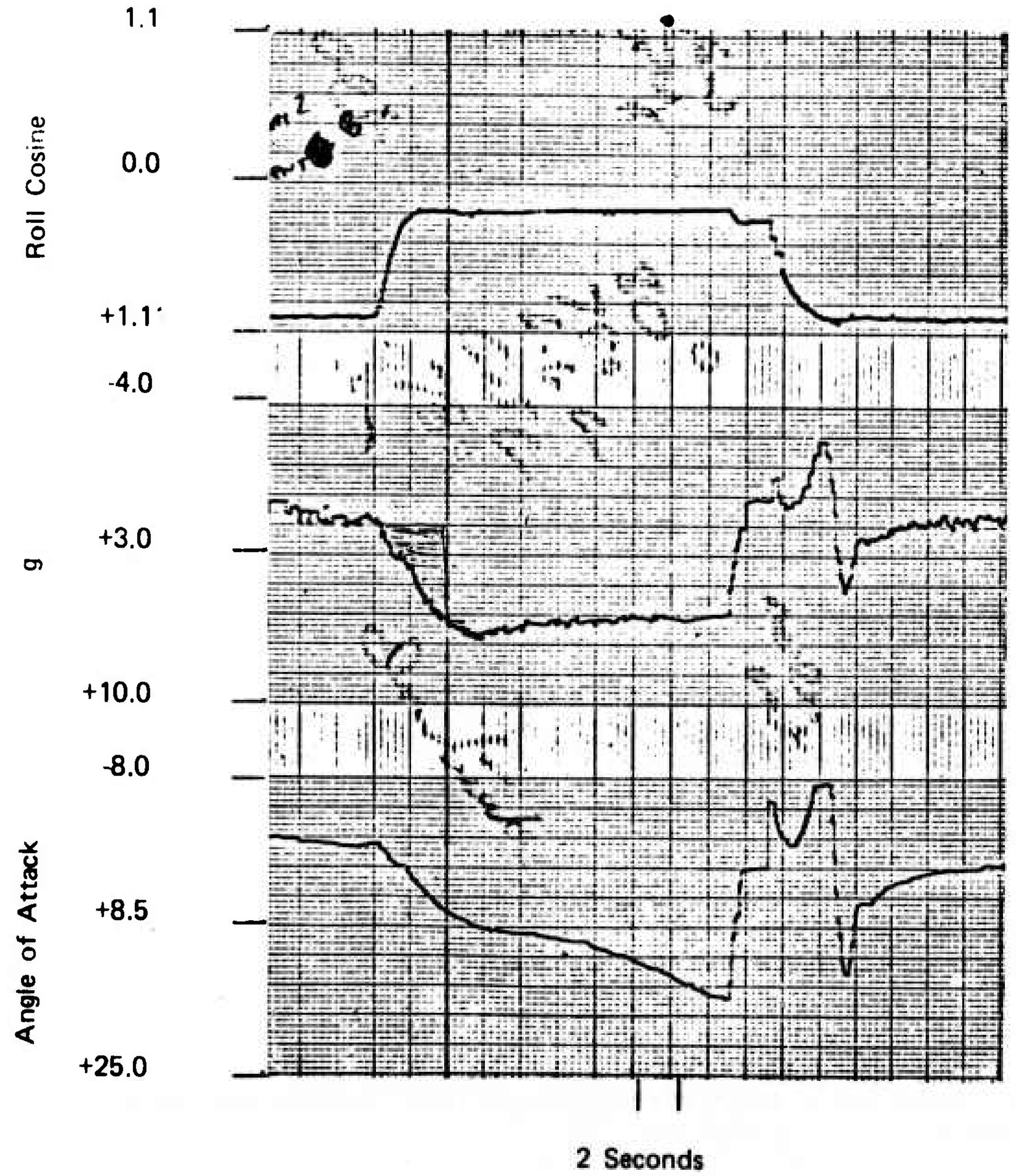


Figure A-19. Presentation Performance During Event 8: Scheduled Bank: 80 degrees; Scheduled g: 6g; Altitude: 18,800 feet MSL; Entry Airspeed: 0.94T Mach

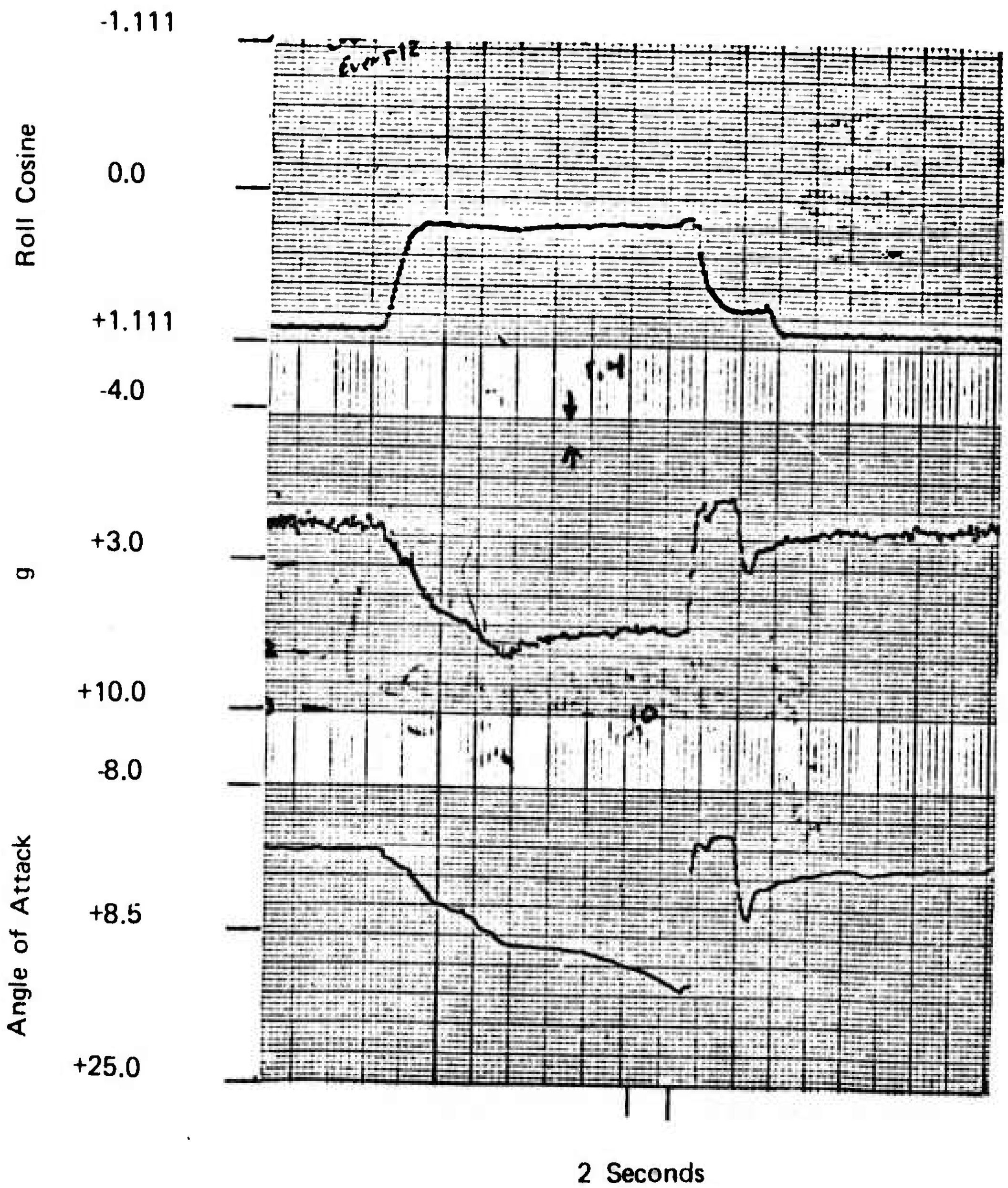


Figure A-20. Presentation Performance During Event 12: Scheduled Bank: 80 degrees; Scheduled g: 6g; Altitude: 20,500 feet MSL; Entry Airspeed: 0.95T Mach

NULLO NO. 7

Mission: AA
Profile: PQM4-6
Date: 4 October 1974

Zulu Time at Brake Release: 14:21:00
Data Sources: Mission Notes, Strip Charts, and PCM Tape

The purpose of this flight was to present a high g maneuver presentation as a target for actual AIM-9J missile firings. For this flight the airspeed input into the artificial feel system was disconnected and noise filters were installed in the programmer to eliminate random timer resets. Communication problems caused the first presentation to be cancelled, but two subsequent 6g maneuvers were accomplished. Since Tactical Air Warfare Center (TAWC) firing aircraft were approximately one mile in trail of the drone from takeoff to the actual missile firing, the normal time constraints at maneuver initiation did not apply.

PQM-102 flight performance during the presentations was excellent. A definite g overshoot between 0.5g and 1g was apparent. This has been noticed previously on NULLO No. 3 (4 September 1974) and NULLO No. 5 (26 September 1974) and is apparently caused by the g-integrator. Data indicates that g-overshoot occurs consistently when the scheduled g force is 6.0 or higher above 18,000 feet. Because of the longer buildup times at higher altitudes, the amount of overshoot is expected to increase with altitude (unless angle-of-attack limiting occurs).

Definite altitude oscillations occurred at 20,000 feet when airspeed exceeded 440 KIAS. This behavior is not typical of previous altitude performance and may be peculiar to aircraft FAD 604. The actual vertical velocity and g force during these oscillations are illustrated in Figure A-21.

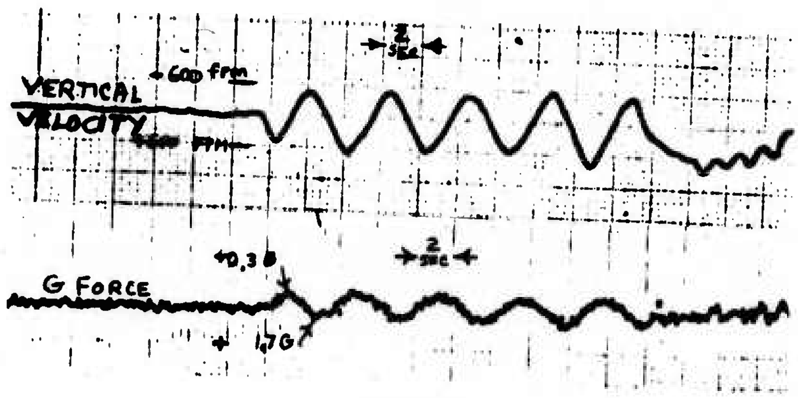


Figure A-21. Altitude Oscillations at 20,000 Feet

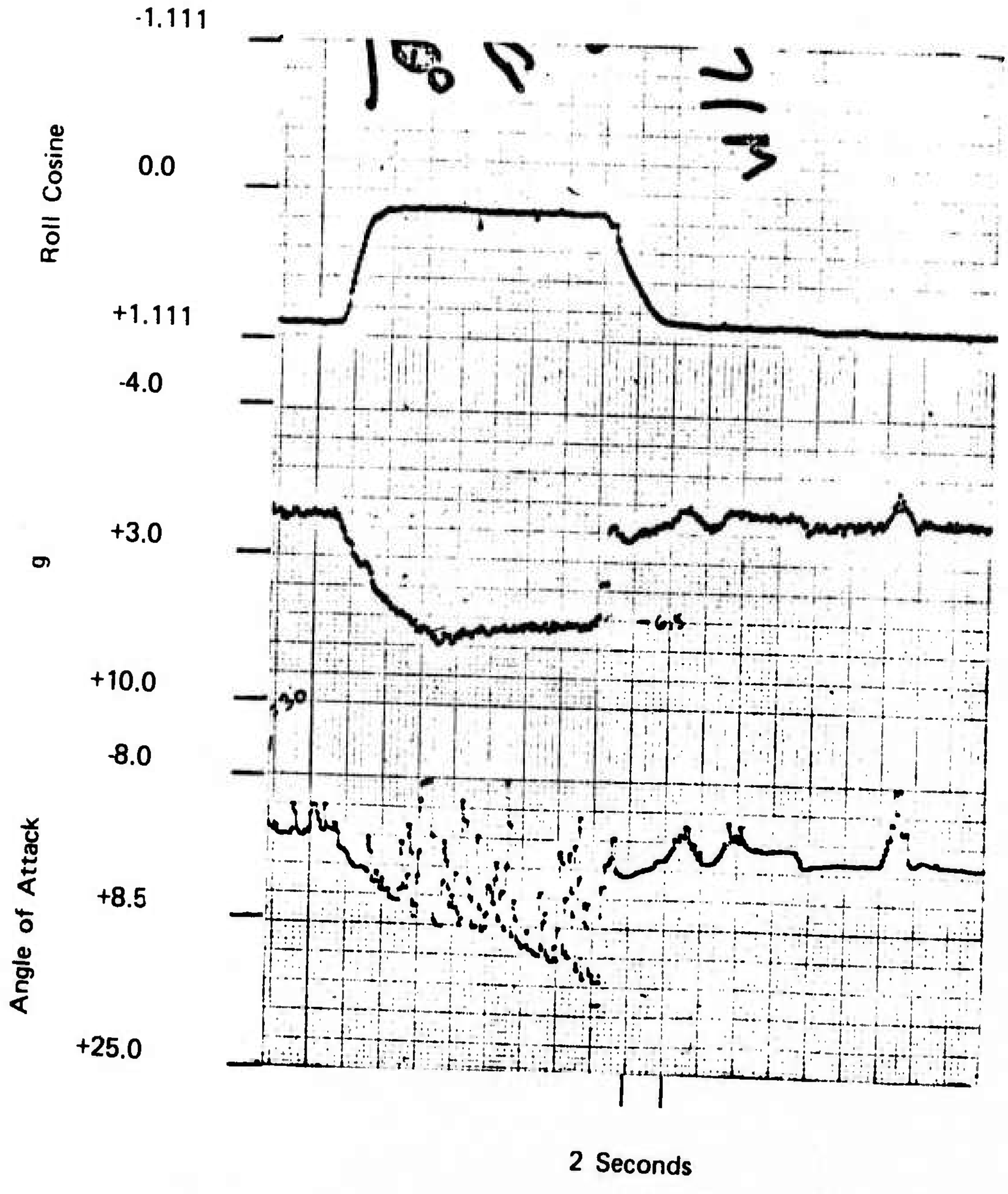


Figure A-22. Presentation Performance During Event 10: Scheduled Bank: 80 degrees; Scheduled g: 6.0g; Altitude: 18,700 feet MSL; Entry Airspeed: 0.94 Mach

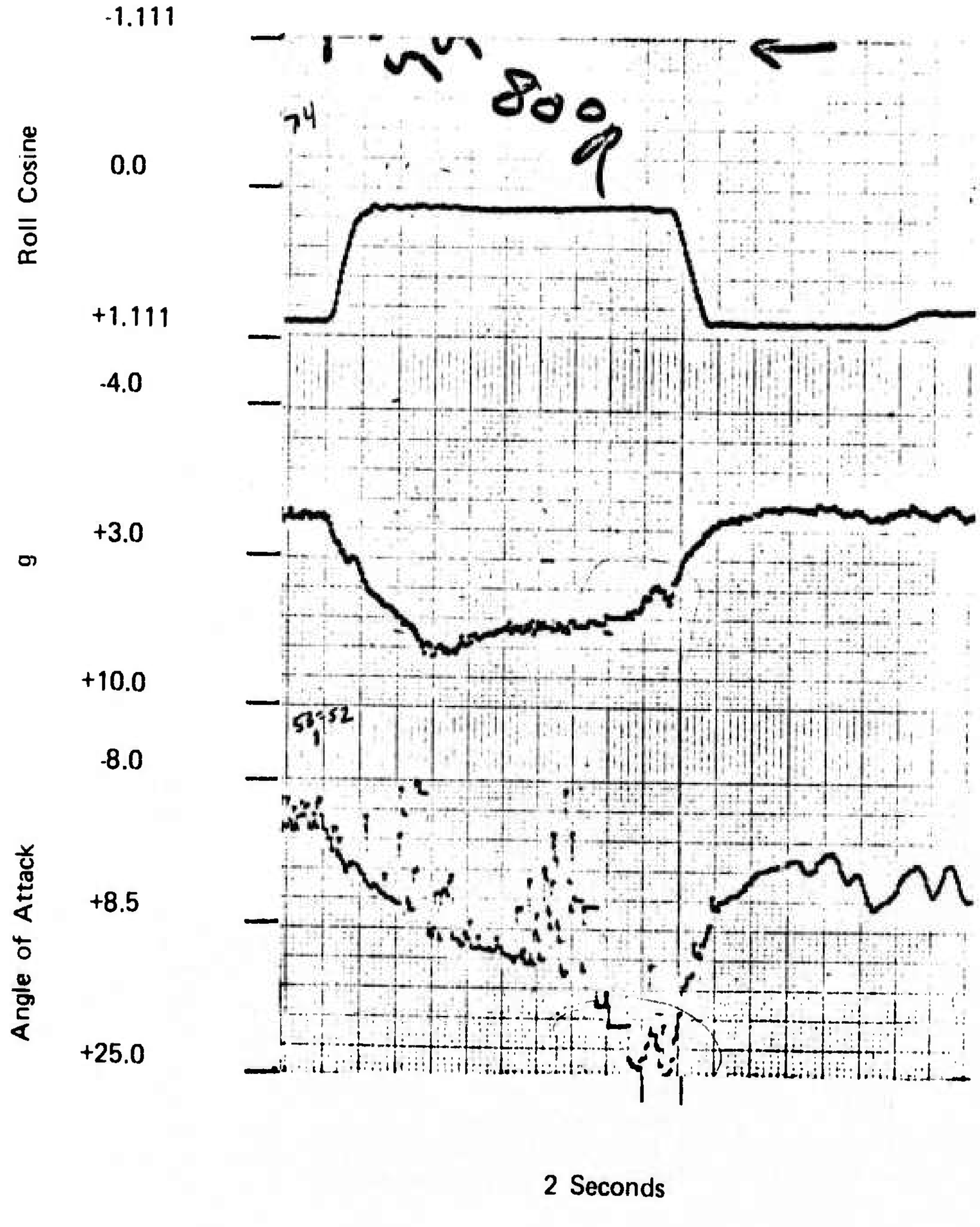


Figure A-23. Presentation Performance During Event 14: Scheduled Bank: 80 degrees; Scheduled g: 6.0g; Altitude: 20,500 feet MSL; Entry Airspeed: 0.94T Mach

NULLO NO. 8

Mission: AA
Profile: PQM6-7
Date: 8 October 1974

Zulu Time at Brake Release: 14:15:11
Data Sources: Mission Notes, Strip Charts, and PCM Tape

This flight was to further test the maneuver presentation abilities with the airspeed input to the artificial feel system disconnected. The noise filters for the programmer were also installed for this mission. Unfortunately, bad weather caused cancellation of the actual missile firings, but one presentation was accomplished.

It is interesting to note that there was only a slight g overshoot which was hardly noticeable in the strip chart performance summary. This was expected since the low initiation altitude (13,270 feet) and high entry airspeed (500 KIAS) combined to shorten g buildup time and reduce the effects of the g-integrator (reference PQM-102 Record Flight No. 7).

The altitude oscillation noticed on the previous NULLO No. 6 flight at high airspeeds (450 KIAS) was not present during this mission. This indicates that the pitch axis control mode of aircraft FAD 604 is defective at high airspeeds.

At 14:48:42 GMT the airspeed on pitch mode was initiated with a 20 KIAS error signal to observe the resulting pitch change. The pitch angle smoothly decreased 5 degrees and showed no instabilities or rapid changing.

Data Loss Intervals:

14:46:08 for 2 seconds (during maneuver presentation)

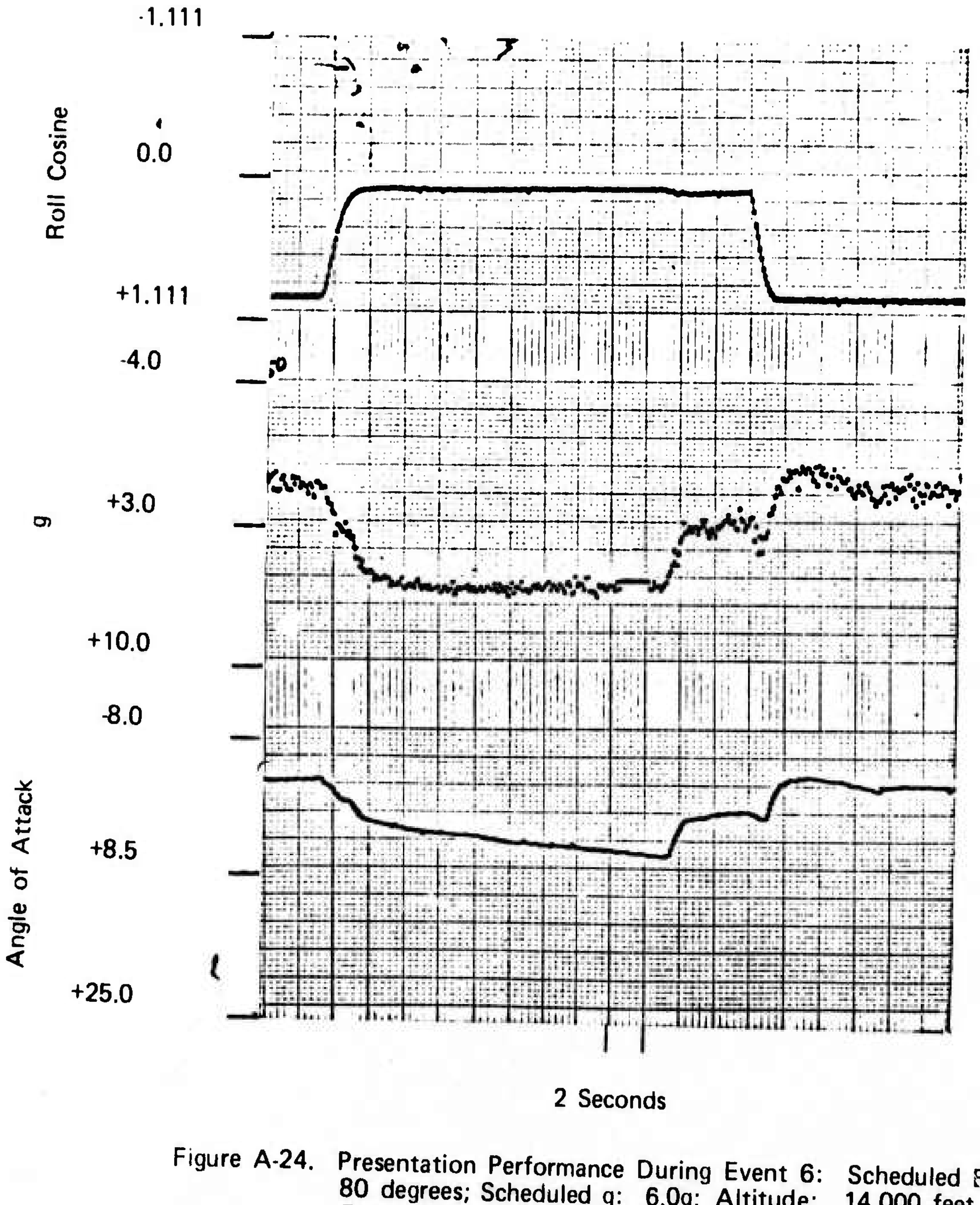


Figure A-24. Presentation Performance During Event 6: Scheduled Bank: 80 degrees; Scheduled g: 6.0g; Altitude: 14,000 feet MSL; Entry Airspeed: 0.93T Mach

QF-102 RECORD FLIGHT NO. 13

Mission: FF
Profile: QF3-V-6
Date: 9 October 1974

Zulu Time at Brake Release: 16:35:10
Data Sources: Mission Notes, Strip Charts, Digital System, and PCM Tape

The objectives of this mission were to test the low altitude maneuver programmer and to obtain altitude hold performance data at 75 degrees of bank during programmed maneuvers. The first objective was not met due to an erratic directional gyro, but a considerable amount of altitude hold data at high bank angles was obtained.

During maneuvers with 75 degrees of bank and altitude hold on, there is a definite tendency for the aircraft to initially lose altitude. The initial altitude loss increases as the reference altitude increases, as shown in Figures A-25, A-26, A-27, A-28, and A-29. Plots were used to present data since typical steady-state altitude hold performance was not observed at high bank angles. Maximum altitude deviations are consistently out of SOW tolerances which is in sharp contrast to the excellent altitude hold performance at lower bank angles.

A 5-degree bank oscillation occurred during the 590-foot above ground level programmed maneuver for approximately 6 seconds. Altitude hold performance, however, was very good as shown by the plot.

Altitude hold performance was also taken during non-programmed flight near 10,000 feet. This data was combined with the performance on 6 September 1974 and is presented in Figure A-25. It appears the roll-in to 75 degrees of bank causes a significant initial altitude loss, one which exceeds the altitude loss caused by an initial vertical velocity of −3000 fpm with a bank of 75 degrees already established. This initial altitude loss caused the FGS controller to discontinue the first 500-foot above ground level presentation at 17:16:54 GMT. This phenomenon can be expected to occur in future flights.

Data Loss Intervals:

16:49:40 for 4 seconds (altitude hold demonstrated at 10,000 feet)
16:50:47 for 3 seconds (altitude hold demonstrated at 10,000 feet)
17:07:33 for 3 seconds (Phase II of 1600-foot above ground level demonstration)

Note: This aircraft did not have the roll-integrator modification or the noise filters on the programmer. The airspeed input to the artificial feel system was not disconnected.

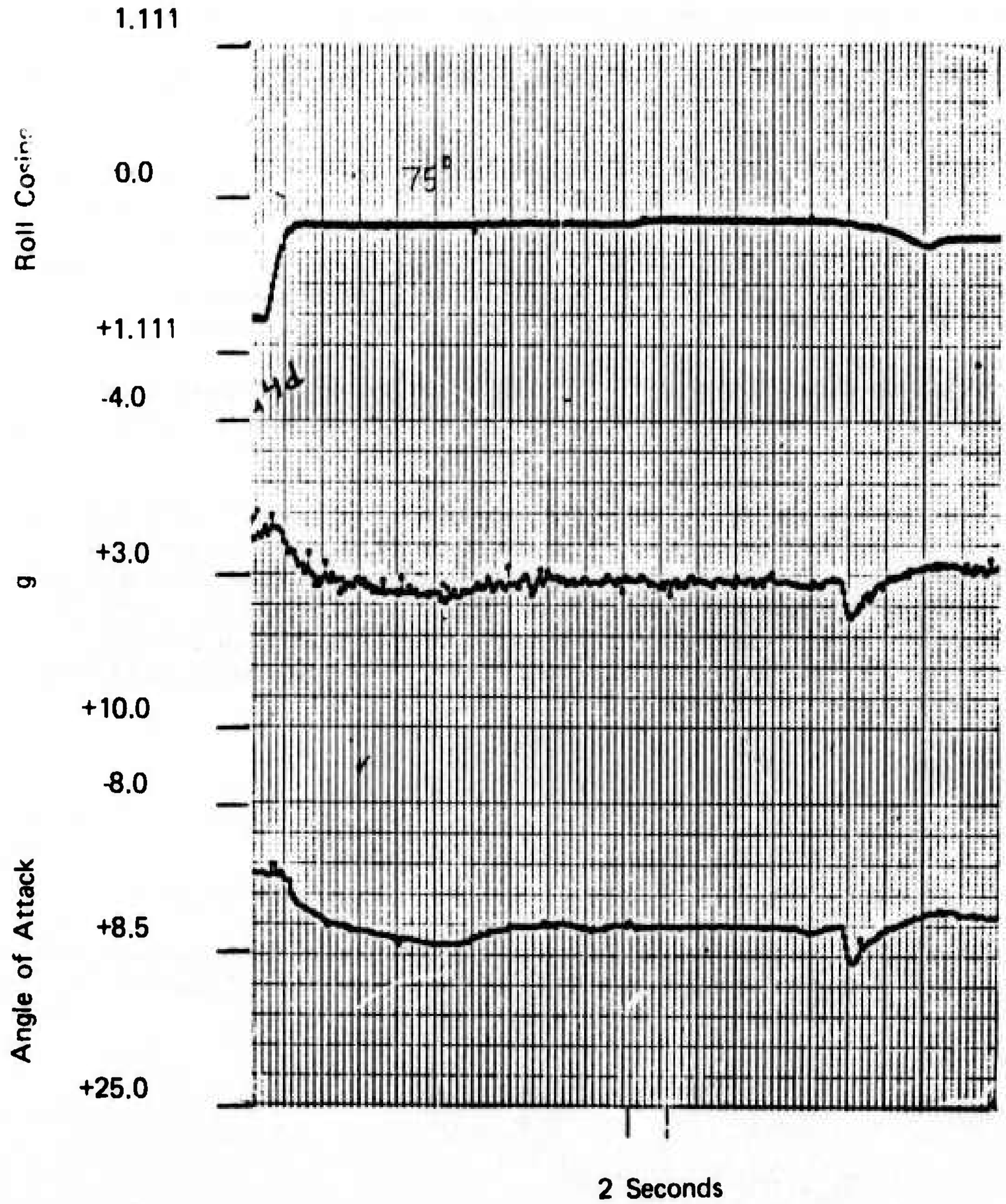


Figure A-25. Presentation Performance During Event 4d: Scheduled Bank: 75 degrees; Altitude Hold On; Altitude: 10,000 feet MSL; Entry Airspeed: 0.74T Mach

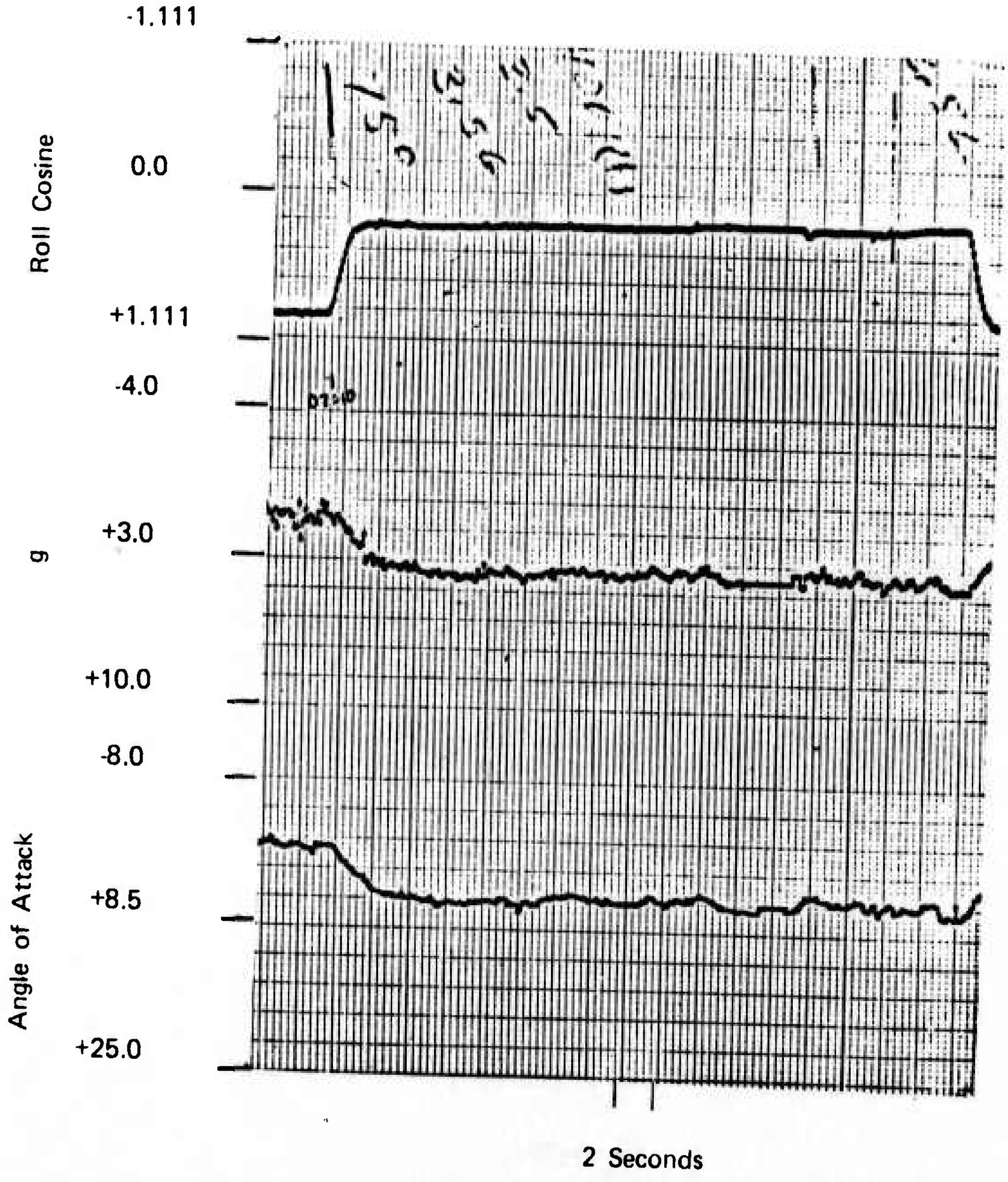


Figure A-26. Presentation Performance During Event 11: Scheduled Bank: 75 degrees; Altitude Hold On; Altitude: 1,600 feet MSL; Entry Airspeed: 0.77T Mach

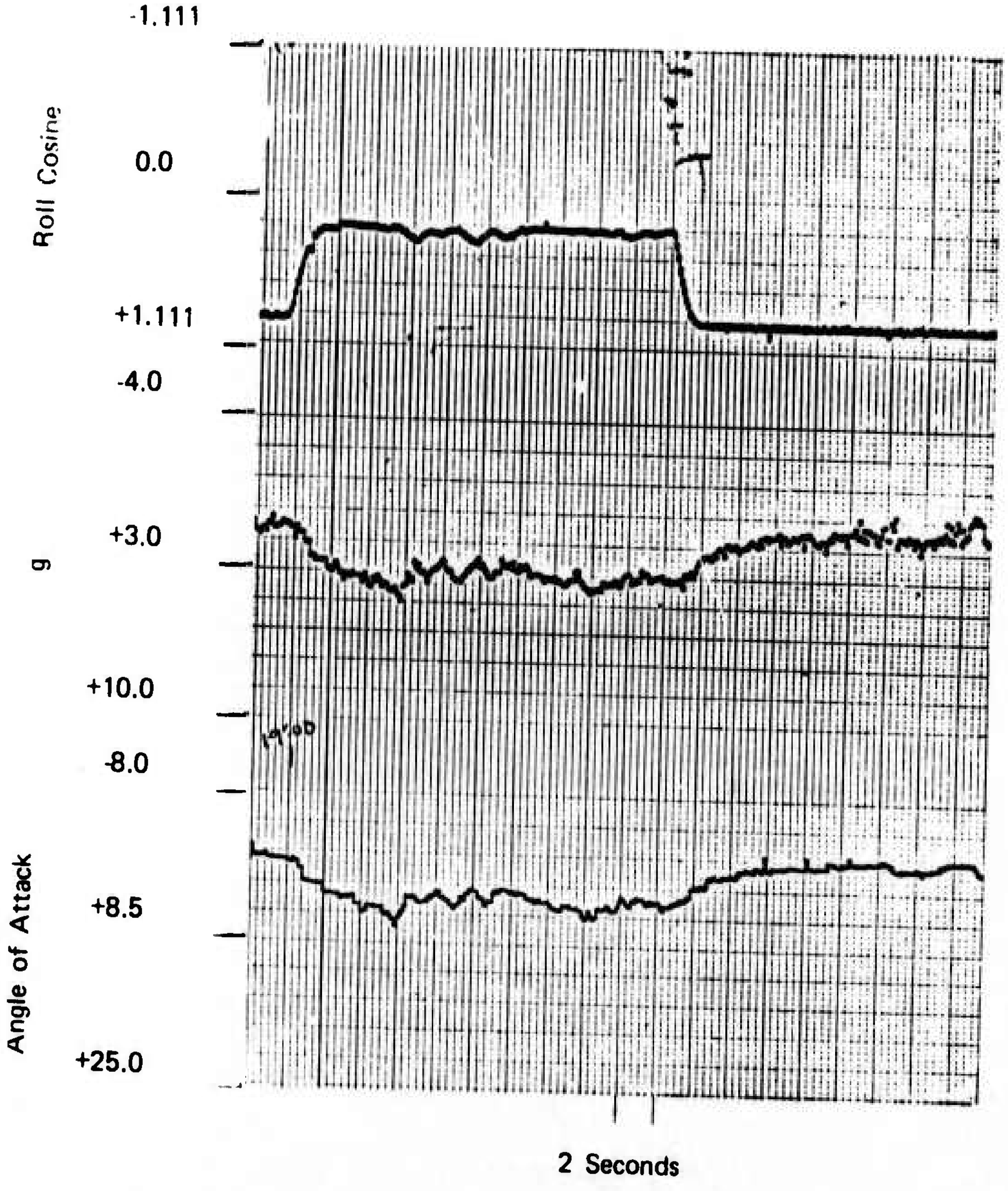


Figure A-27. Presentation Performance During Event 12: Scheduled Bank: 75 degrees; Altitude Hold On; Altitude: 580 feet MSL; Entry Airspeed: 0.63T Mach

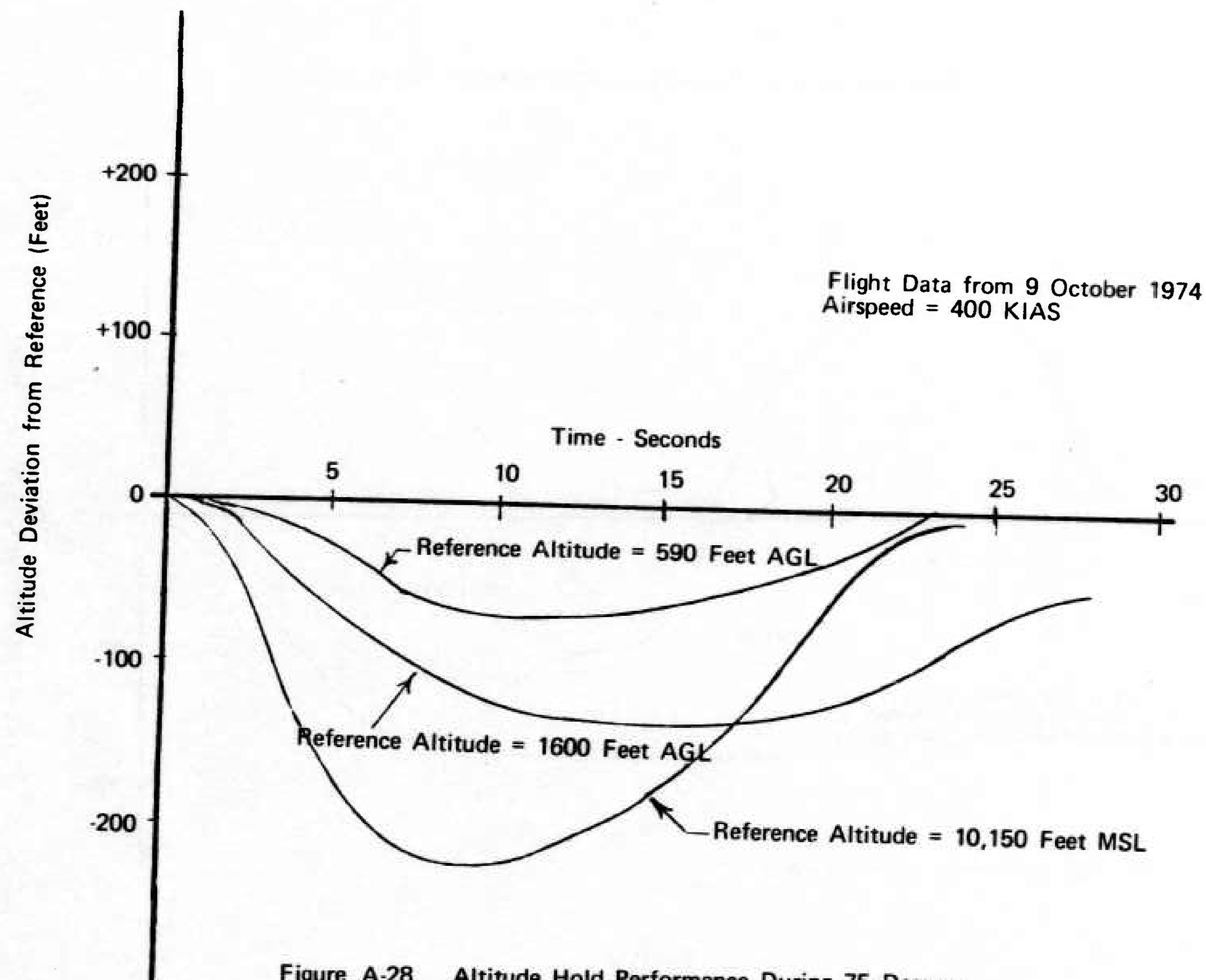


Figure A-28. Altitude Hold Performance During 75-Degree Programmed Maneuvers

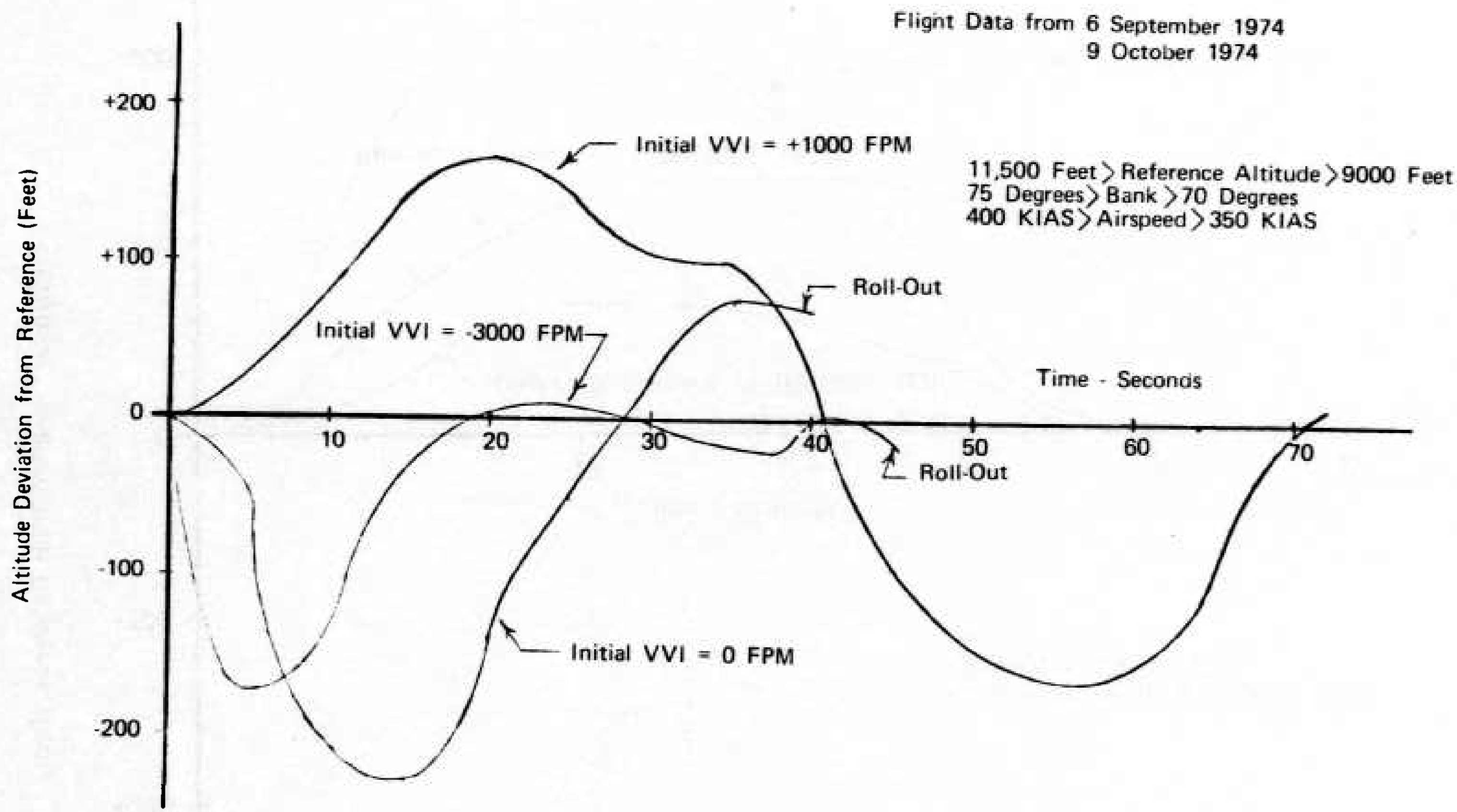


Figure A-29. Altitude Hold Performance at High Bank Angles

QF-102 RECORD FLIGHT NO. 14 (UNSUCCESSFUL)

Mission: FF
Profile: QF2-IV-7
Date: 11 October 1974

Zulu Time at Brake Release: 18:49:00
Data Sources: Mission Notes

The purpose of this flight was to test the roll-integrator modification made to the flight control system. Five minutes into the mission it was obvious that there was a serious lack of stability in the lateral axis of the flight control system. When rolling out of a right turn, the bank angle would overshoot up to 25 degrees using the wings level command. The backup flight control system was selected and recovery was accomplished at 19:05:06 GMT.

During the time that the FGS was in control, the indicated attitude oscillations was between 4000 feet and 5500 feet on the low scale. This recurring and baffling problem was finally traced to the encoders in the aircraft during subsequent ground tests. Apparently the altitude channel was not grounded in the encoder due to a design deficiency, and this caused an atti-tude oscillation when the encoder was responding to a 320 PRF rate from the fixed-site interrogations. All encoders will be modified to correct this deficiency.

A second attempt at a successful record flight was made at 22:10:00 GMT on 11 October 1974 (Mission HB). The previous roll instability was traced to a possible failure of the autopilot rate-sensing gyro, and it was replaced for the re-fly of QF REcord Flight No. 14. Immediately after take-off, however, the lateral axis went completely unstable and the diver-gent roll caused another mission abort. It is possible that the signals from the autopilot rate-gyro had the wrong polarity, and the problem is under investigation.

The PCM data tape was not recorded for QF-102 Record Flight No. 14 or for the re-fly of QF-102 Record Flight No. 14. The results of this abstract are not consolidated in the PQM-102 Target System final report.

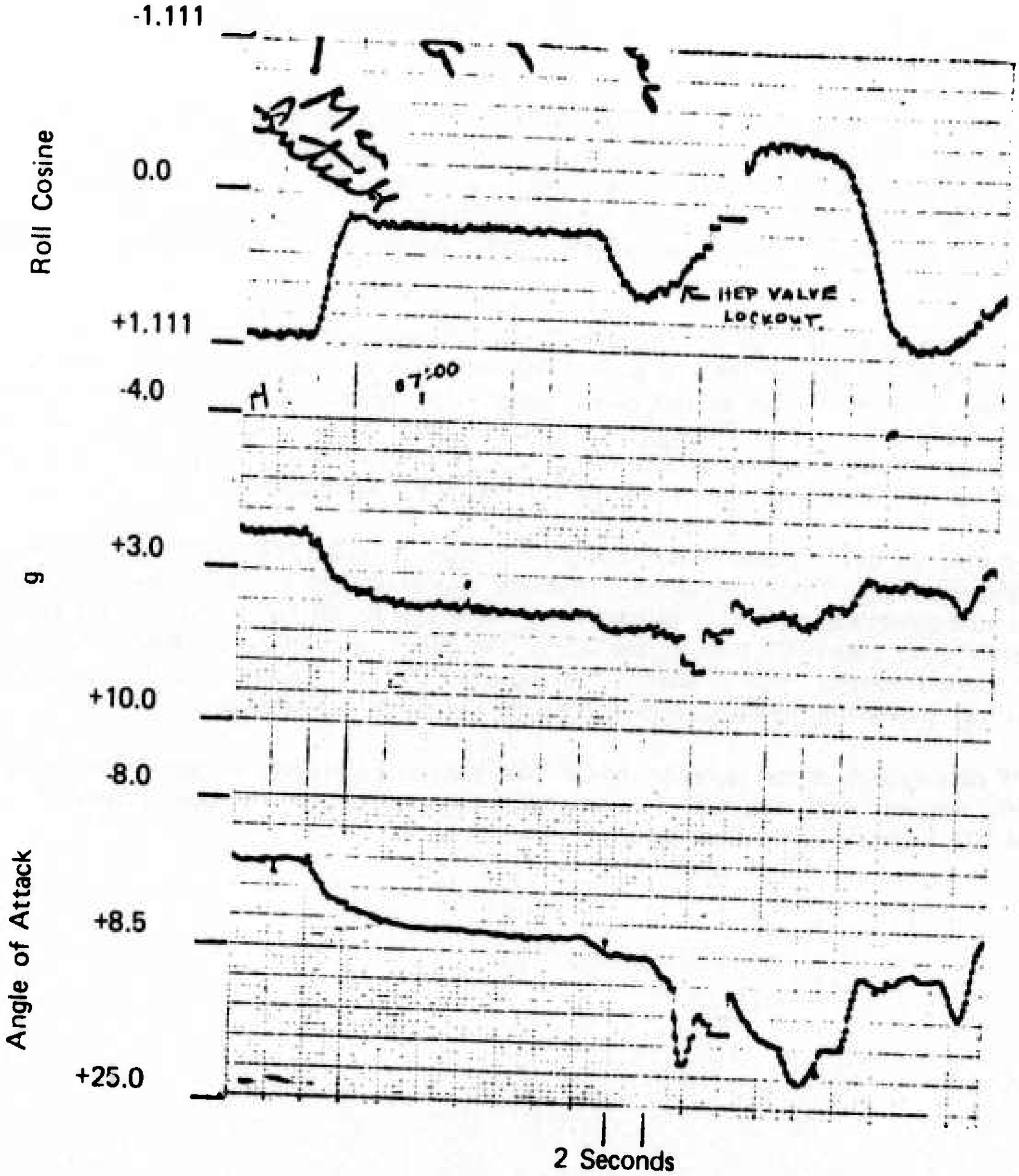


Figure A-30. Scheduled Performance During Event 14: Scheduled Bank: 80 degrees; Scheduled g-force: 4.0; Altitude: 24,000 feet MSL (not graded); Entry Airspeed: 0.86T Mach (not graded)

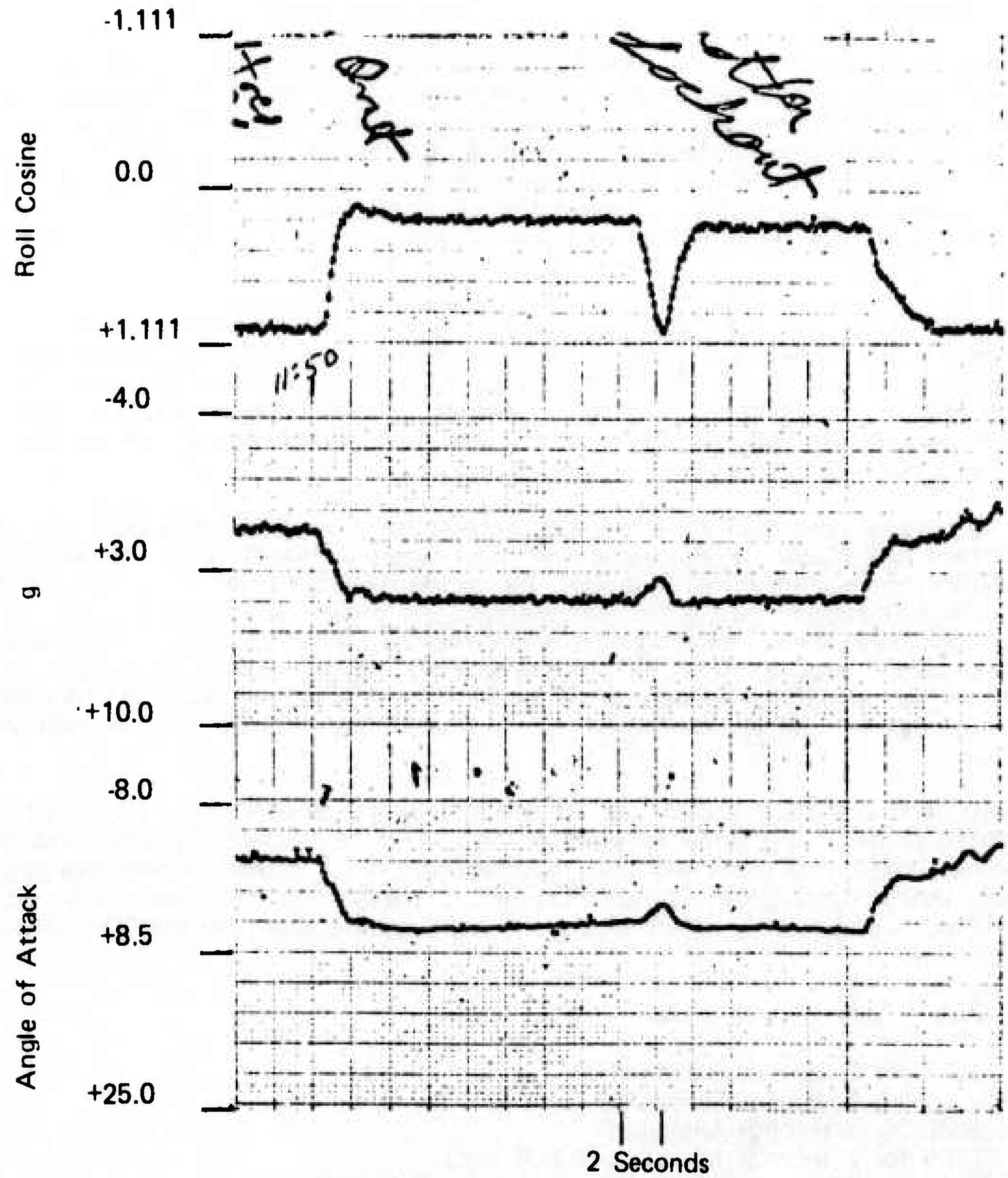


Figure A-31. Scheduled Performance During Event 14 (Repeat): Scheduled Bank: 80 and –76 degrees; Scheduled g-force: 4.0; Altitude: 20,000 feet MSL (not graded); Entry Airspeed: 0.80T Mach (not graded)

QF-102 RECORD FLIGHT NO. 16 (SATISFACTORY)

Mission: CH
Profile: QF1-IV-7
Date: 7 November 1974

Zulu Time at Brake Release: 21:16:25
Data Sources: Mission Notes, Strip Charts, and PCM Tape

The primary purpose of this final record flight was to thoroughly test the roll integrator modification during two-phase maneuver presentations. Although intermittent data loss occurred frequently during the mission, enough data was taken to verify that the roll integrator does cause positive bank control throughout the presentation interval although the steady-state value was slightly out of tolerance once. A definite overshoot of 1 to 2 degrees consistently occurs, but settling time is rapid and almost no oscillations are present in the roll trace. It is recommended that the roll integrator be included in all production aircraft.

Altitude hold at high reference altitudes and high bank angles was also tested during this flight. At 21:39:11 GMT the aircraft exhibited a definite instability when altitude hold was engaged at 45,000 feet in a 45-degree bank. Airspeed at the start of the test was 0.9 Mach and held constant for the first 20 seconds, then airspeed decreased as pitch oscillations reached ±6 degrees. The maneuver was discontinued after 41 seconds due to the divergent pitch oscillations.

Additional altitude hold demonstrations were accomplished at 25,000 feet with bank angles of 75 degrees (0.9 Mach). Performance was much better at this altitude, and deviations from reference were kept within 100 feet. As discussed in the final report, the stability of the pitch axis during altitude hold demonstrations decreases with increasing altitude and increasing bank angle. Below 60 degrees of bank the system operates within specifications at all altitudes up to 40,000 feet. Above 60 degrees of bank the system can consistently meet specifications only below 10,000 feet MSL. The results of this flight conform completely with the conclusions of the final report regarding altitude hold performance.

The results of this flight indicated that the roll integrator has solved the problem of incorrect bank angles during maneuver presentations. This modification, together with the artificial feel system and maneuver timer modifications, has improved performance considerably since record flights began. In summary, it is apparent that the drone is now capable of presenting an afterburning target which is highly maneuverable with the SOW tolerances for performance.

Significant Data Loss Intervals:

21:28:21 for 2 seconds (climbout)
21:28:32 for 6 seconds (climbout)
21:28:40 for 2 seconds (climbout)
21:30:50 for 7 seconds (cruise at 45,000 feet)
21:36:12 for 24 seconds (intermittent) (cruise at 45,000 feet)
21:33:00 for 8 seconds (Phase II of presentation)
21:33:15 for 2 seconds (recovery from presentation)
21:39:13 for 4 seconds (Phase II of presentation)
21:41:30 for 2 seconds (Phase II of presentation)
21:41:50 for 4 seconds (cruise at 28,000 feet)
21:45:15 for 2 seconds (cruise at 28,000 feet)
21:43:46 for 10 seconds (75-degree right turn at 25,000 feet)
21:44:02 for 36 seconds (75-degree left turn at 25,000 feet)

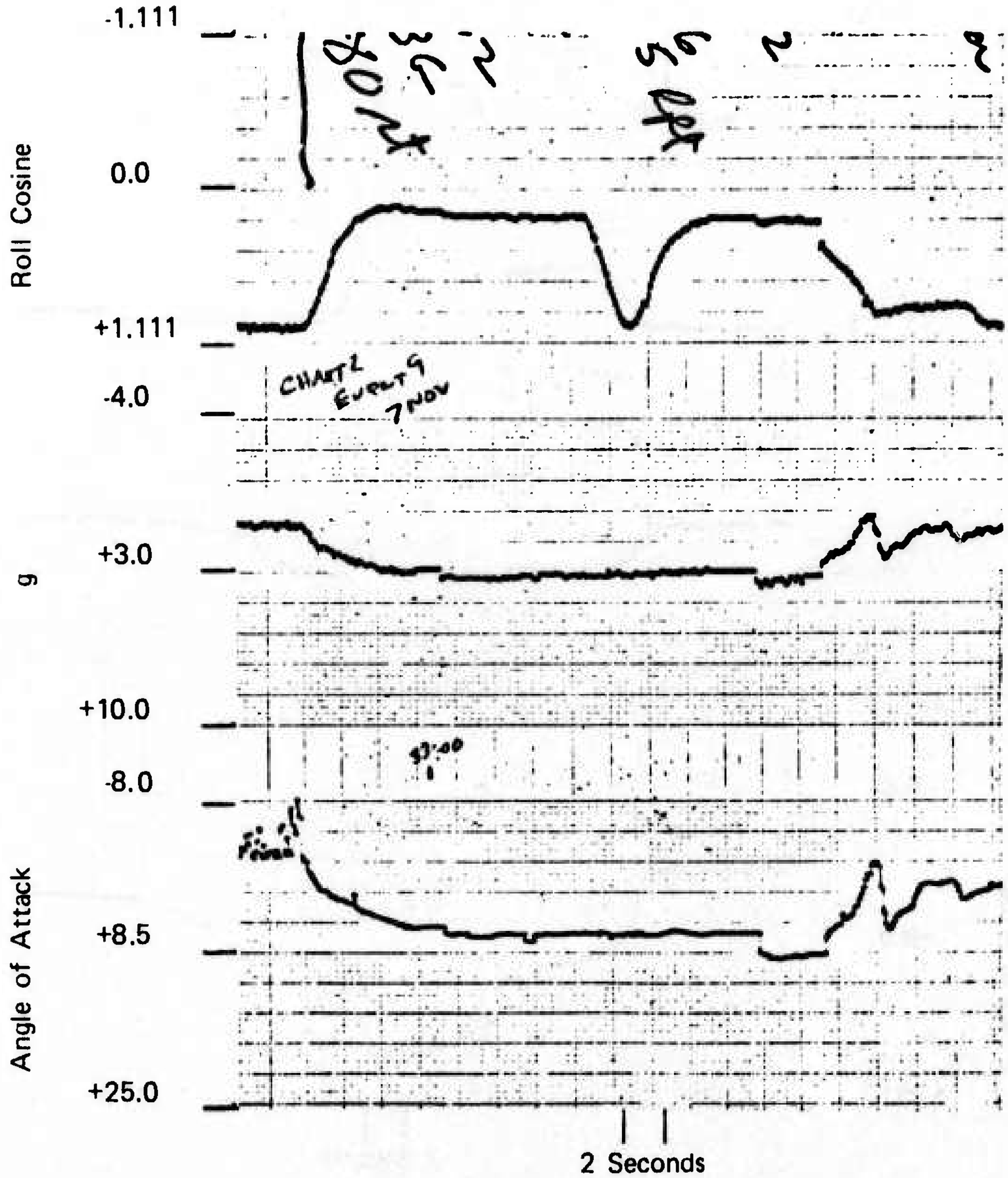


Figure A-32. Performance During Event 9: Scheduled Bank: 80 and −76 degrees; Scheduled g-force: 3.0; Altitude: 35,000 feet MSL; Entry Airspeed: 1.15T Mach

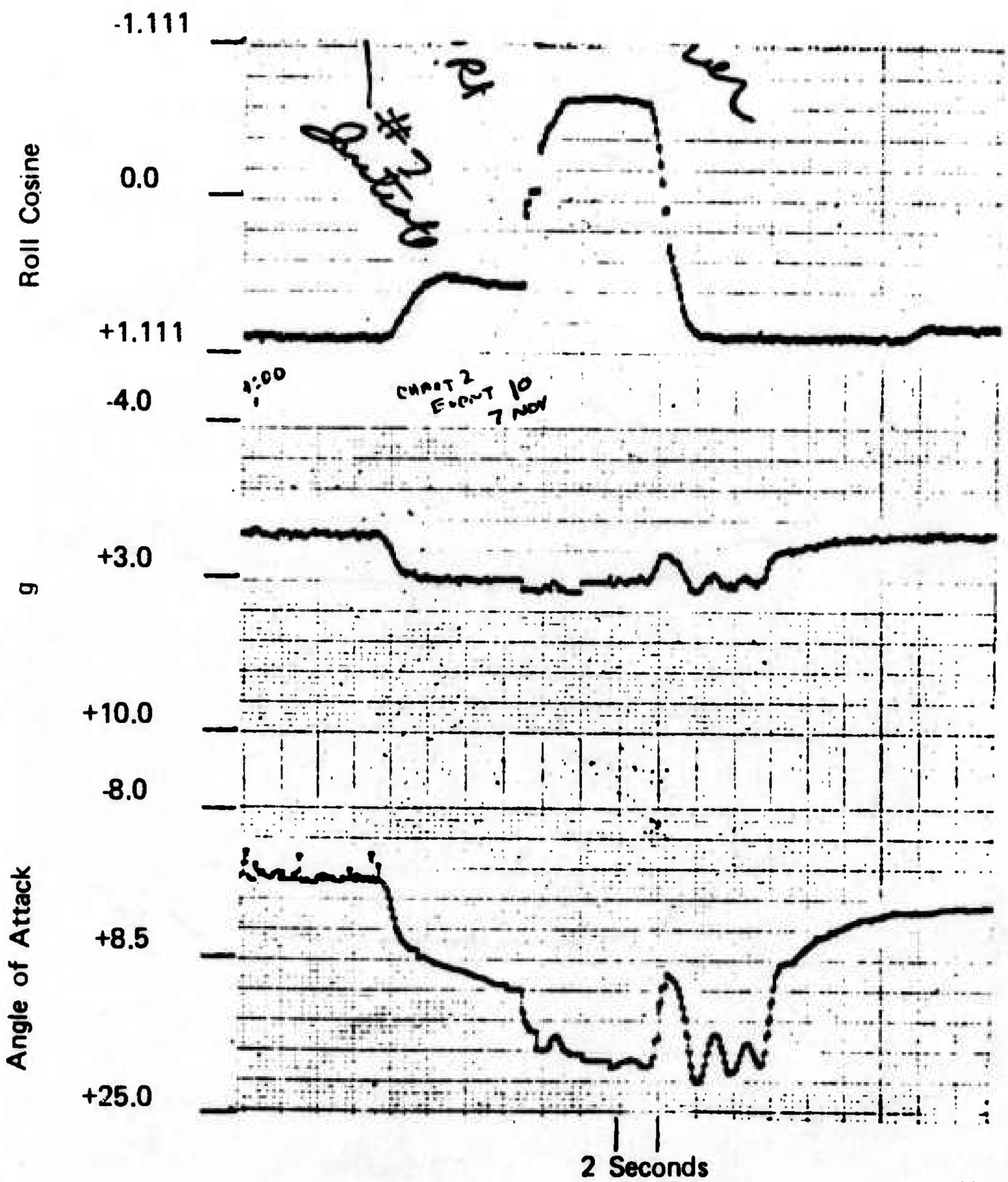


Figure A-33. Performance During Event 10: Scheduled Bank: 50 and 135 degrees; Scheduled g-force: 3.0 and 4.0; Altitude: 34,000 feet MSL; Entry Airspeed: 0.98T Mach

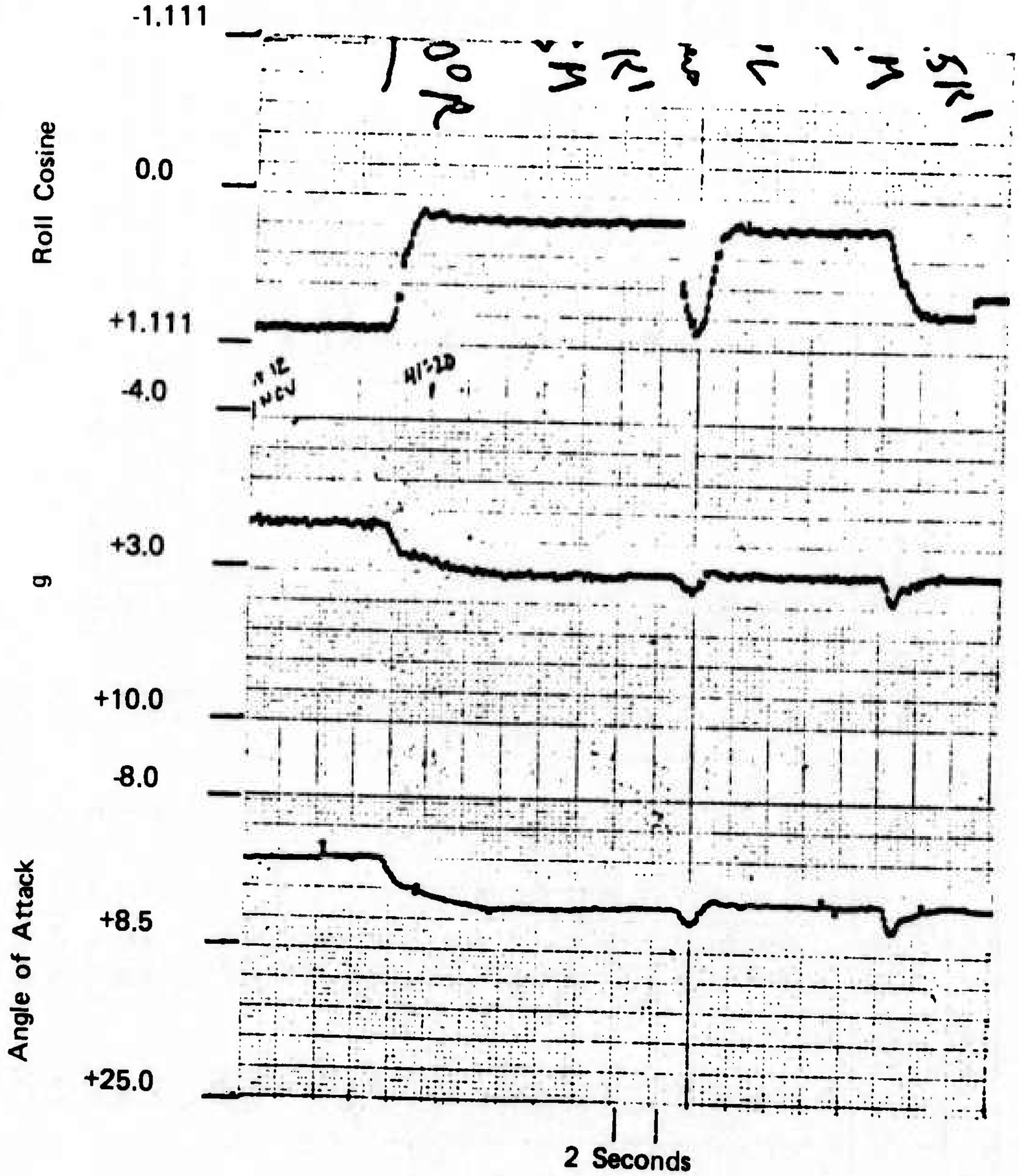


Figure A-34. Performance During Event 12: Scheduled Bank: 80 and −76 degrees; Scheduled g-force: 3.0; Altitude: 27,500 feet MSL; Entry Airspeed: 1.09T Mach

TABLE A-2. SUMMARY OF QF/PQM-102 RECORD FLIGHTS - MANEUVER PROGRAMMER (MP) PERFORMANCE

Record Flight No.	Planned							Actual					
	Aircraft No.	Kilofeet Altitude MSL	Entry Airspeed (knots)	Bank (deg)	g	MP Phase	Altitude Hold	Kilofeet Altitude MSL	Entry Airspeed (knots)	Bank (deg)	g	g Build-up (sec)	Remarks
QF 1	602	25	300	60-R	2	1	On	24.5	250	62-R	2.4	3	Successful
QF 2	602	25	380	72-R	3	1	Off	25	376	74-R	2.84	2	Successful
QF 3	602	35	310	75-R	4	1	Off	35	338	77.3-R	4	4	Unsuccessful(1)
QF 4	601	35	490	85-R	4	1	Off	34.8	398	85.6-R	4	6	Successful
QF 5	601	40	360	85-R	3	1	Off	38.1	368	85.2-R	3	5	Successful
QF 6	602	10	300	60-L	2	1	On	10.1	240	56.1-L	1.8	N/A	Unsuccessful(2)
QF 7	602	10	505	78-L	5.5	1	Off	10.4	505	74.7-L	5.25	4	Unsuccessful(2)
QF 8	602	35	330	72-R	3	1	Off	35.1	302	77.1-R	2.98	3	Unsuccessful(2)
QF 8	602	- -	330	76-L	4	2	Off	- - -	- - -	70.3-L	4	N/A	Unsuccessful(2)
QF 9	602	45	330	85-R	3	1	Off	44.8	250	92-R	4	3	Unsuccessful(3)
QF 9	602	- -	330	80-L	4	2	Off	- - -	- - -	71-L	3.4	N/A	Unsuccessful(3)
QF 10	602	15	465	78-R	5	1	Off	15	485	79.2-R	6	4	Successful
QF 10	602	15	465	80-R	6	2	Off	15	485	79.2-R	6	4	Successful
QF 11	602	N/A	465	78-R	5	1	Off	20	445	79-R	5	4	Successful
QF 12	602	30	430	60-R	4	1	Off	29.4	370	66-R	4	4	Unsuccessful(2)
QF 12	602	- -	300	135-R	4	2	Off	- - -	- - -	141-R	3.82	N/A	Unsuccessful(2)
QF 13	603	10	400	75-L	4	1	On	10	403	74-R	3.8	N/A	Successful
QF 13	603	1.5	400	75-R	4	2	On	1.6	395	75-R	3.8	N/A	Successful
QF 13	603	.5	400	75-R	4	1	On	.58	390	74.2-R	3.7	N/A	Successful
QF 14	602	35	450	80-R	4	1	Off	No maneuver demonstrated on first or second (re-fly 1) missions					
QF 14	602	35	450	76-L	4	2	Off	No maneuver demonstrated on first or second (re-fly 1) missions					
QF 14	602	35	350	50-R	3	1	Off	No maneuver demonstrated on first or second (re-fly 1) missions					
QF 14	602	35	350	125-R	4	2	Off	No maneuver demonstrated on first or second (re-fly 1) missions					
QF 15	601	28	450	80-R	4	1	Off	*	*	78-R	4	3	Marginal
QF 15	601	28	450	80-R	4	Repeat	Off	*	*	77.5-R	3.96	2	Marginal
QF 15	601	28	450	76-L	4	2	Off	*	*	73.6	4	N/A	Marginal

TABLE A-2. SUMMARY OF QF/PQM-102 RECORD FLIGHTS - MANEUVER PROGRAMMER (MP) PERFORMANCE (CONCLUDED)

Record Flight No.	Planned							Actual					
	Aircraft No.	Kilofeet Altitude MSL	Entry Airspeed (knots)	Bank (deg)	g	MP Phase	Altitude Hold	Kilofeet Altitude MSL	Entry Airspeed (knots)	Bank (deg)	g	g Build-up (sec)	Remarks
QF 16	601	35	450	80-R	3	1	Off	35*	410	79.3-R	3	4	Successful
QF 16	601	35	450	76-L	3	2	Off	35*	416	75.8-L	2.98	3	Successful
QF 16	601	35	330	50-R	3	1	Off	34	350	50.8-R	3	N/A	Successful
QF 16	601	35	350	135-R	4	2	Off	34	350	135-R	3.5	N/A	Successful
QF 16	601	28	450	80-R	3	1	Off	27.5	450	78.2-R	2.6	2	Successful
QF 16	601	28	450	76-L	3	2	Off	27.5	450	75.1-L	3.1	N/A	Successful
PQM 1	605	25	380	60-R	2	1	Off	No maneuver demonstrated					Unsuccessful(4)
PQM 2	605	25	380	60-R	2	1	Off	25.2	270	58.7-R	2	4	Successful
PQM 3	605	30	430	75-R	3	1	Off	30	390	74-R	3	4	Successful
PQM 3	605	15	465	80-R	5	2	Off	Cancelled due to weather					
PQM 4	605	15	465	80-R	6	1	Off	15	480	79.3-R	6.12	5	Successful
PQM 4	605	15	465	82-R	7	2	Off	14.7	480	81-R	7.5	6	Successful
PQM 5	604	25	400	75-R	4	1	Off	25.2	350	75.2-R	4	3	Successful
PQM 5	604	25	300	75-R	2	2	Off	25.2	350	75-R	2	N/A	Successful
PQM 6	606	18	465	80-R	6	1	Off	18.8	456	81-R	6.08	4.5	Successful
PQM 6	606	20	450	80-R	6	1	Off	20.5	450	80.6-R	6.01	6	Successful

*Not graded

Notes:

(1) Approximately 7 to 8 seconds after maneuver initiation, the afterburner blew out causing a low airspeed, high angle-of-attack condition, which prevented satisfactory completion of the maneuver. The roll attitude hold performance however, exceeded SOW specifications both before and after the loss of afterburning thrust. The slow g buildup rate which occurred during this maneuver indicates control surface authority was restricted by HEP valve limitations.

(2) QF-102 Record Flight No. 6, 7, 8, and 12 met SOW specifications except for steady-state roll attitude offsets of 3 to 8 degrees encountered during preprogrammed maneuvers. This problem was subsequently corrected by a design modification to the FCSS which was successfully demonstrated for record during QF-102 Record Flight No. 15 and 16.

(3) The preprogrammed maneuver was outside the F-102A performance envelope and therefore could not be successfully sustained.

(4) PQM-102 Record Flight No. 1 aborted prior to the presentation due to a maladjusted trim follow-up micro switch.

APPENDIX B

DATA ANALYSIS METHODOLOGY

The purpose of data analysis in this program is to determine how well the aircraft flight control system performed during test flights and to estimate future performance based on these test results. Flight performance data were recorded using magnetic tape and strip chart recorders. The data reduction procedure depended on the source being used and is described in the following paragraph. Once this data is available, a statistical analysis using conventional techniques was accomplished to estimate future aircraft performance at a given confidence level.

1. DATA REDUCTION AND PRESENTATION

The techniques used in obtaining usable flight data in the form of listings, plots, and formatted data tapes were heavily influenced by the SOW tolerance limits and by the time constraints imposed by the test program. In many instances the flight data must be very accurate to evaluate performance relative to the tolerance limit, which usually is expressed as a maximum allowable deviation. The ten bit data used to report proportional channels (attitude and airspeed) were not accurate enough to allow this type of evaluation in all situations. Moreover, according to MIL-SPEC-9490, the tolerance limit was allowed to be exceeded if the error oscillation had a damping constant greater than 0.4, and again the downlink data in many instances were not sufficiently precise to determine this.

This problem was solved by averaging the reported data over the time interval of interest. This solution at first seems self-defeating since large error oscillations would tend to be cancelled by the averaging process along with the data inaccuracies. During most test intervals (events), however, the actual flight performance as reported by the safety or chase pilot was very stable. This was verified by the downlink data which from the strip chart recorders appeared as a noise signal superimposed on a constant value. In this case, the averaging process would yield a numerical result which converged on the constant value. If oscillations were reported by the safety or chase pilot, or if oscillations were obvious in the strip chart recordings, the averaging procedure was supplemented by a detailed description of actual flight performance.

The time constraints inherent in a development program were also an important factor in choosing data reduction methods. It was obvious, for example, that every performance capability could not be evaluated in all instances where a command mode was engaged. As a practical alternative, performance was sampled for a 20- to 40-second interval (data point) during a scheduled event, and overall evaluations were based on the cumulative results from these sampled data points. The strip chart recordings satisfied the need for quick-look data since they were immediately available for study following a test flight.

a. Magnetic Tape Digital Data

Digital uplink and downlink data were recorded on a FR 1800 seven-track tape at 15 ips. The specific data recorded are depicted in Tables 6 and 7, and in Section IV, paragraph 2.b. The digital data is accurate to 0.3 percent rms and was experimentally determined to be 0.27 percent rms (refer to data summary for QF-102 Record Flight No. 2, Appendix A). This accuracy applies to the ten bits of available data in each proportional channel.

Computer listings of selected data channels were normally available 1 to 2 weeks following a flight. Each listing contained the following flight information versus time (1 second samples): altitude, attitude rate, airspeed, Mach, g-force, EPR, radar attitude, pitch, roll, heading, and discretes 1 through 8. Additional downlink and uplink information was available upon request and required additional processing time.

These digital listings were used to calculate and summarize performance values of interest during a specified time interval. The initial or nominal value of a flight parameter was determined by taking a short-term average of the parameter once it had stabilized during a test event or data point. If the parameter did not stabilize during the data point a detailed performance description was provided in the analyst's summary of the flight. Once a nominal value was determined, the average deviation of the parameter from nominal was calculated over the test interval. This average deviation was compared wtih the tolerance limit to determine system compliance with the SOW. These results were summarized in figures following the narrative portion of each data analyst mission summary (Appendix A).

In addition to this data, plots of aircraft performance (bank angle and g-force) versus time were obtained for each maneuver presentation. The plots were obtained 3 to 5 weeks following a mission and are not included in this report. The primary function of the plots was to check the accuracy of the digital listing by presenting a continuous, rather than intermittent, stream of data. The plots were also useful in checking the amount of parity error present in the digital data.

Finally, seven-track formatted data tapes were obtained from the original magnetic tape approximately 6 to 8 weeks following a mission. All downlink data was stored on these tapes for future reference if necessary. The purpose of these tapes is to maintain complete mission records which are specifically adapted for computer analysis.

b. Strip Chart Data

Selected channels of proportional and discrete data were recorded on three Techni-Rite TR668 hot-pen recorders. The specific data channels are identified in Section IV, paragraph 2.b. Although the primary purpose of the strip charts was to provide quick-look evaluations, they could be used for a more comprehensive analysis if necessary.

In order to analyze the strip chart data comprehensively, individual traces were optically read, scaled, and stored as a set of discrete values versus time. Calculations could then be performed on these values as described in paragraph a. of this Appendix. The optical reading was accomplished by a data reducer operated by integrated systems, and subsequent calculations were performed using the White Sands Missile Range UNIVAC 1108 computer. Due to numerous hardware difficulties in the digital magnetic tape system, this type of analysis was routinely done for all test profile missions prior to July 1974. All record flights were analyzed using digital or analog magnetic tape systems with the above procedure as a backup capability.

c. Magnetic Tape Analog Data

As an alternate source of performance data, 20 selected analog inputs from the digital analog converters were recorded on magnetic tape. This analog information was subsequently digitalized using the general input converter at the Guidance Facility, Holloman Air Force Base. This digital data is accurate within 3 percent and if necessary can be used for the analysis as described in paragraph a. of this Appendix. The flight information contained on these tapes is the same as that provided by the listings of digital data described previously.

2. STATISTICAL ANALYSIS

The preceeding discussions have been concerned with the reduction and presentation of data points which summarize the observed flight performance during testing. The manipulation of this data in order to state conclusions and estimate future performance is covered in this section.

a. Normalized Performance Results

The SOW performance tolerance limits are listed in Section III. For many flight parameters, the limits are not constant but change with stated flight conditions. In the specific case of altitude performance above 10,000 feet, the tolerance limit continually changes with altitude and bank angle. This functional relationship between performance limits and flight conditions makes it very difficult to collect enough data points for generalized conclusions to be made about system performance.

In order to solve this problem, flight performance relative to the tolerance limits was normalized; that is, performance deviation during a specified control mode was divided by the SOW tolerance limit and presented as a result for that data point. For example, at 11,000 feet and 35 degrees of right bank, the tolerance limit for altitude is given by

$$\text{Altitude Limit} = (0.005) \times (11{,}000\ \text{feet}) + 35\ \text{feet} = 90\ \text{feet}.$$

If the magnitude of the altitude deviation during this data point is 60 feet, the normalized performance result is

$$\text{Normalized Altitude Deviation} = \frac{\text{Deviation}}{\text{Limit}} = \frac{60}{90} = 0.67.$$

This result may also be expressed as a percentage of the SOW tolerance limit, and in the above example, the result would be 67 percent. These normalized results are available from data points covering a wide range of flight regimes and changing tolerance limits.

The question now arises as to the validity of combining these normalized results when analyzing a flight control mode. Two assumptions appear to be necessary: First, that the flight control mode has similar operating characteristics over the flight regimes of interest. Second, that the performance deviations increase linearly with the tolerance limits as flight regimes change. With these assumptions, the normalized performance deviations give accurate indications of system performance and may be combined in analysis. The number of data points available for analysis thus increases dramatically for a specified control mode and allows more confidence to be placed in any statistical conclusions which are made.

b. Expected Performance and Confidence Levels

In order to perform a statistical analysis on the available performance data, certain standard assumptions have been made. First, the normalized performance deviations must be assumed to behave as a normally distributed random variable. Second, if an infinite number of data points are available, it is assumed that the average performance deviation is zero. Thus, for an infinite population of data points,

$$\text{Average Performance Deviation} = \overline{X}_{\infty} = 0$$

$$\text{One Sigma Performance Deviation} = \sigma_{\infty}$$

If σ_∞ can be determined, all statistical characteristics which apply to the performance deviations during a given control mode are known. Thus, 64 percent of all data points should have performance deviations within $\pm\sigma_\infty$. Nearly all performance deviations (99.9 percent) would be expected to be less than $3\sigma_\infty$. In short, a variety of statistical conclusions could be made given the standard deviation.

From the data points in the test program, a sample mean, $\overline{X}_n$, and sample deviation σ_n, can be found using,

$$\overline{X}_n = \sum_1^n X_i \Big/ N$$

$$\sigma_{n^2} = \sum_1^n X_i - \overline{X}_{n^2} \Big/ \left(N_1\right)$$

where X_i is the performance deviation for a specific data point. It is fortunate that, given σ_n, statistical tables have been published which will yield σ_∞ at a stated confidence level.

Since $\overline{X}_\infty$ has been assumed zero and σ_∞ is known, the results depicted in Table 2, Section IV, paragraph 2.a.(1), may now be explained. The demonstrated deviation range for a given flight parameter is simply σ_n. With this value and the number of data points N, standard statistical tables provide the estimated deviation range for an infinite number of data points, σ_∞, at a 95 percent confidence level.

To be more rigorous, the statistical tables at a 95 percent confidence level provide two constants, K_1 and K_2, such that

$$\sigma_{\infty 1} > K_1 \sigma_n \qquad \text{(95 percent confidence)}$$

and

$$\sigma_{\infty 1} < K_2 \sigma_n \qquad \text{(95 percent confidence)}$$

Since K_2 is always larger than K_1, the worst case results from selected $\sigma_{\infty 2}$, and this is the actual quantity listed as the estimated deviation range for future flights.

In addition to these quantities, statistical tables are also available that provide a worst case $3\sigma_\infty$ given σ_n and the number of sample points N. Specifically, the tables provide a constant, K, at a confidence level of 90 percent where

$$3\sigma_\infty = K\sigma_n \qquad \text{(90 percent confidence)}$$

Thus 99.9 percent of all future data points will have a range of performance deviation between $-K\sigma_n$ and $+K\sigma_n$.

The application of the above concepts to actual performance data is illustrated in Table B-1. It must be remembered that these results and those presented in Table 2 define the expected range of performance deviations and not the deviation itself. The most likely deviation for a single data point is statistically zero, but give a large group of data points, 64 percent are expected to have deviations between $-\sigma_\infty$ and $+\sigma_\infty$. For example, $\sigma_{\infty 2}$ for altitude hold from Table B-1 is 79.7 percent. If altitude hold performance during level flight below 10,000 feet is of interest, the deviation range is expected to be

$$(0.797) \times 50 \text{ feet tolerance} = 39.8 \text{ feet rms.}$$

Thus, 64 percent of the altitude hold data points will show altitude deviations between −39.8 feet and +39.8 feet.

TABLE B-1. AUTOMATIC FLIGHT CONTROL PERFORMANCE: STATISTICAL RESULTS

Calculation Update Date	Type of Data Points	Number Of Data	Average $\overline{X}_n$ (Percent)	σ_n (Percent)	σ_∞ 95 Percent Confidence (Percent)	Future Data Points[1] (Percent)	90 Percent Confidence	Tolerance Limits[2] (Percent)	Remarks
26 Sep 74	Altitude	53	-8.59	65.0	79.7 to 54.3	Between 79 and 93	3.0	195	Maximum bank angle during testing was 60 degrees
26 Sep 74	Airspeed	31	-11.5	49.9	65.6 to 39.6	Between 87 and 99	3.17	158	
26 Sep 74	Mach	36	-8.0	28.6	36.8 to 23.0	Between 99 and 100	3.11	89	
26 Sep 74	Roll (Non-program)	30	0.83	69.1	91.3 to 54.6	Between 72 and 93	3.17	219	
26 Sep 74	Heading	25	13.7	62.4	84.9 to 48.3	Between 76 and 96	3.9	243	
26 Sep 74	Pitch	33	-3.6	53.9	70.2 to 43.1	Between 84 and 98	3.17	171	

Notes: (1) Percent of future data points that can be expected to be shown within SOW tolerances by downlink data.
(2) All future data points (99 percent) as shown by data are expected to be within the percentage of tolerance limits.

APPENDIX C

AGENCY AGREEMENTS

This appendix consists of three written agreements concerning PQM-102 flight operations over the White Sands Missile Range and Holloman Air Force Base. Part I is a general agreement between the commanders of the Air Force Special Weapons Center and White Sands Missile Range on safety responsibilities for unmanned flights. Part II consists of an operational procedure which executes the philosophy stated in the general agreement (Part I). Part III is an agreement on accident accountability between the Air Force Special Weapons Center, the Armament Development and Test Center, and the Air Force Contract Management Division. There was no written agreement on operations between Air Force Systems Command and Tactical Air Command.

PART I - RANGE SAFETY RESPONSIBILITY

MEMORANDUM OF AGREEMENT

1. Purpose: This agreement defines the organization accepting supervisory safety responsibility for the unmanned (NULLO) phase of the PAVE DEUCE program being conducted at Holloman AFB, New Mexico and White Sands Missile Range, New Mexico.

2. Scope: This agreement applies to all aircraft flights of unmanned PQM-102 drones conducted as part of the PAVE DEUCE program.

3. Reference:

Interservice Agreement between the Commander, Air Force Special Weapons Center, and the Commanding General, White Sands Missile Range.

4. Policy and Guidance:

a. AFSWC will have full safety responsibility for that portion of the mission flight profile where the drone is approaching or over HAFB and outside the WSMR boundaries or within WSMR boundaries as defined in 4b. AFSWC will designate project test directors (PTD) at the Mobile Ground Station (MGS) and Fixed Ground Station (FGS) to execute this responsibility for each flight.

(1) The AFSWC PTD at the MGS will be designated responsible:

(a) from first motion at take off until the drone has completed first turn out of traffic pattern and is on heading for handover box.

(b) from the establishment of final approach until stop at completion of landing.

(2) The AFSWC PTD at the FGS will be designated responsible at all other times.

(3) The AFSWC PTD will have authority to destruct at all times that AFSWC is responsible for safety.

b. WSMR will have full responsibility for that portion of the flight profile where the drone is within WSMR range boundaries except for that portion of WSMR territory traversed during final landing approach (to include only that area of WSMR east of WSTM coordinate line X=572,500 and north of HAFB and south of WSTM coordinate line Y=388,500.) WSMR will designate a missile flight surveillance officer (MFSO) for each flight who will have full authority to destruct the drone or to take or require any other action which in his determination is necessary to carry out the WSMR safety responsibility.

c. While the drone is within WSMR range boundaries:

(1) The responsible AFSWC PTD as defined in 4(a) will insure execution of WSMR MFSO instructions.

(2) The AFSWC PTD at the FGS will be WSMR's single point of contact for transmittal of MFSO instructions to the drone controllers.

(3) Under specified emergency conditions the responsible AFSWC PTD may destruct the drone in accordance with specified pre-agreed procedures without awaiting MFSO concurrence. Under no other circumstances will the PTD take destruct action within WSMR boundaries without MFSO concurrence. These emergency conditions must be defined and appropriate procedures acceptable to both WSMR and AFSWC will be published prior to the first PQM-102 drone flight.

d. Procedures for transfer of ground control and safety responsibility during take off and landing phases will be coordinated between WSMR and AFSWC and published prior to the first PQM-102 drone flight.

e. For recognized potential emergency situations WSMR and AFSWC will coordinate to develop emergency procedures to be followed should these emergency situations arise during periods of WSMR safety responsibility. These procedures will be published prior to the first PQM-102 drone flight.

f. AFSWC will develop safety procedures to be followed during periods of AFSWC safety responsibility. These procedures will be published prior to the first PQM-102 drone flight.

g. AFSWC will be responsible for supplying WSMR with the results of any accident/incident investigation conducted on the PAVE DEUCE program if requested.

h. Public information releases will be in accordance with the provisions of reference in paragraph 3.

5. <u>Terms of this agreement</u>:

a. This agreement is effective when signed by the Commanding General, WSMR and the Commander, AFSWC. Any changes to the document will be only by mutual consent.

b. Procedures developed in response to this agreement may be changed through coordination between WSMR National Range Operations and AFSWC-6585/ST.

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PART II - HANDOVER, EMERGENCY, AND EMERGENCY DESTRUCT PROCEDURES FOR PQM-102 MISSIONS

1. PQM-102 HANDOVER PROCEDURE

In accordance with paragraph 4.d. of the Range Safety Responsibility Memorandum of Agreement (Part I), procedures for transfer of ground control and safety responsibility during takeoff and landing phases have been developed and are defined herein. These procedures may be changed only through prior coordination and mutual approval of the White Sands Missile Range NR-M and the 6585th Test Group (JT).

a. Takeoff Phase

Step 1: Handover control from MGS to FGS upon entering Box A.

Step 2: Command failsafe ON upon entering Box B.

Step 3: Command UHF receiver OFF upon successful completion of Step 2.

b. Landing Phase

Step 1: Command UHF receiver ON upon entering Box C.

Step 2: Command failsafe OFF upon successful completion.

Step 3: Handover control from FGS to MGS upon entering Box D.

Step 4: MGS verify control by maneuver sequence.

Step 5: Program test director at the FGS will request permission to proceed off range for landing at a line 6,000 yards from the White Sands Missile Range east boundary.

Step 6: If permission to proceed off range is granted by the Missile Flight Surveillance Officer, the program test director becomes responsible for off range flight.

c. Definitions of boxes are as follows (all numbers are WSTM):

Box A: Two statute miles wide centered on line defined by points P_1 (X = 533,500; Y = 363,000) and P_2 (X = 525,000; Y = 372,000).

Box B: Two statute miles wide centered on line defined by points P_2 (X = 525,000; Y = 372,000) and P_3 (X = 517,000; Y = 381,000).

Box C: Two statute miles wide centered on line defined by points P_4 (X = 517,500; Y = 403,000) and P_5 (X = 529,000; Y = 403,000).

Box D: Two statute miles wide centered on line defined by points P_5 (X = 529,000; Y = 403,000) and P_6 (X = 533,000; Y = 403,000).

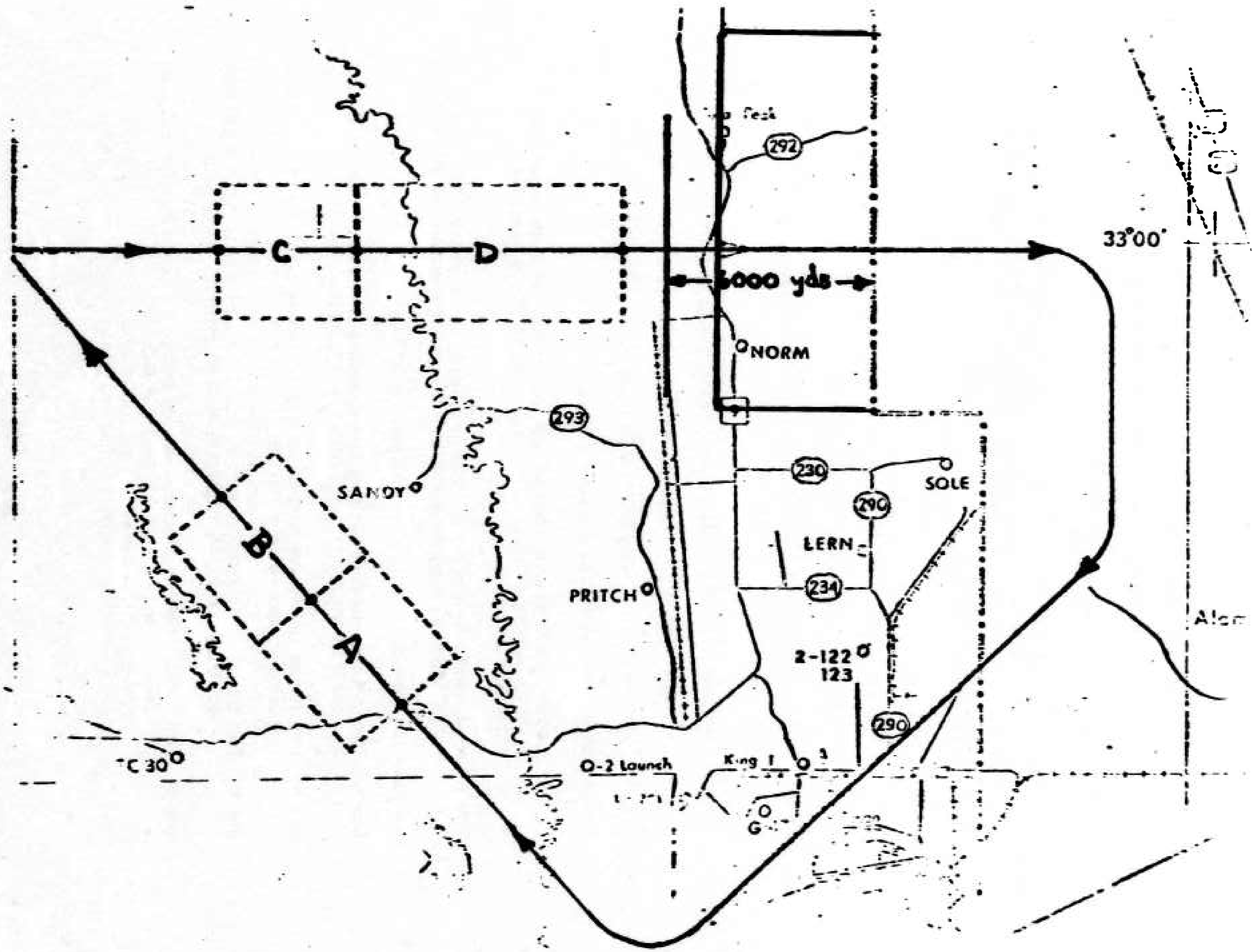


Figure C-1. Takeoff and Landing Range Area

2. PQM-102 EMERGENCY PROCEDURES

In accordance with paragraph 4.e. of the Range Safety Responsibility Memorandum of Agreement, several recognized potential emergency situations that could arise during periods of White Sands Missile Range safety responsibility have been defined and procedures have been developed. The narrative portion herein identifies procedures which will apply at all times during periods of White Sands Missile Range safety responsibility. Table C-1 identifies procedures applicable only to specific portions of the mission profile. These procedures may be changed only through prior coordination and mutual approval of the White Sands Missile Range NR-M and the 6585th Test Group (JT).

a. For each flight test profile, White Sands Missile Range will identify a safety boundary specific to that profile. Avoidance of encroachment of this boundary by the drone will override all other mission requirements.

Procedure: The drone controller will take any flight control action necessary to avoid encroachment of the safety boundary.

The program test director at the FGS will notify the Missile Safety Surveillance Officer immediately if the drone flight pattern is broken to avoid safety boundary.

b. In any instance where an abnormal flight condition is detected in the drone, the program test director at the FGS will communicate this information immediately to the Missile Flight Surveillance Officer.

c. Destruction of the drone will be at the discretion of the Missile Flight Surveillance Officer.

Procedure: Dependent upon situation.

The program test director will monitor HEFU Arm indicator for warning of imminent destruct possibility.

d. The MGS will at all times maintain failsafe ON/OFF command in same status as currently commanded by the FGS.

Procedure: The program test director will verify failsafe system status.

e. If a fire is confirmed aboard the drone, placing the command control or safety systems in imminent jeopardy, destruct action must be taken immediately.

Procedure: Reduce throttle.
Command dive.
Command destruct.
If failsafe system ON, switch all ground control stations to track mode.

f. If drone landing cannot be accomplished safely at Holloman Air Force Base, with the concurrence of the Missile Flight Surveillance Officer, an attempt may be made to land the drone at Northrup Strip under the FGS control.

Procedure: The program test director will notify the Missile Flight Surveillance Officer of the emergency situation and request permission for emergency landing.

If permission is granted by the Missile Flight Surveillance Officer, initiate landing procedure.

If permission is not granted by the Missile Flight Surveillance Officer or if emergency landing cannot be executed, proceed with Missile Flight Surveillance Officer's instructions for destruct of drone over the White Sands Missile Range.

g. Loss of drone position display at King I.

Procedure: The program test director will immediately obtain drone position data from the MGS and proceed with the Missile Flight Surveillance Officer's instructions.

h. Loss of drone position display at MGS.

Procedure: The program test director will notify the Missile Flight Surveillance Officer immediately and proceed in accordance with his instructions.

3. PQM-102 EMERGENCY DESTRUCT PROCEDURES

In accordance with paragraph 4.c.(3) of the Range Safety Responsibility Memorandum of Agreement, the responsible Air Force Special Weapons Center program test director may destruct the PQM-102 drone within boundaries under specified emergency conditions without awaiting the White Sands Missile Range Missile Flight Surveillance Officer's concurrence. These specified emergency conditions and the pre-agreed sequence of actions are defined in Table C-2. Under no other circumstances will the program test director take destruct action within White Sands Missile Range boundaries without concurrence of the Missile Flight Surveillance Officer. These procedures may be changed only through prior coordination and mutual approval of the White Sands Missile Range NR-M and the 6585th Test Group (JT).

TABLE C-1. PQM-102 SPECIFIC MISSION PROFILE EMERGENCY PROCEDURES

Mission Segment	UHF Condition	Failsafe Condition	MGS Mode	FGS Mode	Responsibility	System/Drone Response and Required Action
Takeoff Leg (Range boundary to handover box)	ON	OFF	Control	Tracking	Program Test Director	Normal for takeoff leg
	ON	OFF	LOC	Tracking	Program Test Director	MGS experiences LOC: 1. Switch to FGS control 2. Proceed to handover box for entry 3. Await White Sands Missile Range decision to continue
	ON	OFF	LOC	LOC	Program Test Director	LOC Malfunction: Notify Missile Flight Surveillance Officer immediately
	ON	OFF	Control	N/A	Program Test Director	No valid radar position data FGS and MGS: Apply automatic takeoff mode
Handover (entry)	OFF	ON	Tracking	Control	White Sands Missile Range	Normal for handover completion
	ON	OFF	Tracking	LOC	Program Test Director	FGS unable to assume control within Box A: 1. MGS resume control 2. Turn on failsafe system 3. Enter right hand orbit centered at WSTM coordinates (X = 500,000; Y = 400,000) 4. Prepare to initiate landing procedure
	ON	OFF	Tracking	Control	Program Test Director	LOC malfunction prior to Box B: Notify Missile Flight Surveillance Officer immediately

TABLE C-1. PQM-102 SPECIFIC MISSION PROFILE EMERGENCY PROCEDURES (CONTINUED)

Mission Segment	UHF Condition	Failsafe Condition	MGS Mode	FGS Mode	Responsibility	System/Drone Response and Required Action
	ON	OFF	Tracking	Control	Program Test Director	Failsafe fails to switch on: Program test director initiates landing procedure
	ON	ON	Tracking	Control	Program Test Director	UHF fails to switch off: 1. White Sands Missile Range will decide whether to proceed with mission 2. If unable to proceed, program test director will initiate landing procedure
Inflight	OFF	ON	Tracking	Control	White Sands Missile Range	Normal flight conditions
	OFF	ON	Tracking	LOC	White Sands Missile Range	FGS experiences LOC: 1. MGS assumes control, verifies failsafe on 2. Turn drone immediately toward interior of White Sands Missile Range 3. Take heading toward WSTM coordinates (X = 500,000; Y = 400,000) and/or enter right hand orbit centered at this point
	OFF	ON	No Track	Control	White Sands Missile Range	MGS loses track: Notify Missile Flight Surveillance Officer immediately
Handover (return)	ON	OFF	Control	Tracking	Program Test Director	Normal for handover completion

TABLE C-1. PQM-102 SPECIFIC MISSION PROFILE EMERGENCY PROCEDURES (CONCLUDED)

Mission Segment	UHF Condition	Failsafe Condition	MGS Mode	FGS Mode	Responsibility	System/Drone Respones and Required Action
	OFF	ON	Tracking	Control	White Sands Missile Range	UHF will not turn on: Program test director will decide whether to continue with handover procedure
	ON	ON	Tracking	Control	White Sands Missile Range	Failsafe will not turn off: Program test director will decide whether to continue with handover procedure
	ON	ON	Tracking	Control	White Sands Missile Range	MGS unable to assume control: 1. FGS resume control 2. Initiate left turn immediately 3. Proceed to right hand orbit centered at WSTM coordinate (X = 500,000; Y = 400,000) 4. Attempt correction of MGS failure
	ON	OFF	LOC	LOC	White Sands Missile Range	LOC malfunction: Program test director will notify Missile Flight Surveillance Officer immediately

TABLE C-2. EMERGENCY CONDITIONS

Normal Conditions	Emergency Condition	Source of Actions
(1) Any	Fire Aboard Drone: Imminent danger to command control or safety systems	Reduce throttle. Command - maximum drive. Command destruct. If failsafe system ON, switch all ground stations to tracking mode.
(2) Following completion of handover procedure, landing phase, step 6.	Any	Drone may be destructed at the program test director's discretion within area defined by the following: WSTM coordinate line X = 560,000 WSTM coordinate line Y = 422,000 WSTM coordinate line Y = 386,000 White Sands Missile Range eastern boundary

PART III - PQM-102 ACCIDENT ACCOUNTABILITY MEMORANDUM OF AGREEMENT

1. PURPOSE. This agreement defines the organization accepting supervisory responsibility and accident/incident accountability for aircraft, missiles, or drones during the phase of the "Pave Deuce" Program conducted at Holloman AFB, New Mexico.

2. SCOPE. This agreement applies to all aircraft, drones, and missiles assigned to the "Pave Deuce" Program under the operational control of AFCMD and AFSWC at Holloman AFB.

3. REFERENCES:

a. Paragraph 2b(13), AFSC Supplement 1 to AFR 80-14, dated 9 July 1973

b. Paragraph 9c(6)(a), AFSC Supplement 1 to AFR 127-4, dated 5 June 1973

c. Paragraphs 9c(3) and 9c(4), AFR 127-4, dated 1 January 1973

d. AFSC/IGF letter, "Aircraft Accident Accountability," dated 17 October 1973

4. POLICY AND GUIDANCE:

a. AFCMD will have mishap reporting and investigative responsibilities for the "Pave Deuce" Program under its cognizance at Holloman AFB. AFSWC and ADTC will have at least one voting member each appointed to Accident/Incident Investigation Boards if requested by the Commander, AFSWC, and/or the Commander, ADTC.

b. If an aircraft, drone, or missile mishap occurs, AFCMD will accept responsibility for AFCMD or contractor personnel and/or procedural error.

c. If an aircraft, drone, or missile mishap occurs, AFSWC will accept responsibility for personnel and/or procedural error on the part of AFSWC or personnel under the supervisory control of AFSWC.

d. If an aircraft, drone, or missile mishap occurs, ADTC will accept responsibility for deficiencies in the design as approved by the SPO.

e. Accident accountability will be assigned by the mishap investigating officer/board to the organization most responsible for the mishap.

5. TERMS OF THIS AGREEMENT. This agreement is effective when signed by the Commander, AFCMD, the Commander, AFSWC, and the Commander, ADTC. Any changes to the document will be only by mutual consent.

HENRY B. KUCHEMAN, JR Maj Gen, USAF Commander, Armament Development and Test Center	THOMAS W. MORGAN Maj Gen, USAF Commander, AF Special Weapons Center	DONALD G. NUNN Maj Gen, USAF Commander, AF Contract Management Division

APPENDIX D

PQM-102 TARGET SYSTEM RELOCATION

1. At the completion of the DT&E/IOT&E effort at Holloman Air Force Base, the majority of the development resources were relocated to the primary target system operating location at Tyndall Air Force Base. These development assets consisted of QF-102 and PQM-102 aerospace vehicles; ground control equipment for remote operations; test/checkout equipment; aircraft equipment spares; and F/PQM-102 peculiar AGE. The major relocation effort began on 3 February 1975 and was completed by 1 March 1975. During this period, the support equipment was prepared and transported; two PQM-102 aircraft were re-manrated and ferried; two QF-102 aircraft were ferried; and the vehicles and support equipment were setup and operationally verified at Tyndall Air Force Base.

2. The participating organizations in the relocation were the PQM-102 SPO, the Air Force Contract Management Division, the Air Defense Weapons Center, and the prime contractor. The PQM-102 SPO provided overall management support for the relocation effort including the procuring and funding of transportation, providing logistics and engineering support, and directing the system setup and checkout at Tyndall Air Force Base. The Air Force Contract Management Division provided coordination for a local Holloman Air Force Base support and acted as the government on-site representative to monitor the re-manrating effort and other contract requirements. At Tyndall Air Force Base, the Air Defense Weapons Center arranged for local support and provided coordination on matters relating to facilities, operational requirements, and procedures demonstration for the target system activation. The prime system contractor provided the following support:

a. Prepared an inventory of all equipment to be relocated.

b. Took down and prepared equipment for shipment.

c. Packed and crated selected equipment including the MGS and various RF laboratory equipment.

d. Assisted in the loading/unloading of transportation vehicles.

e. Unpacked, setup, and operationally checked the relocated equipment.

f. Coordinated with the PQM-102 SPO on procedures and prepared modification instructions to re-manrate the PQM-102 aircraft.

g. Re-manrated the PQM-102 aircraft.

h. Prepared and ferried the QF/PQM-102 aircraft from Holloman Air Force Base to Tyndall Air Force Base.

i. Assisted in the development of an operational plan to verify the PQM-102 Target System interface with Tyndall Air Force Base.

j. Coordinated with the government agencies to interface contractor and government efforts during the relocation.

3. The tasks to accomplish the relocation were basically organized into two functional areas: (1) equipment preparation and transportation, and (2) aircraft preparation and ferry. A brief synopsis of these tasks is as follows:

a. The major portion of equipment preparation was the disassembly and securing of the larger items including the non-power AGE, the external antennas and consoles on the MGS, and the system test benches and related equipment in the RF laboratory. In addition, the bits and pieces of spare materials and equipment in the contractor's supply area required packing and crating by government provided support. The total time required to prepare the equipment was approximately 10 work days.

b. To transport the equipment, requests were submitted for opportune airlift on C-130 aircraft through the Air Force Reserve. Due to the general non-availability of opportune airlift support, only one load of equipment was transported by C-130 aircraft. The remaining equipment was transported by surface shipment which included four electronic van and four flatbed truck loads. The average intransit time to transport the equipment was three days. The total transportation cost for the relocation of equipment to Tyndall Air Force Base was approximately $14,000, with the electronic vans costing approximately $2,200 per load, and the flatbed trucks costing approximately $1,300 per load.

c. To re-manrate the PQM-102 aircraft, the following general tasks were accomplished:

(1) The FCSS pallet was removed.

(2) Provisions for emergency and normal landing gear systems were installed.

(3) The ran air turbine, control stick, seat and egress system, and flight and navigational instruments were reinstalled.

(4) Miscellaneous drone peculiar hardware were secured and the cockpit cabin was sealed for pressurization.

(5) Various affected aircraft systems were operationally checked in accordance with standard F-102 Technical Orders and an abbreviated functional check flight was completed on both PQM-102 aircraft.

The above tasks required approximately 260 manhours per aircraft and were completed in 11 work days.

d. The two QF-102 aircraft, FAD 602 and FAD 603, were ferried on 6 February 1975 and the two PQM-102 aircraft, FAD 605 and FAD 608, were ferried on 19 February 1975. The ferry flights were accomplished without incident and all aircraft arrived at Tyndall Air Force Base in commission.

4. The operational verification at Tyndall Air Force Base began on 18 February 1975 with formal transition of target system to the Air Defense Center on 1 April 1975.

APPENDIX E

FINAL TEST REPORT OF QF/PQM-102, PROJECT PAVE DEUCE

This appendix is organized into four parts, representing operational results, remaining development test topics, general comments, and QF/PQM-102 aircraft performance summary. Project PAVE DEUCE and its supportive efforts closed on 31 January 1975. Including pilot proficiency flights, a grand total of 287 flights were flown at Holloman Air Force Base, including 23 NULLO flights. During the last 18 NULLO missions, 31 missiles, not including HVAR firings, were launched. The system sustained six hits with four drones destroyed.

1. OPERATIONAL RESULTS

a. Tables E-1, E-2, and E-3 detail the operational use of the system. The most significant statistic is the 1.3 missiles fired per scheduled PQM-102 mission. Table E-3 cancellations refer only to the PQM-102 missions.

b. Three significant events took place on the last day (31 January 1975) of operational flying at Holloman Air Force Base. The first was the successful morning launch of PQM-102, FAD 607; the second was the successful launch of PQM-102, FAD 601 in the afternoon; and the third was the unsuccessful recovery of PQM-102, FAD 601, at Holloman Air Force Base.

c. The morning flight was significant in that it was the first flight at Holloman Air Force Base for PQM-102, FAD 607. The drone performed well and provided a maneuver for the first target presentation exactly as planned. The drone was hit by the AIM-9L missile on the first hot firing and was destroyed.

d. The afternoon flight was unique in that it successfully met the unprecedented operational demand for two missions in one day. Although a minor gyro compass problem evolved early in the flight, the drone successfully accomplished two target presentations. The second missile firing resulted in damage to the vertical stabilizer of the drone. The drone was controllable and recovered at Holloman Air Force Base.

e. PQM-102 drone operations at Holloman Air Force Base were hampered by the requirement to have the White Sands National Monument closed for all takeoffs. During the last two days of operation, this requirement was deleted for missions utilizing drone FAD 601. This action resulted in the successful accomplishment of two afternoon missions which could not have been accomplished under the previously existing rule. Deleting the closed monument restriction definitely added flexibility to range scheduling, and, as was demonstrated on the final day of operation, permitted maximum operational capabilities by allowing two launches in a single day.

2. DEVELOPMENT TEST TASKS

a. PQM-102 Mission Evaluations:

Method: Evaluation of PQM-102 missions was modified as the program moved into the target presentation phase. Complete PCM and Sanborne strip data were recorded for each flight. No attempt was made to reduce or evaluate any data except to provide the shooters with a strip chart of the drone's performance during the presentation and missile launch. As all target presentation missions were satisfactory (from the standpoint of the PQM-102 performance), only qualitative observations were recorded. Hence, Table E-4 lists only the significant comments relative to the PQM-102 operation from 1 November 1974 through 31 January 1975.

TABLE E-1. AIM TESTING: RESULTS TO DATE

Series		Missions					Presentations			
				Abort						
AIM	Phase	Scheduled	Flown	Contractor	Projected	Weather	Captive	Target	Shots	Hits
9J	1	8	7	1			10	4	3	0
9L NTE	1	2	2				3	2	2	0
9J	2	10	6	1	2	1	4	10	8	1
7E-3	1	4	2	2			3	4	2	0
9L NTE	2	3	2			1	3	1	1	1 Kill
9J	3	1	1					3	3	1 Kill
9L IOT&E	1	3	3				10	1	1	1
9J	4	4	3			1	1	6	6	0
9L IOT&E	2	3	2			1		4	4	2 Kill
Totals:		38	28	4	2	4	34	35	31	2 Hit 4 Kill

TABLE E-2. PAVE DEUCE SCOREBOARD

Missile	PQM-102 Missions		Results		
	Scheduled	Flown	Fired	Hit	Kill
AIM-9J	14	11	21	2	1
AIM-9L	7	6	8	4	3
AIM-7E-3	3	1	2	0	0
Totals:	24	18	31	6	4

TABLE E-3. CANCELLATIONS

Date	Missile	Contractor	Weather	Comments
1 Oct 74	AIM-9J	X		HEFU
8 Oct 74	AIM-9J		X	
4 Dec 74	AIM-7E-3	X		Both failed checkout
5 Dec 74	AIM-7E-3	X		Both failed checkout
22 Jan 75	AIM-9J		X	
29 Jan 75	AIM-9L		X	
Totals:		3	3	

TABLE E-4. PQM-102 MISSION EVALUATION

Official PQM-102 Flight No.	Flight Date	PQM-102 No.	Significant Comments
9	1 Nov 74	606	ECU inoperative. Excellent mission. First maneuver limited to 5g because of fuel load (AIM-9L, 2 shots).
10	6 Nov 74	606	On takeoff roll (approximately 130,000) the automatic takeoff mode unlatched. The MGS elevator controller recognized the problem and completed a manual takeoff. During flight, the RMI hung up twice giving errors to 30 degrees, for landing, the RMI was corrected. Overall, the mission was satisfactory (AIM-9J, 1 shot).
11	12 Nov 74	605	The MGS primary antenna was inoperative causing a backup antenna recovery. Otherwise the mission was good (AIM-9J, 3 shots).
12	20 Nov 74	606	One PQM-102 problem: On first pass (5g), the gear unsafe light came on; after recycling, the light remained off. All presentations were within specification limits; mission was good (AIM-9J, 2 shots).
13	22 Nov 74	605	Excellent mission throughout. All procedures and actions were smooth. Drone sustained missile hit on left elevon (AIM-9J, 2 shots).
14	7 Dec 74	606	Best mission to date in terms of PQM-102 performance. No discrepancies (AIM-7E-3, 2 shots).
15	11 Dec 74	606	Good mission. First hot pass aborted because of FGS controller's mistake; no effect on mission. Drone killed on first shot (AIM-9L, 1 shot).
16	17 Dec 74	604	Good launch and presentations. Third missile severely damaged drone. Controllers did an excellent job recovering at Northrup Strip (AIM-9J, 3 shots).
17	15 Jan 75	605	Good mission; drone hit on second pass. G loading at intercept was 7.7 (set at 8g). Drone was recovered at Holloman Air Force Base. Damage: Destroyed aspirator and afterburner can. No damage to engine mounts (AIM-9L, 1 shot).
18	21 Jan 75	601	First NULLO mission for QF-102. One good 5g presentation was made. The drone experienced numerous data loss problems at the FGS (AIM-9J, 1 shot).

TABLE E-4. PQM-102 MISSION EVALUATION (CONCLUDED)

Official PQM-102 Flight No.	Flight Date	PQM-102 No.	Significant Comments
19	27 Jan 75	601	Excellent mission. Three high quality presentations (one 5g, two 6g) made. The only problem was a 7-degree left bank after take-off. The situation was corrected (AIM-9J, 3 shots).
20	28 Jan 75	601	Good mission with two successful 6g presentations made. There was some difficulty with the afterburner not lighting. Also, King I communication problems caused one aborted pass (AIM-9J, 2 shots).
21	30 Jan 75	601	One presentation was made (8g). Another was aborted due to vectorer error. A third attempt was not made because of uncertainty on the fuel gauge reading. This was also the first flight not requiring Monument closure (AIM-9L, 1 shot).
22	31 Jan 75 Morning	607	One presentation was made resulting in a kill (8g). This was the first NULLO flight of drone 607. All went well except for an aborted pass due to the afterburner not lighting (AIM-9L, 1 shot).
23	31 Jan 75 Afternoon	601	Two successful presentations were made both at 8g. The second resulted in a hit; the drone was destroyed in an unsuccessful attempt to recover at Holloman Air Force Base. This was the first time two PQM-102 missions were conducted in one day. (AIM-9L, 2 shots).

Conclusion: The PQM-102 target presentation flights have been very successful. The operating and emergency procedures were complete and effectively used. System design redundancy should provide the necessary safety margin for a reliable and efficient target system.

b. Evaluation of LAMP Systems with FGS in Control:

The LAMP systems were evaluated on a manned captive flight on 23 January 1975 near Northrup Strip. QF-102, FAD 603, was used. The weather was clear, no turbulence, and the temperature was +47 degrees Fahrenheit.

Both modes, radar and barometric altimeter, were tested. The system worked as designed, as these observed values demonstrate:

Maneuver One: Radar Altitude

	Planned	Actual
Airspeed	0.8M	0.79M
Degree Roll	0 degree	0 degree
Descend to	500 feet AGL	485 feet AGL
For Seconds	30	30
Up Pitch	+30 degrees	+28 degrees

Maneuver Two: Barometric Altitude

	Planned	Actual
Airspeed	0.8M	0.78M
Degree Roll	0 degree	0 degree
Descend to	4600 feet AGL	4500 feet AGL
For Seconds	30	30
Up Pitch	+30 degrees	+28 degrees

In summary, the LAMP systems work completely satisfactory under FGS control.

c. Nose Wheel Steering Modification:

The requirement for an improved remote control nose wheel steering system became evident early in the DT&E program at Holloman Air Force Base. The original remote control circuitry limited nose wheel steering control authority during taxi such that heading changes greater than 10 degrees required reengagement of the skid command switch several times to accomplish the desired turn. During takeoffs and landings in the landing/takeoff mode, the original nose wheel steering circuit configuration demonstrated control lag characteristics resulting in erratic aircraft control commonly referred to as snaking.

The remote nose wheel steering circuit modification started by changing the system circuit integrator to a lag amplifier, synchronizing heading during skid command, and increasing the command time constant. Later, the heading hold gain was varied for evaluation and the skid command authority decreased 20 percent. The last change in the circuit was to add a 1-second delay to the heading hold latch for smooth transition to the new heading.

By changing the nose wheel steering skid command circuit from integrator sum with heading error to lagged amplifier with delayed heading synchronization, remote nose wheel steering commands resulted in more effective and efficient aircraft response. This final modified circuit configuration was incorporated into two QF-102 aircraft for evaluation and improved remote nose wheel steering control was evident in both aircraft. Taxi tests and flight tests were conducted on both aircraft to insure that skid commands in the landing/takeoff mode did not adversely affect flight performance in the takeoff and landing phase. No abnormal flight performance was noted for either aircraft although taxi tests revealed slightly better nose wheel steering response from one aircraft than demonstrated by the other. This slightly different taxi response was determined to be the result of differences inherent in the nose wheel steering systems of the two aircraft.

d. Evaluation of 8g Maneuver:

The DT&E SOW called for the PQM-102 aircraft to demonstrate an 8g (±0.5g) capability with a maximum overshoot of 1g. This capability was demonstrated during the AIM-9L IOT&E. Flights took place on 15 January 1975, 30 January 1975, and two sorties on 31 January 1975.

Two techniques were used: For low aspect angle shots, the maneuver programmer commanded an immediate buildup to 8g. For medium to high aspect angle shots (greater than 60 degrees), the maneuver programmer was set to hold 5g until just before missile launch. The drone then was commanded to 8g, buildup began, the missile was launched, and the missile impact/near miss occurred.

Figure E-1 shows g histories of these two techniques. In the low aspect case, approximately 8 seconds were required to reach 8g. Termination was caused by a drone hit. In the high aspect case, 22 seconds of 5g turn with buildup are shown (the programmed value). The drone then increased its bank, where 10 seconds of stable 8g were demonstrated.

As shown in both cases, the system demonstrated an excellent 8g capability. Overshoot and ±0.5g deviation appear to be within specifications although the trace is quite noisy. All the above results were substantiated by the other presentations. The only possible problem is performance at medium altitudes. All flights except one, took place below 8500 feet MSL. The one 8g presentation above 8500 feet (20,000 feet) was terminated by a missile hit.

e. DPN-82 Transponder Evaluation:

The objective was to evaluate the DPN-82 transponder for EMI/EMC. No EMI related problems have been observed on the NULLO missions flown to date. Operation of the DPN-82 was verified on several NULLO flights. Contact with Holloman Air Force Base RAPCON indicated reception of a weak signal from the DPN-82 in each case. Recommend ground test equipment be obtained in order to insure proper operation of the DPN-82.

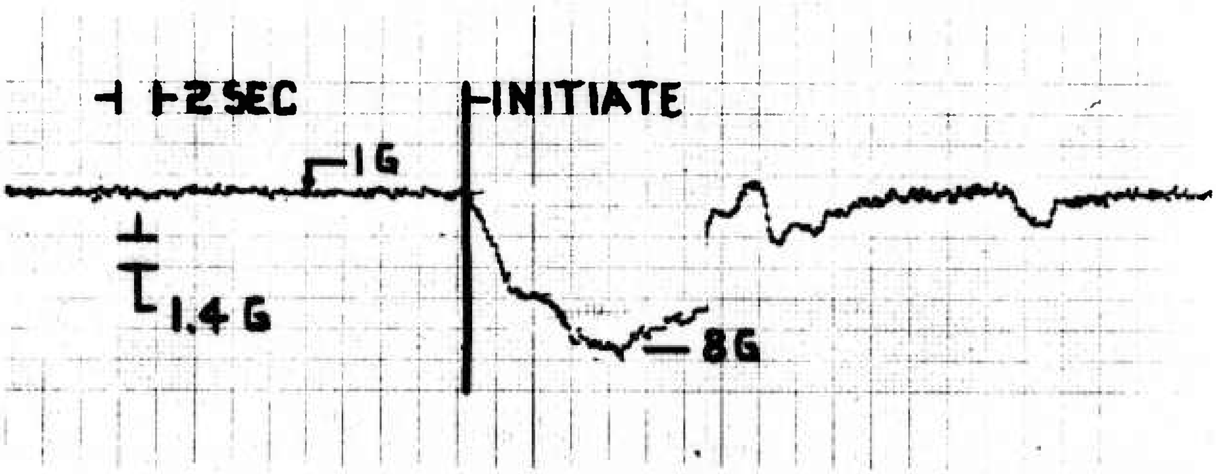
f. Evaluation of FGS Control over South End of White Sands Missile Range.

<u>Introduction</u>: Data was requested to evaluate the ability of the FGS to control a target on the south end of the White Sands Missile Range near Launch Complex 34 (LC-34), or WSTM coordinates X = 470,000; Y = 150,000. The flight was conducted on 12 December 1974 using the following equipment:

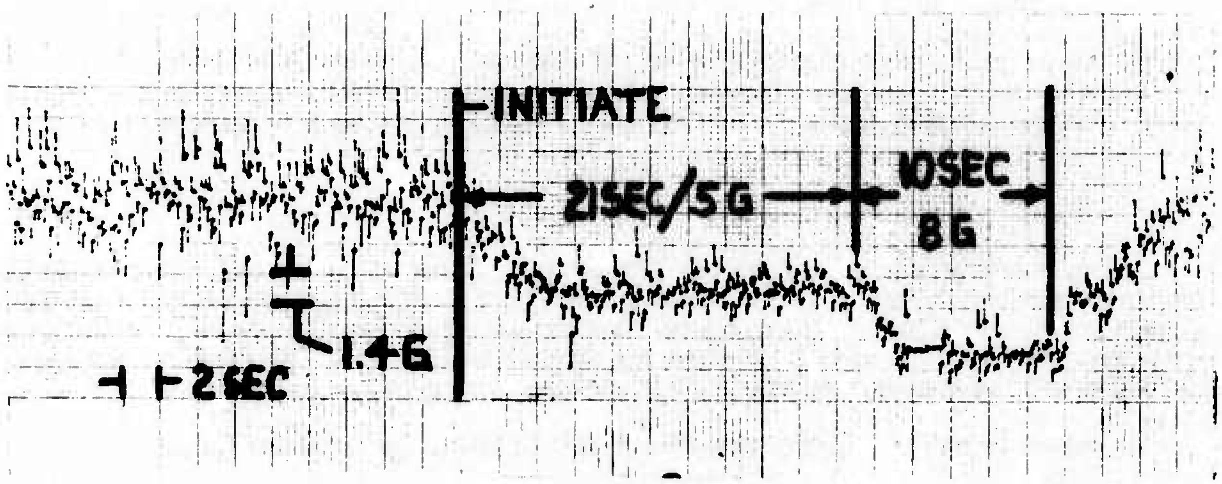
QF-102 Aircraft, FAD 603

FPS-16 Radars R-122D/123D Control, R-113D Skin Track

No MGS; FGS fully operative



Low Aspect Case



High Aspect Case

Figure E-1. 8g Maneuver

Objective: Fly multiple tracks on a north to south run-in to LC-34 intercept area at 700, 500, and 200 feet AGL and ascertain position and time of all LOC and data loss. The White Sands Missile Range X–Y plot was to be annotated when either or both control radars lost control, track, or data.

Flight Conditions: Date - 12 December 1974; Technical Order - 1440L; Weather - clear; Temperature - +53 degrees Fahrenheit.

Mission Comments: After manual takeoff by the safety pilot, the aircraft made two orbits of Northrup Strip to enable the radars to acquire and lock-on. After acquisition, the runs began:

Run 1: 700 feet AGL; data and control remained solid. At 7 to 9 nmi from the intercept point, track became unsteady, R-122 lost data, and the run was terminated.

Run 2: 500 feet AGL; data, control, and track remained solid.

Run 3: 200 feet AGL; again, solid data, control, and track.

Run 4: Sufficient time and fuel enabled a fourth run. The track was moved west to determine any interference of the ridge line or mountains; 350 feet AGL; again, solid data, control, and track.

Conclusions: Run 1 was prematurely terminated. Data was lost on R-122 because the radar operator did not follow the drone. On subsequent runs, both operations followed the drone at all times.

Both control radars appear satisfactory for presentation purposes, given a down-range radar is available for skin track.

Any proposed low-level track should be planned and test-flown to assure that no ground towers would impair a safe operation.

3. GENERAL COMMENTS

a. UHF Communications at King I

UHF communications at King I presented the worst problem and the one which occurred most frequently throughout the Holloman Air Force Base/White Sands Missile Range phases. Several letters, detailing the instances and nature of the difficulties, have been sent to White Sands Missile Range. Any future plans for PQM-102 missions at White Sands Missile Range must take into consideration the limited capability of King I for UHF communications.

b. QF-102 Operations During Operational Phase

Contractor maintenance support deteriorated to the point that QF-102 aircraft use for shooter captive flights was unsatisfactory and unreliable. At least three captive flights had to be flown using F-4 shooter aircraft as the target. Future PQM-102 aircraft use should consider QF-102 aircraft support as integral to the system's suceess.

4. QF/PQM-102 TARGET SYSTEM OVERALL PERFORMANCE SUMMARY

The QF/PQM-102 Target System overall performance data is presented in Table E-5.

TABLE E-5. QF/PQM-102 TARGET SYSTEM OVERALL PERFORMANCE SUMMARY, IOT&E FLIGHTS - NULLOS 9 THROUGH 23 (1 NOVEMBER 1974 THROUGH 31 JANUARY 1975)

NULLO No.	Aircraft No.	Planned Kilo-feet MSL	Planned Entry Airspeed (knots)	Planned Bank (deg)	Planned g	Planned MP Phase	Actual Kilo-feet MSL	Actual Entry Airspeed (knots)	Actual Entry Airspeed T. Mach	Actual g	Actual Bank (deg)	Remarks
9	606	20	450	81R	6	2	20	450*	0.95	5	81R	Fuel quantity was above 4200 pounds; g force limited to 5.
		N/A	N/A	81R	7	-	N/A	N/A	N/A	-	N/A	Two AIM-9L missiles launched/missed this NULLO.
		20	425	81R	7	1	20	425	0.90	7	81R	
10	606	18	450	81R	6	1	18.4	475	0.97	6.5	81R	One AIM-9J launched/missed
		20	450	81R	7	1	20.3	462	0.96	7	81.5R	Shooter not positioned this presentation
11	605	18	450	78R	6	1	18.8	460	0.89	6.3	78R	One AIM-9J missile launched/missed during each of the three single phase presentations
		20	460	78R	6	1	20.7	462	0.94	5.3	78R	
		20	460	78R	5	1	21	450	0.96	5.4	78R	
12	606	18	435	81R	6	1	18	435	0.86	6	80R	One AIM-9J launched/missed
		20	435	78R	5	1	20	440	0.93	5.5	78R	One AIM-9J launched/missed
13	605	5.5	540	74R	5	1	5.5	540	0.92	5	70R	One AIM-9J launched/missed
		5.5	540	74R	5	1	5.5	540	0.92	5	70R	One AIM-9J launched/hit left elevon
		5.5	540	70R	5	1	5.5	540	0.92	5	70R	AIM-9J failed to launch
14	606	5.6	480	78R	5	1	5.6	480	0.80	5	78R	AIM-7E-3 failed to launch
		5.6	480	78R	5	1	5.6	480	0.80	5	78R	One AIM-7E-3 launched/missed
		14	420	81R	6	1	14	420	0.82	6	81R	One AIM-7E-3 launched/missed
15	606	18	460	78R	6	2	18.7	459	0.90	5.8	77R	
		N/A	N/A	78R	7	-	N/A	N/A	0.77	7.2	77R	One AIM-9L launched/kill

TABLE E-5. QF/PQM-102 TARGET SYSTEM OVERALL PERFORMANCE SUMMARY, IOT&E FLIGHTS - NULLOS 9 THROUGH 23 (1 NOVEMBER 1974 THROUGH 31 JANUARY 1975) CONCLUDED

NULLO No.	Aircraft No.	Planned					Actual					Remarks
		Kilo-feet MSL	Entry Airspeed (knots)	Bank (deg)	g	MP Phase	Kilo-feet MSL	Entry Airspeed (knots)	Entry Airspeed T. Mach	g	Bank (deg)	
16	604	20	450	78R	6	1	20	450	0.95	6	81R	One AIM-9J launched/missed
		20	450	81R	6	1	20	450	0.95	6	81R	One AIM-9J launched/missed
		20	450	81R	6	1	20	450	0.95	6	81R	One AIM-9J launched/hit. Target destroyed on landing Northrup Strip
17	605	20	465	85R	8	1	20	465	0.97	7.8	87R	One AIM-9L launched/hit. Recovered Holloman Air Force Base.
18	QF 601	20	465	78R	5	1	20	440	0.92	5.2	78R	One AIM-9J launched/missed
19	QF 601	10	550	78R	5	1	10.5	524	0.91	5.1	77R	One AIM-9J launched/missed
		10	535	81R	6	1	10.5	537	0.94	6.2	81R	One AIM-9J launched/missed
		10	535	81R	6	1	10.1	534	0.93	6	80R	One AIM-9J launched/missed
20	QF 601	18	465	81R	6	1	17.7	466	0.93	6.1	83R	One AIM-9J launched/missed
		18	465	81R	6	1	17.6	466	0.93	6.1	83R	One AIM-9J launched/missed. AIM-9J firings completed.
21	QF 601	12	560	78R	5	2	7.5	561	0.94	5	78R	One AIM-9L launched/missed.
		12	560	83R	6	1	N/A	N/A	N/A	6	83R	Mission flown at 7.5 due to weather.
22	607	8	560	83R	8	1	8	570	0.96	8.4	83R	One AIM-9L launched/direct hit/destroyed.
23	QF 601	8	560	83R	8	1	8	560	0.97	8	83R	One AIM-9L launched/missed
		8	560	83R	8	1	8	560	0.97	8	83	One AIM-9L launched/hit. Target destroyed upon recovery at Holloman Air Force Base.

*Not graded

APPENDIX F

SAMPLE 48-HOUR FLIGHT TEST PLAN

FOR QF/PQM-102 AIRCRAFT

Flight No. QF2-I-9 (RECORD)

Profile ONE (A)

Aircraft Serial Number 1347 Call Sign Leroi 02

Alternate Aircraft No. ______ Call Sign ______

Chase Aircraft No. ______ Call Sign ______

Mission Commander WOOD

Safety Pilot PEARCE

Mission Briefer PARKER/TOTTEN

Chase Pilot McCORMACK

Briefing Time 0900 / 29 July 74
Time Date

MGS Elevator Station PARKER

Rudder Station GEORGE

Radar Operator WILKINS

Sperry Engineer TUNHEIM

AF Representative SMITH

Takeoff Scheduled 1100 / 29 July 74
Time Date

Actual 1101 / 29 July 74
Time Date

FGS Control Position 1 TOTTEN

Control Position 2 WOOD

AF Representative HALSTEAD

Objectives:

- Remote Takeoff and Landing
- Control Transfer
- LOC Sequence Above Lower Reference Alt.
- Airspeed and Mach Hold During Climb
- Pitch, Roll, and Altitude Hold in Turns
- Single-Phase Programmed Maneuver
- Heading, Altitude, Airspeed, and Mach Hold

APPROVALS:

Earl S Pearce 27/07/
Chief Pilot Date

[signature] 27/07/
RTO Representative Date

Coordinated with RTO 27 JUL 74 1330
Date Time

DATE

FLIGHT NO.

ALT 25K'

EVENT	MODE	PARAMETER (A)	CRITERIA	SOW REF
1. Takeoff	Remote	ATO or Remote Manual	Completed	4.1.c & a
2. Handover MGS-FGS	As Required	As Required	Handover Completed	4.1.a
3. LOC Above Lower Reference Altitude	ATO ON Alt Hold OFF A/S on Thr OFF	270 Deg Hdg 8K Ft Press Alt 275 Kts Ref A/S	Completed	4.1.c(3)
*4. Climbout				
a. A/S Hold - Pitch	A/S on Pitch	280 Kts Ref A,6	± 2 KTs < 275 Kts ± 10 Kt > 278 Kts ± 10 Kts	4.1.1e
b. Mach Hold - Pitch	Mach on Pitch	0.6 Ref Mach	± .03 Mach ± 0.03 M	4.1.1e
5. Command Transfer FGS^1 - FGS^2 - FGS^1	As above	As above	Completed and control demonstrated	4.1.a
*6. a. Pitch Attitude Hold in Turn	Direct Pitch A/S On Throt	Rate Climb < ± 1000 ft/min 250 Kts Ref A/S 30° Bank Angle	± 0.5° ∅ < 20° ± 1.0° ∅ 21°-45° ± 2.0 ∅ > 45°	4.1.1g

DATE FLIGHT NO.

ALT 25K'

EVENT	MODE	PARAMETER (A)	CRITERIA	SOW REF
*6. b. Roll Attitude Hold in Turn	Stick Detent	As above	$\pm 1.0^{o}$ $\emptyset \leq 45^{o}$ $\pm 2.0^{o}$ $\emptyset > 45^{o}$ ±1.0 Deg	4.1.1.g
c. Altitude Hold in Turns	Alt Hold ON Stick Detent A/S On Throt	Current Altitude and As Above	1 ft/^{o} bank + 50 ft or 0.5% of Altitude whichever is greater ± 155 ft	4.1.1c
d. Handover FGS-MGS	As above	As above	Completed and control demonstrated	4.3.1.2(b)
e. Handover MGS-FGS	As above	As above	Completed	4.3.1.2(b)
*7. a. Heading Hold	Alt Hold ON MACH On Throt	25K Ft Press Alt 0.6 Ref Mach 188 Deg No wind hdg	$\pm 1^{o}$	4.1.1.h
b. Altitude Hold	As above	As above	± 50 ft or .5% of alt ± 125 ft	4.1.1.c
c. Mach Hold	Alt Hold ON Mach on Throt	25K Ft Press Alt 0.6 Ref Mach	± .03 Mach	4.1.1e
d. A/S Hold	Alt Hold ON A/S on Throt	25K Ft Press Alt 250 Kts Ref A/S	± 2 Kts < 275 Kts ± 10 Kts > 275 Kts	4.1.1e

DATE FLIGHT NO.

ALT 25K'

EVENT	MODE	PARAMETER (A)	CRITERIA	SOW REF
8. Maneuver Program - Single Phase	Alt Hold ON Man Select No 3	A/S Ref 300 Kts Degrees Roll 60 Rt- G Force * 2 Timer 36 sec. *N/A with Alt Hold ON	≥ 1G Buildup/Sec. ± .5G 1G Overshoot ± 1 ft/deg + 50 ft or 2% of Ind Alt with Alt Hold - ON ± 560 ft Bank ± 2 deg initially, then ± 2 deg of Reference Bank, Airspeed ± 10 Kts	4.1.d 4.1.1a 4.1.1c 4.1.1.i 4.1.1.j
9. a. Pitch Attitude Hold in Turn	Direct Pitch A/S On Throt	Rate of Climb < ± 1000 ft 250 Kts Ref A/S 60° Bank Angle	± 0.5 Ø < 20° ± 1.0° Ø 21°-45° ± 2.0° Ø > 45° ± 2.0 Deg	4.1.1.g
b. Roll Attitude Hold in Turn	Stick Detent	As above	± 1.0° Ø ≤ 45° ± 2.0° Ø > 45° ± 2.0 Deg	4.1.1g
c Altitude Hold in turn	As Above and Alt Hold ON	Current Altitude and As Above	± 1 ft/Deg Bank +50 ft or .5% of Altitude ± 185 ft	4.1.1c

DATE FLIGHT NO.

ALT 25K'

EVENT	MODE	PARAMETER (A)	CRITERIA	SOW REF
0. Descent	As Required	As Required	Completed	4.1.a
1. Handover FGS-MGS	As Required	As Required	Completed	4.1.a
2. Landing	Remote	As Required	Completed	4.1.d

These events are for demonstrating overall contract performance requirements IAW para 4.6.3a of the SOW and failure to satisfy these criteria on this sortie does not constitute an unsuccessful mission as relates to para 4.6.3b or 4.6.3c of the SOW.

NOTE: Any system or Mode that is engaged; ie, Altitude Hold, during this flight is subject to evaluation as required by para 4.6.3a of the SOW.

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6585 Test Gp/XO	8
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ADTC/SD102	25
AFATL/DLOSL	2
AFATL/DLM	4
ADTC/TGO	1
ADTC/TG	1
ADTC/TS	2
ADTC/CS	1
3201 ABG/HO	1

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