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Space Administration

Space Shuttle Program Orbiter Approach & Landing Test

OFFICE OF SPACE FLIGHT

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Pre-ALT Report

FOREWORD

The Orbiter Approach and Landing Test (ALT) Reports are published to provide senior NASA management with timely information on ALT program plans and accomplishments.

The ALT Reports will be comprised of this PRE-ALT REPORT, ALT PRE-FLIGHT MEMORANDA, and an ALT POST-FLIGHT REPORT following each flight.

The purpose of this PRE-ALT REPORT is to provide an overview of the ALT program, describing the flight vehicles involved and summarizing the planned flights. The ALT PRE-FLIGHT MEMORANDA will provide updated information as data of significance become available during the ALT program lifetime. The ALT POST-FLIGHT REPORTS will be memoranda covering accomplishments of individual flights.

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NASA HEADQUARTERS

MEMORANDUM

February 11, 1977

TO: A/Administrator

FROM: MH/Director, Space Shuttle Program

SUBJECT: Space Shuttle Orbiter Approach and Landing Test (ALT) Program

The first flight of the ALT Program for the Space Shuttle Orbiter will be conducted at the Dryden Flight Research Center at Edwards Air Force Base, California, not earlier than February 18, 1977. This flight will be the beginning of a planned 20-flight series.

The primary goal of the ALT Program is to verify safe, subsonic, aerodynamic flight and landing capability with an Orbiter, ground support equipment, and facilities configured as closely as practical to the hardware and software to be used in subsequent orbital missions.

The final flight of the ALT series is planned for January 1978.

M. S. Malkin

Approval:

John F. Yardley

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GENERAL

This report describes the Approach and Landing Test (ALT) Program for the Space Shuttle Orbiter. The ALT Program precedes the Orbital Flight Test (OFT) Program as the first of two series of flight tests in the overall Space Shuttle Program.

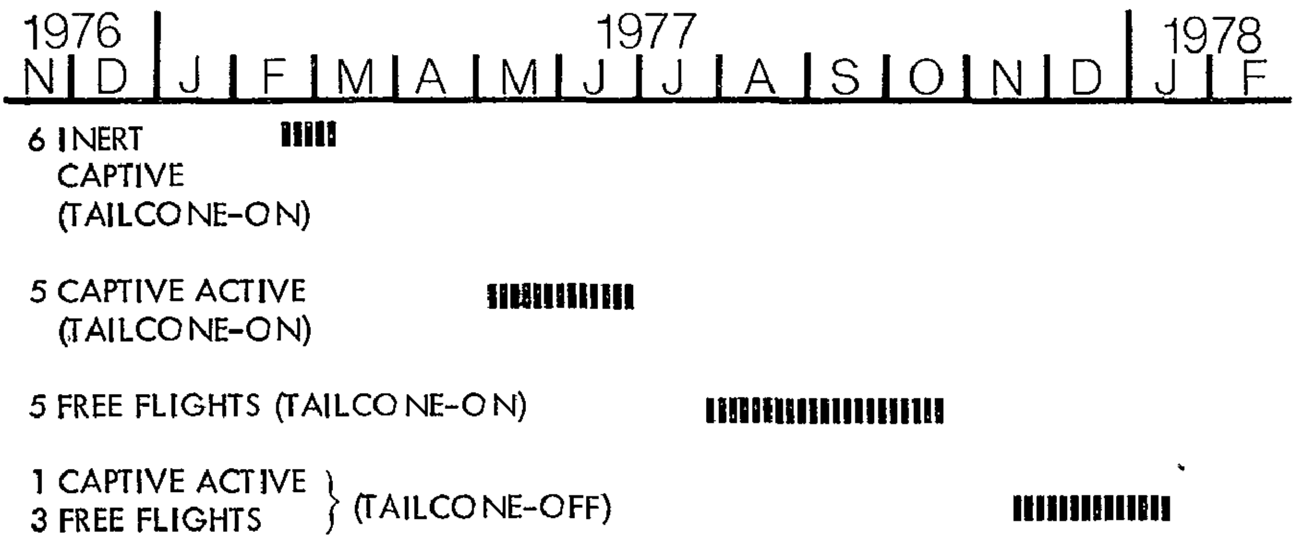
The primary goal of ALT is to gather sufficient flight test data to verify safe Orbiter subsonic aerodynamic flight and landing with an Orbiter, ground support equipment, and ground facilities configured as closely as practical to the hardware and software to be used in the approach and landing phase of subsequent orbital missions. The ALT program is designed to progress, in minimum steps consistent with flight safety, from test conditions that provide the greatest margins of safety to test conditions anticipated on the first OFT approach and landing.

ALT will be conducted at the NASA Dryden Flight Research Center (DFRC) at Edwards Air Force Base (EAFB), California. These tests are scheduled to begin in February 1977, in a series of Orbiter unmanned and manned flights atop a modified Boeing 747 jetliner, designated the Shuttle Carrier Aircraft (SCA). The exact number of flights to be flown in the ALT series will be determined as the program progresses; however, a provisional 20-flight schedule has been formed for planning purposes. Within this framework, the sequence of events will call for the Orbiter to be placed atop the 747 for a number of taxi runs along EAFB runways. The taxi-tests will be followed by six captive flights where the unmanned Orbiter will be carried to an altitude of approximately 25,000 feet by the 747, but not released. These unmanned Orbiter flights will be followed by a series of five captive flights, with the two-man ALT crew aboard the active Orbiter. These tests are designed to verify most of the Orbiter systems and crew procedures, as well as provide some verification of Orbiter dynamics and controllability. The first of eight free flights will be conducted in July 1977. The manned Orbiter will be released from the 747 carrier at about 24,000 feet, and will be flown to an unpowered landing about 5 minutes later on a dry lake bed landing strip at EAFB. The first five of the free flights, as with all of the preceding captive flights, will be flown with the Orbiter equipped with a tailcone. The tailcone is an aerodynamic fairing that attaches to the aft end of the Orbiter to reduce drag and alleviate buffeting of the mated SCA/Orbiter configuration and thereby increasing Orbiter launch altitude and flight time. Following the fifth tailcone-on free flight, a manned captive high speed taxi test and flight is planned with the tailcone off to evaluate SCA tail surface buffeting in that configuration. Based on the buffeting experienced, a decision will be made whether or not to proceed with up to three additional free flights with the tailcone off. Tailcone-off flights, if flown, will duplicate subsonic Orbiter aerodynamic characteristics that will be experienced during OFT approaches and landings. If tailcone-off flights are not flown, tailcone-off subsonic aerodynamic flight characteristics will be determined through analysis of the tailcone-on flight test results.

Summary descriptions of each flight, including profiles of the free flights, comprise the Appendix to this report.

The ALT Program is scheduled to be completed in January 1978. The ALT schedule is shown in Figure 1.

ALT SCHEDULE



NOTE: This schedule is for planning purposes only. The exact number of flights to be flown and the dates thereof will be established as the ALT program progresses.

Fig. 1

ALT OBJECTIVES

The overall objectives of the ALT Program are to:

- Verify an Orbiter pilot-guided approach and landing capability
- Demonstrate an Orbiter autoland capability
- Verify Orbiter subsonic airworthiness, integrated systems operation, and selected subsystems operation for first orbital flight
- Demonstrate an Orbiter capability to safely approach and land in selected control weight and center-of-gravity configurations within the operational envelope

FLIGHT DESCRIPTIONS

The ALT Program flight tests fall into three major categories. The initial flights involve the mated Orbiter/SCA with the Orbiter unmanned and all systems inert. The second category of flights relates to the mated Orbiter/SCA with the Orbiter manned and active. The final flights involve release of the active manned Orbiter for free flight.

INERT CAPTIVE FLIGHTS

The initial operations of the mated Orbiter/SCA will be performed with the Orbiter in the tailcone-on configuration, unmanned, and all systems inert. In this configuration, the Orbiter essentially serves as a boiler plate vehicle with no Orbiter data source above the separation plane of the mated vehicles. Subsequent to the taxi testing, the first three flights will be performed to establish the airworthiness of the mated combinations and to describe the useful operational flight envelope. Upon completion of these flights, three additional flights will be conducted to obtain a preliminary assessment of the ALT mission profile, ground track, and overall procedures. Chase aircraft will be used on all flights. Summary descriptions of each of the six flights planned in this category are included in the Appendix.

CAPTIVE ACTIVE FLIGHTS

This category of testing consists of manned active Orbiter/SCA mated testing. The active Orbiter mated testing is designed to verify the optimum separation profile developed in inert testing and assess this profile with the Orbiter control system active, refine and finalize Orbiter/SCA crew procedures and evaluate Orbiter integrated systems operation to the extent possible prior to the first free flight. Chase aircraft will be used on all flights.

Summary descriptions of each of the six flights scheduled in this category are included in the Appendix.

FREE FLIGHTS

The Orbiter free flight tests will complete the integrated system testing while verifying Orbiter aerodynamics, avionics, structures and mechanical systems performance and satisfying the test objectives. During this test phase, additional Orbiter/SCA mated test data may be developed during the climb to separation altitude; however, no specific mated flight tests are planned during the climbs. Chase aircraft will be used on all flights.

The initial part of all flights, from the takeoff of the mated configuration through

Orbiter separation, will be as similar as possible and use flight techniques and procedures verified during mated testing. The test procedures and maneuvers described in this section will begin after the Orbiter completes its part of the separation and avoidance maneuvers.

The free flight program consists of eight Orbiter flights, designed to accomplish the test objectives while progressing from the most benign flight regime to the most critical. The eight flights are planned to develop basic aerodynamics, avionics, structures and mechanical systems flight test data while verifying the pilot-guided approach and landing capability and satisfying prerequisites to automatic flight control and navigation mode testing. Flights 6, 7, and 8, if flown, will provide Orbiter aerodynamics, stability, and control data for the tailcone-off configuration. Summary descriptions and profiles of each of the free flights are included in the Appendix.

CONFIGURATION DESCRIPTIONS

Brief descriptions of the 747 Shuttle Carrier Aircraft (SCA) and Orbiter are presented for general information.

SHUTTLE CARRIER AIRCRAFT

The Shuttle Carrier Aircraft (SCA) is a commercial 747-100 series aircraft which has been modified structurally and aerodynamically for flight transport of the Orbiter as shown in Figure 2. An illustration of the SCA structural modifications is shown in Figure 3. Structural modification was accomplished by the addition of one forward and two aft mounting pylons to the top of the SCA fuselage to which the Orbiter is secured. In addition, substantial structural modifications were made to the SCA fuselage and empennage areas to accomodate the Orbiter-imparted flight and static loads. Aerodynamic modification to the SCA includes the addition of fixed vertical stabilizer tip fins which provide an additional 200 square feet each of vertical stabilizer area. The tip fin installation consists of left and right hand fin assemblies which are identical except for the attachment fittings, a faired diagonal support strut for each fin on the stabilizer upper surface, stabilizer attach fittings on each side and stabilizer-to-fin fairings and seal panels. The tip fins are of conventional two-spar, rib-skin-stringer construction. The airfoil section is symmetrical bi-convex, designated as BAC 482, with a thickness ratio of 9 percent. Static dischargers are installed on both tip fins. The fin is capable of being disassembled to facilitate transport in the aircraft. Additional flight control changes include increased nose down trim authority, yaw damper modification, and autopilot gain change provisions. Other changes include engine modifications permitting the use of increased thrust levels, the relocation and/or addition of some communication/navigation antennas, the addition of a special ballast system and the removal of all superfluous passenger accommodation items.

ORBITER VEHICLE

The ALT Orbiter (OV-101) is the first Orbiter Vehicle and is configured to evaluate vehicle approach and landing performance during the terminal phase of operational missions. The primary Orbiter structural subassemblies consist of the crew module, forward fuselage, mid-fuselage, payload bay doors, aft fuselage/engine thrust structure, double-delta wing, and vertical stabilizer. A general three-view drawing of the Orbiter is given in Figure 4.

ORBITER/SHUTTLE CARRIER AIRCRAFT

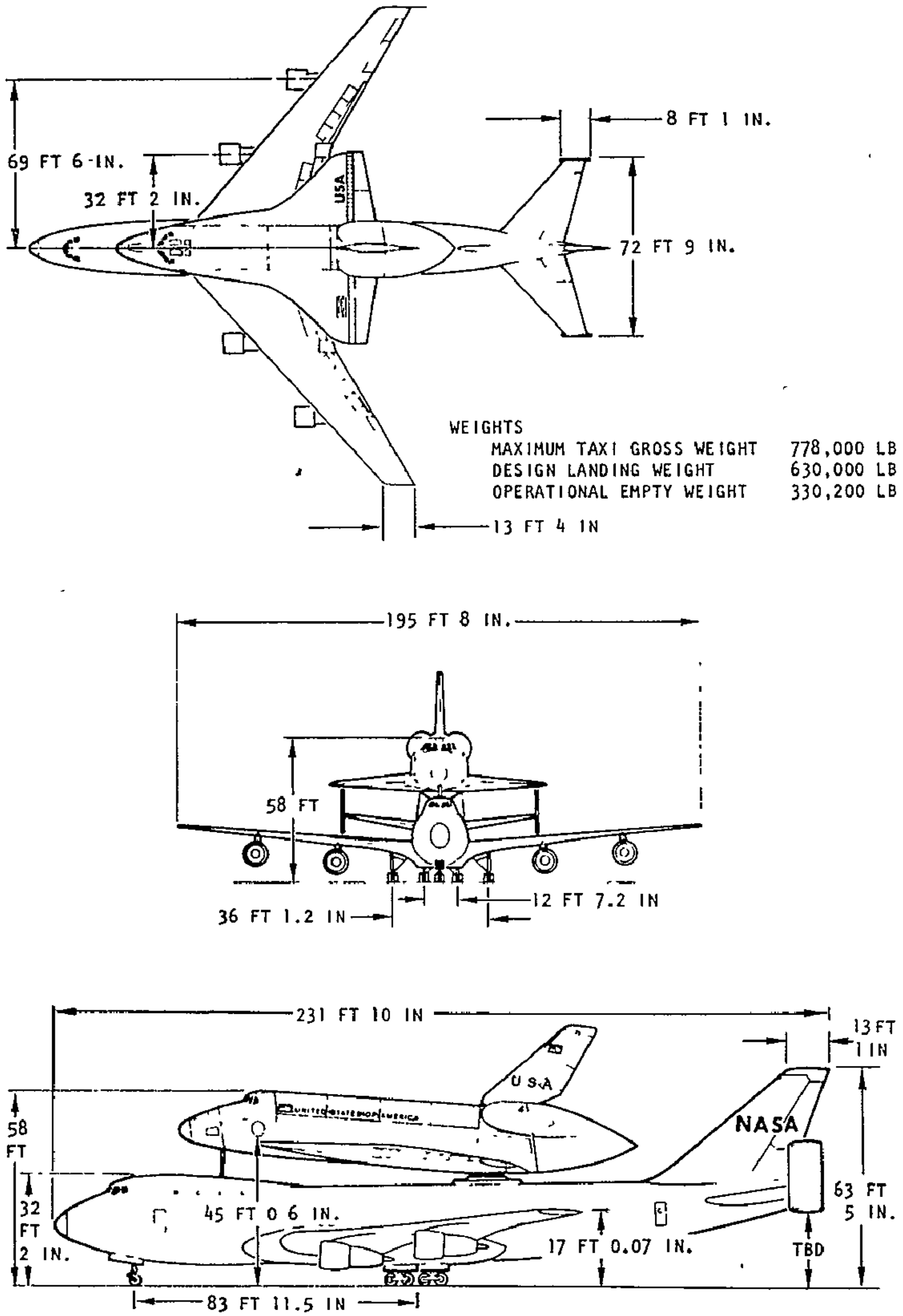


Fig. 2

SCA STRUCTURAL MODIFICATIONS

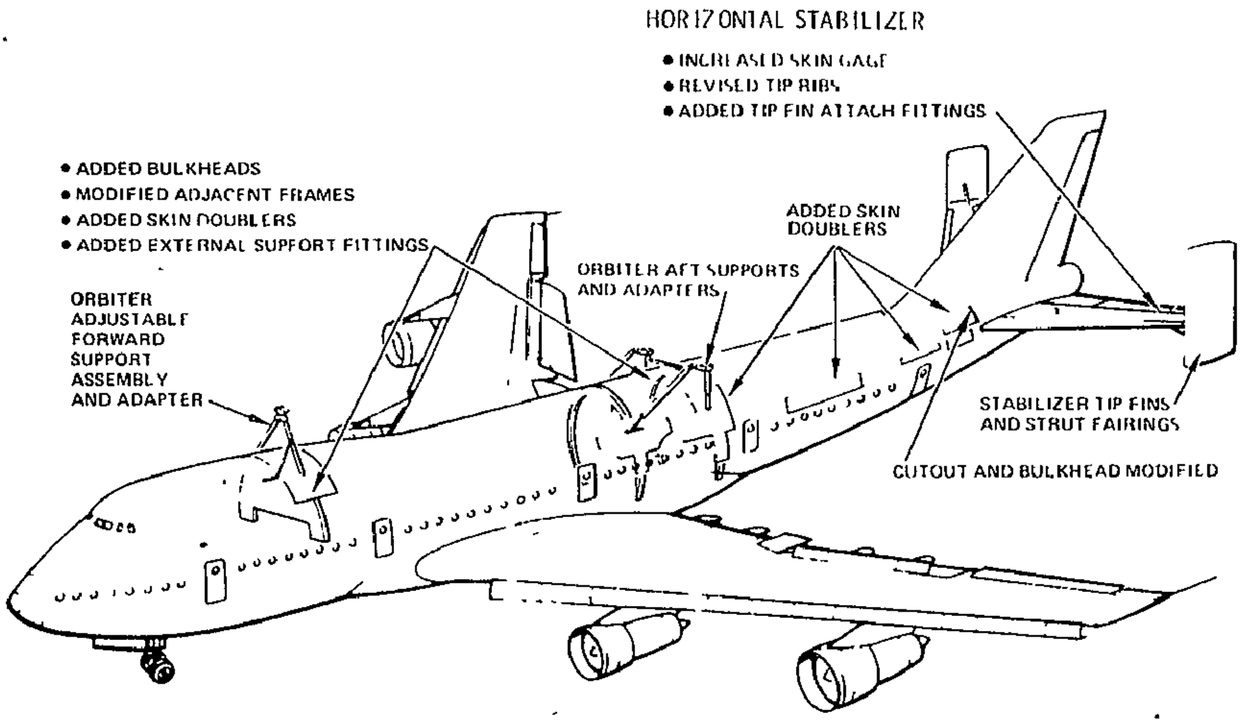


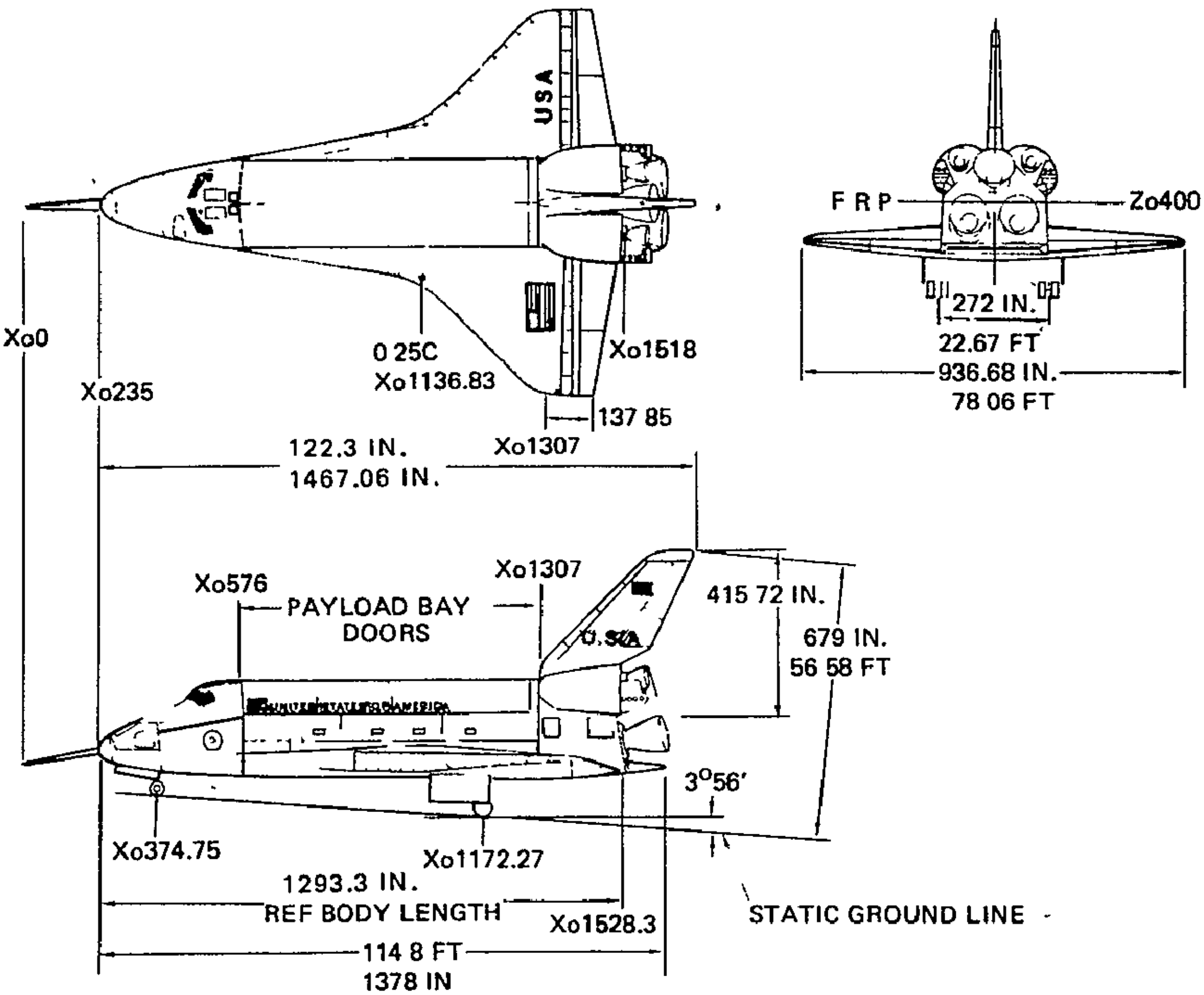
Fig. 3

Orbital systems that will not be installed on OV-101 are listed in the following table:

ORBITAL SYSTEMS NOT INSTALLED ON OV-101

- Orbital Manuevering System
- Reaction Control System
- Space Shuttle Main Engine
- Electrical Power System Cryogenic Tanks
- Payload Accommodations
- Radiators
- Thermal Protection System
- Payload Specialist Crew Station
- Water, Waste & Food Management System
- Star Trackers
- Unified S-Band
- Rendezvous Radar
- Ku-Band Systems

ORBITER VEHICLE



DIMENSIONS AND WEIGHT

WING SPAN	78.06 FT
LENGTH	122.3 FT
HEIGHT	56.58 FT
TREAD WIDTH	22.67 FT
GROSS TAKE-OFF WEIGHT	VARIABLE
GROSS LANDING WEIGHT	VARIABLE
INERT WEIGHT (APPROX)	131,300 LBS

MINIMUM GROUND CLEARANCES

BODY FLAP (AFT END)	144.8 IN	12.07 FT
MAIN GEAR (DOOR)	34.2 IN	2.85 FT
NOSE GEAR (DOOR)	35.4 IN	2.95 FT
PITOT BOOM	204.0 IN	17.00 FT
WING TIP	143.0 IN	11.92 FT

Fig. 4

Orbiter systems modified for or unique to OV-101 are identified in Figure 5. Brief descriptions of OV-101 systems with emphasis on differences between OV-101 and subsequent vehicles follow:

- The Electrical Power System (EPS) includes three fuel cells to provide electrical power for OV-101; however, high pressure bottles of gaseous oxygen and hydrogen will replace cryogenics for the fuel cell supply. Sufficient gaseous oxygen and hydrogen will be carried to allow for 208 minutes of EPS operation at the presently baselined power profile (59.9 kilowatt hours).

- Three Auxiliary Power Unit (APU)/Hydraulics (HYD) systems will provide hydraulic power for operation of the aerodynamic control surfaces and the landing gear. Sufficient APU fuel (hydrazine) and hydraulic cooling water will be carried to allow for 129 minutes of APU/HYD system operation (the system will be cycled to accommodate the total operating time requirements of an ALT flight).

- The Atmospheric Revitalization System consists basically of the cabin fans and a special OV-101 unique ram air vent system used for contamination removal. There will be no cabin gas makeup on OV-101.

- The Active Thermal Control System consists of freon loops cooled by ammonia supplied from six special add-on tanks. There will be no actual Thermal Protection System (TPS) on OV-101, but simulated TPS will be installed to maintain aerodynamic characteristics.

- Three Inertial Measurement Units will provide output signals proportional to both vehicle attitude and velocity changes.

- Three Rate Gyro Assemblies per axis will provide OV-101 with analog measurements of the angular rates about the pitch, roll, and yaw axes.

- Six Body Mounted Accelerometers, three for the normal axis and three for the lateral axis, will provide analog measurements of the acceleration in these axes.

- Four Air Data Transducer Assemblies will provide the following digital outputs to the multiplexer/demultiplexer: total pressure, static pressure, static pressure rate, two angle-of-attack pressures, and total temperature. These data are routed to the General Purpose Computers where they will be used to derive parameters for navigation, guidance, control, and display.

ORBITER SYSTEMS MODIFIED FOR OR UNIQUE TO OV-101

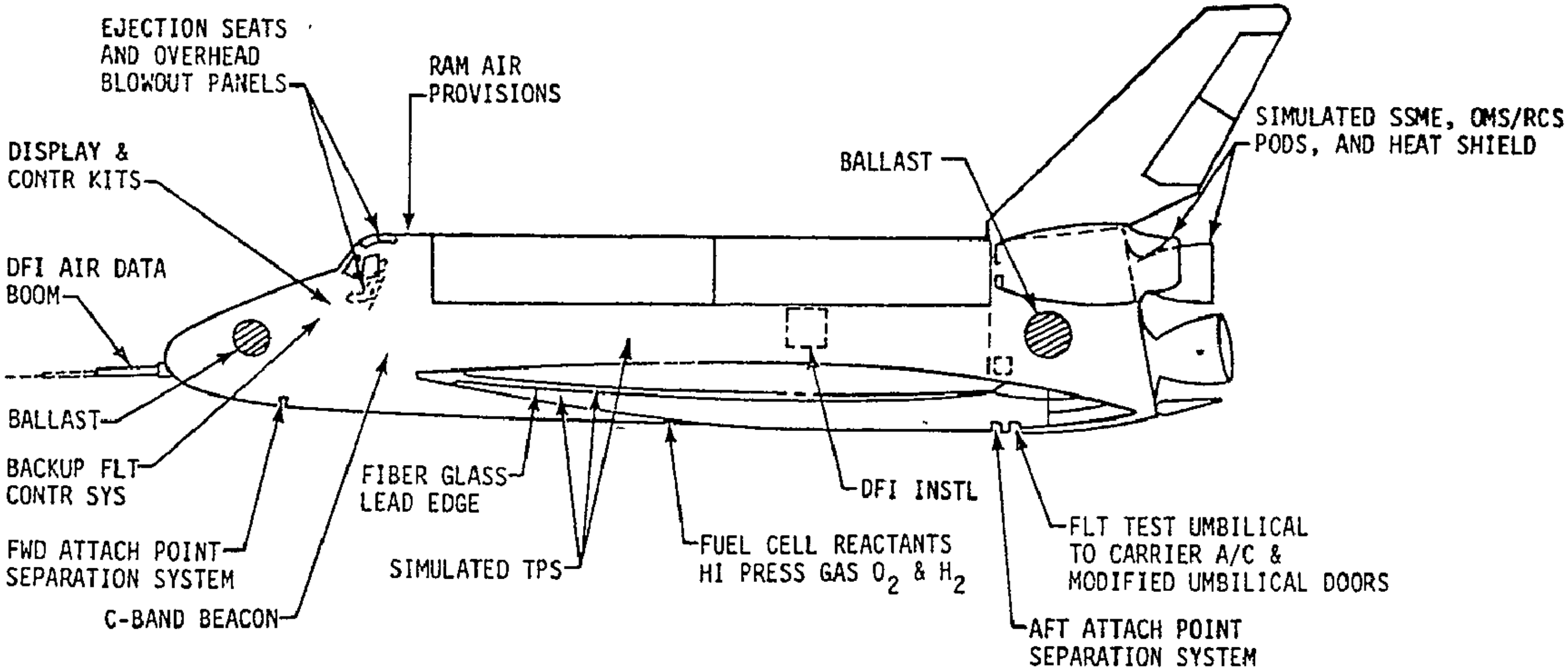


Fig. 5

- The Nose Boom Air Data System, which will be installed only on OV-101, consists of a nose-mounted boom/probe, a dedicated air data computer, and dedicated instruments for crew display. This air data system will provide inputs to the Backup Flight Control System.

- Three Tactical Air Navigation (TACAN) Units will be installed to provide bearing and slant range data from the vehicle to the TACAN ground stations. For ALT, TACAN data will be available during mated and free flights.

- Three Microwave Scanning Beam Landing System (MSBLS) Units will be installed to provide elevation, azimuth, and range data relative to MSBLS ground stations at the runway. These data will be available from the approach and landing interface point through rollout.

- Two Radar Altimeters will provide accurate altitude information. These data will be provided for crew display from 5000 feet to touchdown. During the final landing phase (400 feet to touchdown), radar altimeter data are incorporated into the onboard determined navigation state.

- The Backup Flight Control System (BFCS), as configured for ALT, utilizes a single string of specified control components from the Primary Flight Control System (PFCS) in conjunction with its own General Purpose Computer. Engagement of the BFCS disables the PFCS and prohibits return to the PFCS on a given flight. The BFCS utilizes a Control Stick Steering flight control mode.

  Five General Purpose Computers (GPC) are installed in OV-101 to provide guidance, navigation, and control; avionic sensor maintenance; subsystem monitoring; and crew displays. Four GPCs operate simultaneously to provide redundancy to the PFCS. The fifth GPC, although active, has no control responsibilities unless the BFCS is engaged.

  The Communications and Tracking Subsystem for OV-101 consists of a UHF voice communication subsystem, an Orbiter/SCA intercom, an S-Band Frequency Modulation transmitter and antenna subsystem for downlinking Orbiter Operational Instrumentation (OI) and Development Flight Instrumentation (DFI), and a C-Band radar beacon and antenna subsystem. Each of these subsystems has a unique configuration on OV-101 for the ALT phase of the Space Shuttle Program.

  An integrated OI and DFI Pulse Code Modulation subsystem will be utilized in OV-101 in contrast to the OV-102 system, which will use separate OI and DFI subsystems. The functions of this subsystem are to acquire, condition, digitize, format, and distribute data for onboard display, performance monitoring, telemetry, recording, and ground checkout. It also provides timing for onboard systems.

- Provisions will be made to obtain Gross Weight/Center of Gravity combinations specified by the flight test requirements by the use of appropriate ballasting techniques.

- Two zero-zero ejection seats will be provided for OV-101. They will eject upward, and require special overhead blowout panels above the commander and the pilot.

ALT MANAGEMENT

The Space Shuttle Program Director at NASA Headquarters is responsible to the Associate Administrator for Space Flight for overall management of the Space Shuttle Program. Responsibility as the lead Center for the program is assigned to the Johnson Space Center (JSC). In this role, JSC will be responsible for the overall management of the ALT Program. The manned active Orbiter portion of the program will be controlled by JSC, the SCA and unmanned Orbiter portion of the project by the Dryden Flight Research Center (DFRC), and the Orbiter ground operations by the Kennedy Space Center (KSC). DFRC, and the Air Force Flight Test Center will provide test and base support and advisers as required.

The ALT elements will be under the overall direction of the Orbiter Approach and Landing Test Office of the JSC Space Shuttle Program Office. The ALT on-site organizational structure consists of an ALT Site Manager supported by an Active Orbiter Flight Team, SCA Team, Test Evaluation Team, and a Ground Operations Team. The Ground Operations Team is responsible to manage, monitor, and approve the ground turnaround activities of the Rockwell International Space Division and other on-site KSC contractors. A chart of the ALT on-site organizational structure is shown in Figure 6.

ALT MANAGEMENT RELATIONSHIPS

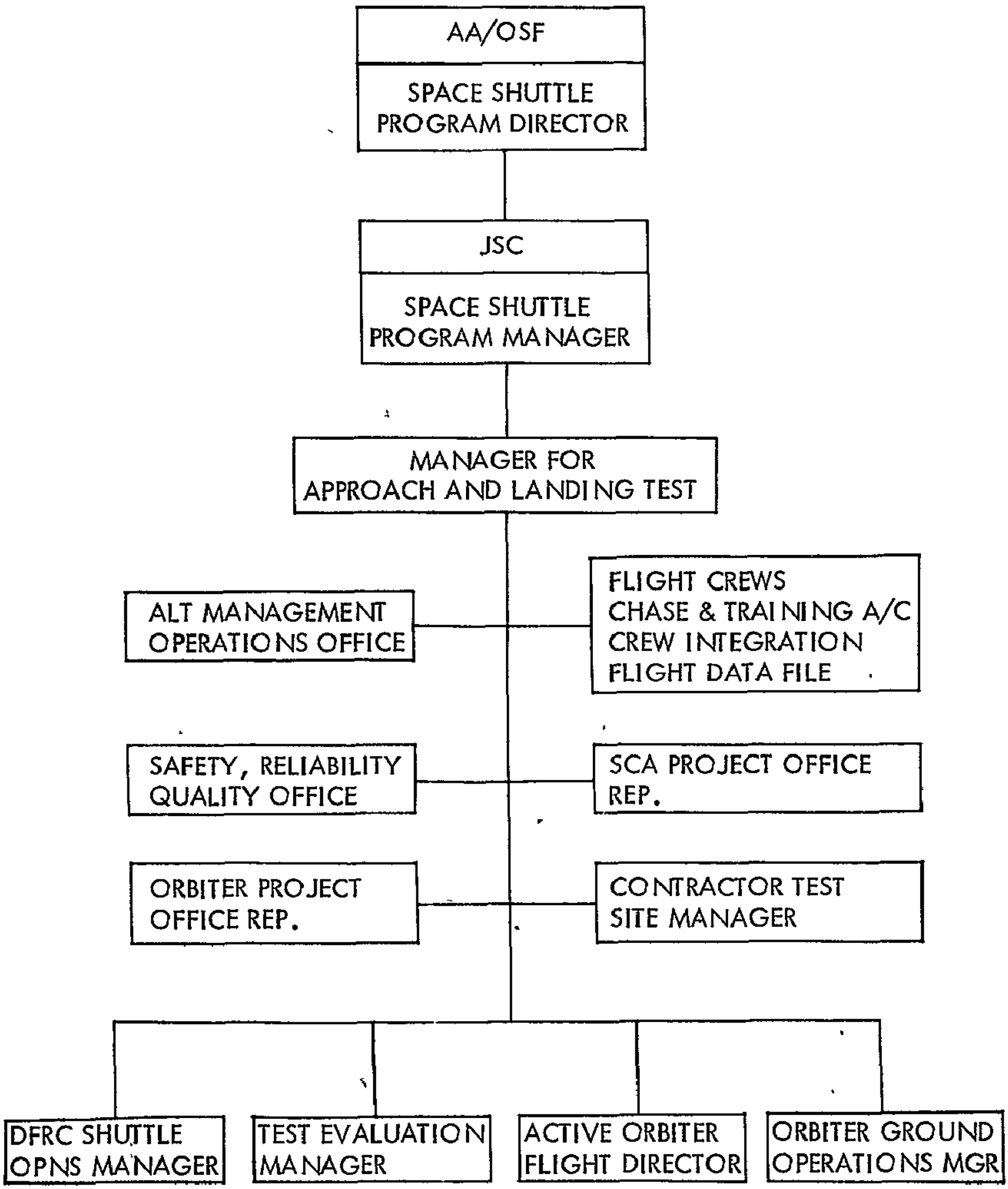


Fig. 6

ALT FLIGHT CONTROL

A DFRC flight team at DFRC will control SCA and unmanned Orbiter operations. A JSC flight team in the Mission Control Center-Houston (MCC-H) will control the manned Orbiter tests.

All Orbiter and selected wideband data will be transmitted to an S-band ground station at EAFB. The SCA data will be transmitted to an L-Band station at EAFB. Selected Orbiter operational and development flight instrumentation and carrier data will be sent to JSC for real time display in the MCC-H. Orbiter, SCA and chase aircraft voice communications and ground radar data will be sent in real time from DFRC to the MCC-H. Onboard recorded data will be sent to JSC for processing and analysis. Real-time data monitoring will be limited to safety of flight and test objective verification items only, and real-time flight test plan changes will be constrained to the selection of preplanned alternate missions.

ALT SUPPORT

FACILITIES

The Orbiter, SCA and selected NASA support aircraft will be maintained and operated at EAFB; therefore, a hangar facility, a mate/demate device (MDD) to enable Orbiter/SCA mating, servicing and checkout, and a connecting tow way to existing EAFB taxi ramps have been provided. The MDD, illustrated in Figures 7 and 8, is a structural steel, gantry-type, cantilevered structure approximately 100 feet (30.5m) high, with a hoisting device capable of lifting approximately 225,000 pounds (102,058 kg). Ground turnabout test and checkout operations will be conducted at DFRC using the Acceptance Checkout Equipment (ACE) facility at Palmdale. An ACE data link and communications between Palmdale and DFRC have been provided.

COMMUNICATIONS AND TRACKING LINKS

Figure 9 depicts the voice communications, telemetry, and tracking links between the test site and the airborne vehicles. Also shown is the data flow from the test site to the MCC-H. A brief description of the communications and tracking links follows:

- Ground-based UHF transceivers will be used at the test site to conduct air-to-ground communications with the Orbiter, SCA, and chase aircraft.
- For telemetry data support, an S-band ground station at EAFB will receive and record the Orbiter 128 kbps OI/DFI and wideband data downlink, and an L-Band ground station will receive and record the SCA downlink.
- C-Band radar facilities will provide and record range, azimuth, and elevation data for the Orbiter during test operations and for the Shuttle Training Aircraft during certain flights.
- The DFRC Long Range Video System will be used to provide real-time viewing in the MCC-H of the separation sequences and free flights. Television coverage will also be provided from a mobile van, one of the chase aircraft, and a TV helicopter. The ALT television system is illustrated schematically in Figure 10.

  The TACAN and MSBLS ground stations at EAFB will be used by both the Orbiter and the Shuttle Training Aircraft as sources of navigation information during terminal area energy management, approach, and landing.

ORBITER/SCA MATE/DEMATE DEVICE

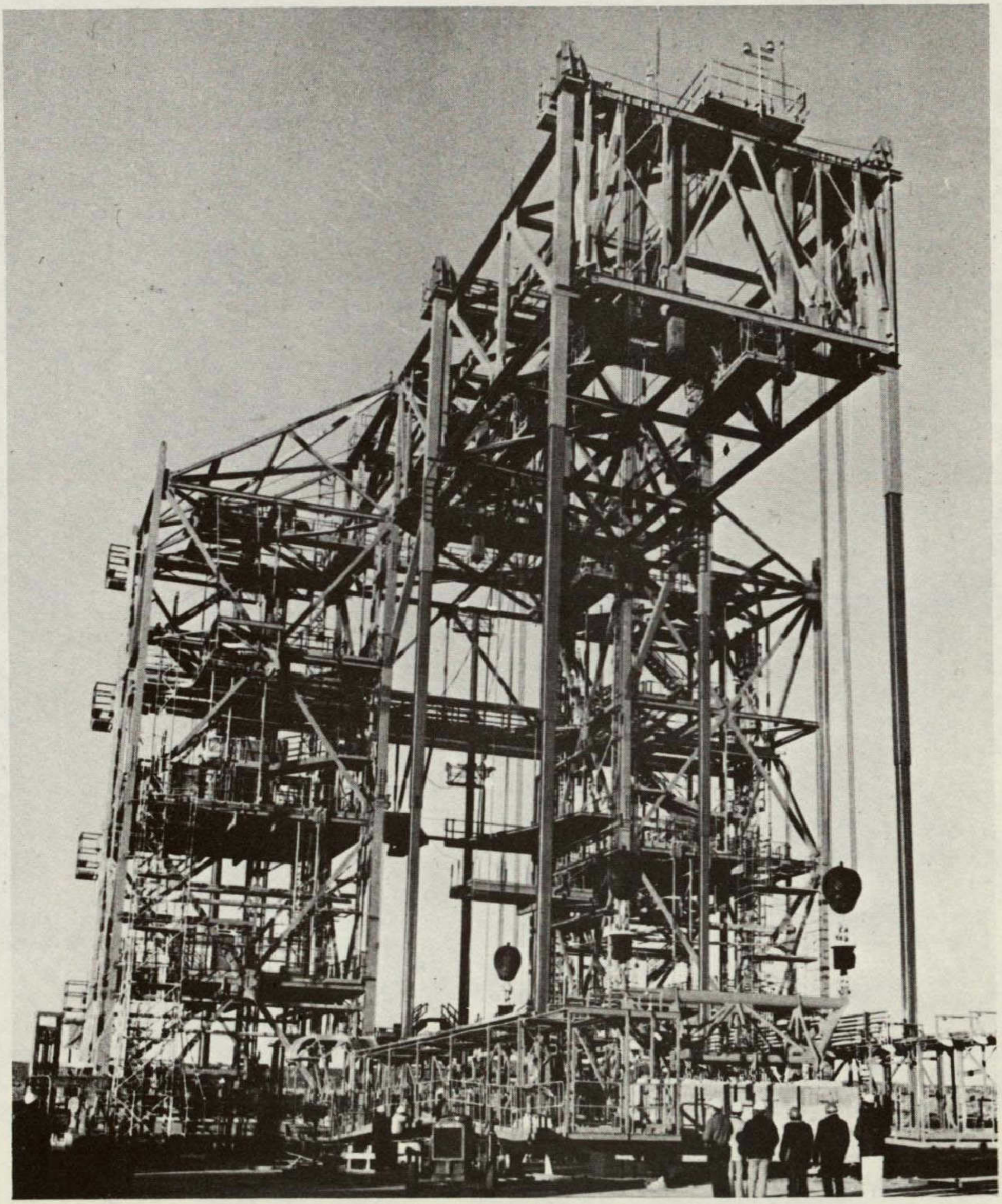


Fig. 7

ORBITER/SCA IN MATE/DEMATE DEVICE

Fig. 8

ALT TELEVISION SYSTEM CONFIGURATION

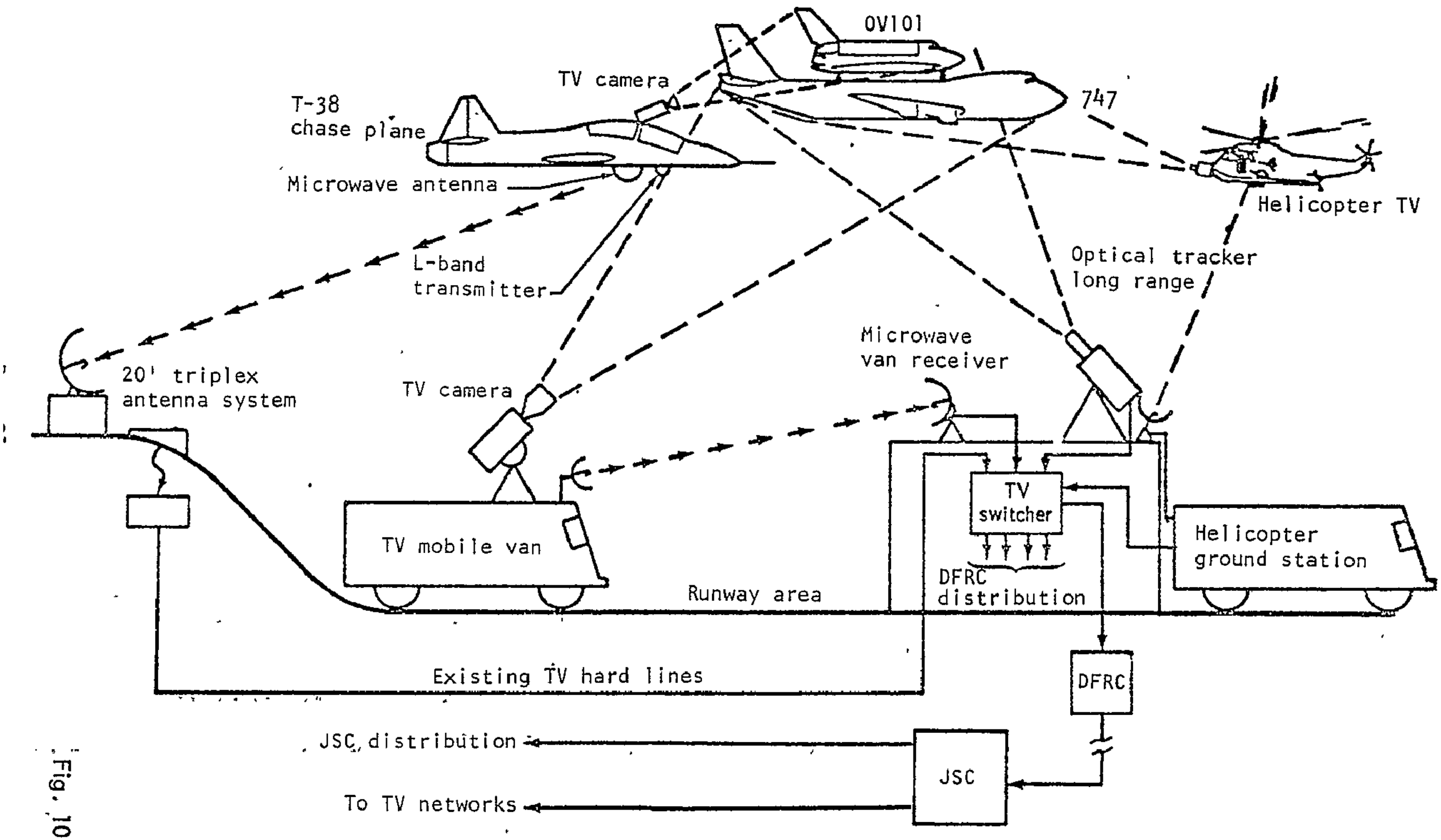


Fig. 10

CRASH AND RESCUE SUPPORT

EAFB crash-fire-rescue equipment and personnel, trained and certified in fire suppression and rescue techniques applicable to the SCA and Orbiter, will be positioned at alert stations adjacent to runway operations for all landings and takeoffs. Medical support includes paramedical personnel and medevac aircraft and vehicles. Two EAFB helicopters with paramedic personnel will be dedicated to rescue support during the manned Orbiter portions of ALT.

APPENDIX

FLIGHT DESCRIPTIONS

This appendix contains summary descriptions of each of the planned ALT Program flights. In addition, a flight profile is included for each of the planned Orbiter free flights.

CAPTIVE INERT FLIGHT 1

CONFIGURATION

SCA: Taxi Weight 435,000 pounds

Orbiter: Weight 150,000 pounds

SUMMARY

As this will be the first flight of the mated vehicles, the testing will be planned to obtain a broad evaluation of the low speed performance and handling qualities and, at the same time, provide a functional check of the airborne data and airplane systems. In addition, there will be time devoted to an initial check calibration of the airspeed system with that of a pacer airplane. The primary test altitude will be 16,000 feet, and the maximum speed will be 250 knots calibrated airspeed (KCAS).

Following the takeoff, a climb will be performed to the test altitude of 16,000 feet. At the test altitude, the airspeed system calibration check will be conducted at speeds of 250, 225, 200, 175, and 145 KCAS. At each speed, a series of control inputs will be made to check the flutter response. This test sequence will then be followed by a set of stability and control maneuvers performed at indicated airspeeds of 250 and 200 KCAS at 16,000 feet and 170, 160, and 145 KCAS at 10,000 feet. These maneuvers are designed to evaluate the static and dynamic longitudinal and lateral directional stability with the yaw damper on/off and flap position consistent with the airspeed requirements. At the conclusion of the stability and control test, the airplane will descend to an altitude of 7500 feet where a simulated landing approach will be performed to an altitude of 5000 feet. At 5000 feet, a preliminary evaluation will be made of the directional control behavior associated with a simulated outboard engine failure. This evaluation will be followed by the normal approach and landing on the runway.

CAPTIVE INERT FLIGHT 2

CONFIGURATION

SCA: Taxi Weight 445,000 pounds

Orbiter: Weight 150,000 pounds

SUMMARY

This flight will be devoted primarily to expanding the flutter free envelope to the M=0.7 boundary at the pressure altitude of 24,000 feet with interim evaluations of the stability and control characteristics and the completion of the airspeed systems calibration. In conjunction with these tests, performance and structural loads will be monitored and assessed. After takeoff, a climb will be initiated at an airspeed of 235 KCAS to a test altitude of 24,000 feet. At the test altitude, an airspeed system check will be made in the Mach number range from 0.56 to 0.70 at intervals of $\Delta M=0.02$. In this series, discrete test points will be selected to check the influence of the autopilot on the structural response. Simultaneously, airspeed checks will be made at the Mach numbers of 0.56, 0.60, 0.64, 0.68, and 0.70. To attain speeds above 0.64, it may be necessary to trade altitude for airspeed. In these cases, the airplane will climb to an altitude of approximately 26,000 feet, push over, obtain the desired speed at an altitude of 24,000 feet, and level off for the test sequence.

In addition to the above, the flight plan is arranged to perform stability and control maneuvers at the Mach numbers of 0.48, 0.59, and 0.64 after the flutter clearance has been established and while the next higher increment in Mach number is being analyzed for flutter clearance in the ground station.

Upon completion of the test effort at the altitude of 24,000 feet, the airplane will descend to an altitude of 16,000 feet at an airspeed of 200 KCAS. At these conditions, the landing gear will be extended, the flaps will be set at 20°, and a gradual deceleration will be performed to evaluate the acceptable flying speed for this configuration.

With the completion of the minimum speed check, the airplane will proceed to the base for a normal landing.

CAPTIVE INERT FLIGHT 3

CONFIGURATION

SCA: Taxi Weight 480,000 pounds

Orbiter: Weight 150,000 pounds

SUMMARY

The primary objective of this flight, will be to complete the basic flutter and stability testing within the design envelope. In addition, the minimum flying speed will be explored for heavy and light gross weight conditions at several flap settings. Also, the three engine climb performance will be checked after takeoff and the directional control will be evaluated with a simulated critical engine out. As on the previous flights structural loads will be monitored and analyzed for all stability testing.

After takeoff at an altitude of approximately 500 feet the number 4 engine will be reduced to idle and the climb continued to a target altitude of 16,000 feet. At the maximum altitude attainable ($R/\dot{C}$ = 200 fpm), climb power will be re-established on number 4 engine, and the climb will be continued to 16,000 feet. At an altitude of 16,000 feet and an airspeed of 200 KCAS, tests will be conducted to evaluate the minimum flight speed with flap settings of 10°, 20°, and 30°. Following these tests, the flutter envelope will be explored between a Mach number of 0.50 to 0.62 (V_i=312 KCAS). As on the previous flight, discrete speeds will be selected to check the effects of the autopilot operation on the structural response to rapid control inputs. In addition, stability and control maneuvers will be performed at Mach numbers of 0.51, and 0.59. Upon completion of these tests, the airplane will climb at an indicated airspeed of 235 KCAS to an altitude of 24,000 feet. At this altitude, dynamic stability and control tests will be conducted at M=0.59 and 0.64 to assess the airplane response with the yaw damper off and the effects of speed brake application. Upon completion of these tests a descent will be performed to an altitude of 5000 feet and an airspeed of 200 KCAS. At this condition, a three engine minimum control speed evaluation will be performed. The flight will be concluded with a landing on the main runway with normal braking, full speed brakes, and thrust reversal applications.

CAPTIVE INERT FLIGHT 4

CONFIGURATION

SCA: Taxi Weight 480,000 pounds

Orbiter: Weight 150,000 pounds

SUMMARY

This flight will consist of investigating marginal operational characteristics with simulated engine-out conditions for the ALT configurations and evaluating configuration variables, dictated by the characteristics.

The first time assessment will be made of the performance with special thrust rating on the engines and the related climb performance. In addition, the rapid descent performance will be evaluated.

After the takeoff, a climb will be initiated to a pressure altitude of 10,000 feet. At 10,000 feet, the minimum acceptable flying speed with 10 degrees of flaps will be evaluated. The altitude will then be reduced to an altitude of 5000 feet, and this test will be repeated along with tests to evaluate minimum control speed under simulated static and dynamic conditions. Following this test series, a climb will be performed to an altitude of 24,000 feet. At 24,000 feet, the special thrust rating will be evaluated during a climb to establish the service ceiling (R/C = 200/fpm or t=10 min. thrust applications). Subsequently, the airplane will re-establish the test altitude of 24,000 feet, and an investigation of the buffet level and stability characteristics at various spoiler deflections will be made to a maximum indicated airspeed of 270 KCAS (M_i= 0.64). Beginning at an indicated airspeed of 240 KCAS (maximum gear down speed) and an altitude of 24,000 feet, an emergency descent will then be performed to an altitude of 16,000 feet. The flight will be concluded with a missed approach performed before the final approach and landing on the runway.

CAPTIVE INERT FLIGHTS 5 AND 6

CONFIGURATION

SCA: Taxi Weight 435,000 pounds

Orbiter: Weight 150,000 pounds

SUMMARY

These two flights, for the most part, will be similar in that the primary purpose will be to evaluate the performance and procedures associated with the two launch attempt ALT missions. The major difference will be that each launch maneuver will be initiated at a different airspeed to evaluate the separation criteria for a range of conditions.

After takeoff, a climb schedule with an indicated airspeed of 235 KCAS will be performed to a pressure altitude of approximately 25,000 feet. At this altitude, the airplane will establish an indicated Mach number of 0.48. At this speed, the special rated thrust will be applied and a climb initiated to the maximum altitude attainable (R/C=200/fpm) without exceeding the 10 minutes of special thrust application. At the maximum altitude, a gradual pushover will be performed to accelerate to an indicated airspeed of 255 KCAS. The SCA will then be configured to meet the ALT launch requirements relative to spoiler and thrust settings. When the simulated launch sequence is completed, an abort maneuver will be performed. Following the abort, the airplane will establish a 15 minute cruise at an indicated airspeed of 250 KCAS and an altitude of 15,000 feet. At the conclusion of the 15 minutes, a 235 KCAS climb will be performed to an altitude of 25,000 feet. At this altitude, the climb with the special rated thrust will be performed; and on the second launch attempt, the target launch airspeed will be 265 KCAS. At the completion of the second airlaunch simulations and abort, a normal descent and landing will be performed.

Flight No. 6 will essentially follow the same flight profile and ground track. However, the target launch airspeeds will be 265 and 275 KCAS, respectively.

CAPTIVE ACTIVE FLIGHT 1

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on

SUMMARY

The first Orbiter/SCA mated captive flight is dedicated to the verification of the separation conditions and tolerances, avionics systems checks, mated climb performance, and procedures development. After takeoff, the SCA will climb to 25,000 feet and fly three circuits around a racetrack trajectory approximately 55 NM by 15 NM. The inbound leg will be aligned with runway 17L and positioned to intercept the auto guidance localizer for the third circuit.

The Orbiter crew will perform the normal operational checks and system operations functions from preflight through powerdown. However, during the climbout and the third racetrack circuit, specific systems checks will be performed. These include FCS mode switching and verification tests and redundancy management tests.

On the first and second inbound legs, a pushover and separation trajectory will be flown to collect separation performance data. However, special rated thrust is not required because the intermediate (loiter) altitude is sufficient for these tests. The first descent will start from approximately 25,000 feet and end 60-80 seconds later at 18,000 feet. After SCA pull-up, the second descent will occur in approximately 20 minutes.

During the initial climb, the Orbiter elevon will be set to the nominal value for climb; however, during the second climb, the elevon will be set to the nominal plus 1° to collect climb performance data.

When in position, the SCA will pitch over and establish equilibrium glide conditions (240 KEAS, spoilers deployed, engines at idle). During the equilibrium glide, the following test sequence will be performed:

- The Orbiter elevon (elevator) will be varied in 1.5° increments about the nominal separation setting (5 seconds each increment) up to ± 3°.
- Differential Orbiter elevons (ailerons) of 1° will be commanded (5 seconds) about nominal elevon setting.
- Orbiter rudder deflection of 1° will be commanded (5 seconds).
- The SCA will establish 1° sideslip (5 seconds).

The second descent will be executed similarly except the glide airspeed will be 260 KEAS.

During the third inbound leg, the SCA will establish a glide slope and ground track that will fly through the TAEM trajectory. The Orbiter crew will call the TAEM major mode in the GPC and monitor the auto guidance behavior with TACAN updating the navigation state.

After the TAEM fly-through, the SCA will establish a normal approach to landing.

CAPTIVE ACTIVE FLIGHT 2

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on

SUMMARY

This flight is dedicated to the verification of the separation conditions and tolerances, avionics systems checks, mated climb performance, and further procedures development. The SCA will fly three circuits of the racetrack trajectory as Flight 1 with two descents to collect separation performance data.

Special rated thrust is not required because the intermediate Orbiter altitude is sufficient for these tests. The first descent will start from approximately 25,000 feet and end 60-80 seconds later at 10,000 feet. After SCA pull-up, the second descent will occur in approximately 20 minutes.

During the initial climb, the Orbiter elevon will be set to the nominal value for climb; however, during the second climb, the elevon will be set to the nominal minus 1^{o} to collect climb performance data.

In addition to the normal Orbiter checks, the Orbiter crew will perform avionics redundancy management tests during this flight.

When in position, the SCA will pitch over and establish equilibrium glide conditions (250 KEAS, spoiler deployed, engines at idle). During the equilibrium glide the following test sequence will be performed:

- The Orbiter elevon (elevator) will be varied in 1.5^{o} increments about the nominal separation setting (5 seconds each increment) up to $\pm 3^{o}$.
- Differential Orbiter elevons (ailerons) of 1^{o} will be commanded (5 seconds) about nominal eleven setting.
- An Orbiter rudder deflection of 1^{o} will be commanded (5 seconds).
- The SCA will establish 1^{o} sideslip (5 seconds).

The second equilibrium glide will be executed similarly except the glide airspeed will be 270 KEAS.

During the third inbound leg, the SCA will establish a glide slope and ground track that will fly through the Approach and Landing (A/L) trajectory. The Orbiter crew will call the A/L major mode and monitor the auto guidance behavior with MSBLS updating the navigation state.

After the autoland fly-through, the SCA will establish a normal approach to landing.

CAPTIVE ACTIVE FLIGHTS 3, 4, 5

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on

SUMMARY

These flights are dedicated to the refinement and demonstration of separation procedures, separation abort techniques, exact separation profile, repeatability of the separation profile, ground vectoring techniques, chase aircraft operations, and performance of the remaining avionics tests.

The SCA will fly a racetrack exactly like that of the first free flight mission. Special rated thrust will be employed to attain the altitude for separation sequence initiation.

Both the SCA and Orbiter crews will go through the preseparation procedures including ground vectoring and navigation updates. All procedures and maneuvers will be performed according to the nominal plans. After the separation profile is flown, the SCA will execute a separation abort sequence and go around for a second separation profile demonstration exactly like the first. After the second separation abort sequence, the SCA will establish a normal approach to landing.

The TACAN range tests will be performed on Flights 3 and 4, and mated Programmed Test Inputs will be performed during Flight 3. On Flight 5, the Orbiter landing gear will be deployed during SCA rollout after touchdown.

CAPTIVE ACTIVE FLIGHT 6

CONFIGURATION

150,000 pound - 65% cg - tailcone off

SUMMARY

This flight will be conducted after the fifth tailcone on free flight. The purpose of this flight is to demonstrate the separation performance and mated flight worthiness with the Orbiter tailcone off configuration. The Orbiter elevon settings (needed for separation and climb performance) will be analytically derived by extrapolating the tailcone on data prior to this flight.

The SCA will fly a racetrack trajectory approximately 50 NM X 23 NM which will be exactly like that of the first tailcone off free flight. Special rated thrust of the SCA engines will be used to attain the altitude for separation sequence initiation (23,000 feet MSL).

After SCA takeoff, the Orbiter body flap may be moved from the best preflight predicted position as required to improve inflight conditions. During the initial climb out, particular attention will be focused on the buffet and other flight worthiness conditions of the mated configuration. The remainder of the flight will be dedicated to the demonstration of the separation procedures, separation abort techniques, exact separation profile, and repeatability of the separation profile.

The Orbiter and SCA crews will go through the preseparation procedures including ground vectoring and navigation updates. All procedures and maneuvers will be performed according to the nominal plans. After the separation profile is flown, the SCA will execute a separation abort sequence and go around for a second separation demonstration exactly like the first. After the second separation abort sequence, the SCA will establish a normal approach to landing.

FREE FLIGHT 1

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on - CSS PCS mode

SUMMARY

After separation, the Orbiter will accelerate to 270 KEAS (pitch = -10°). At 270 KEAS, the crew will initiate a practice flare and simulated landing (18,000 ft. AGL).
During the deceleration of the flare, the altitude rate will be held to essentially zero while the crew evaluates the handling qualities. At 185 KEAS and an alpha approximately that of landing (11°), the Orbiter will pitchdown to -60° and roll left 30°.

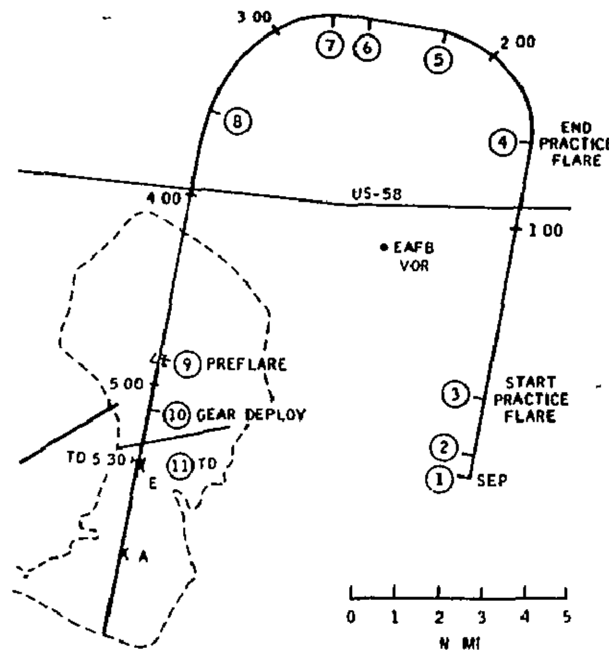
After turning to base leg, the Orbiter will roll to wings level and continue to accelerate to 270 KEAS. At 265 KEAS, a pitchup to -2° will be initiated and equilibrium glide conditions at 270 KEAS will be established and maintained. A 30° banked turn to final will be performed to line up with the lake bed runway.

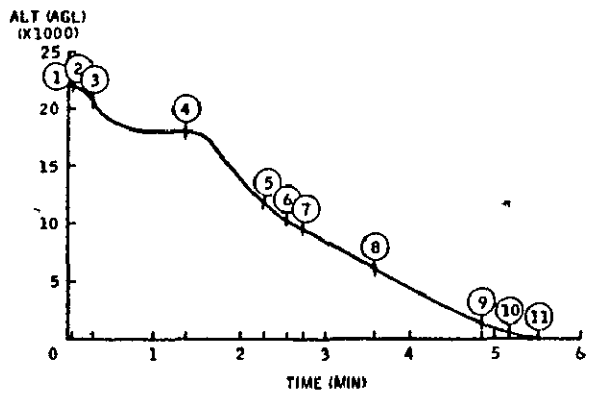
At approximately 900 feet AGL, the preflare maneuver will be initiated. At 250 KEAS, the landing gear will be deployed and touchdown will occur about 20 seconds later.

Gentle braking will be applied between 100 KEAS and 80 KEAS. At 50 KEAS nosewheel steering will be engaged and the Orbiter will be allowed to roll unbraked to a stop.

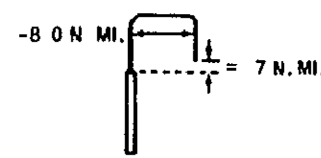
ALT FREE FLIGHT 1

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0 00	22100	260	10	.5	SEP, $\dot{\theta}$ = 2°/SEC, 3 SEC, $\dot{\theta}$ = 0, 2 SEC
2	0-05	21900	250	7	6 5	ROLL RIGHT ϕ = 20°, $\dot{\theta}$ = -1°/SEC AT θ = -5° ROLL ϕ = 0, CONTINUE $\dot{\theta}$ = -1°/SEC TO θ = -10
3	0 18	20400	270	6	-10	AT AS = 270 INITIATE PRACTICE FLARE $\dot{\theta}$ = 2°/SEC, CONTINUE FLARE TO HOLD h = 0, AS = 185
4	1 25	17900	185	11	11	AT AS = 185 ROLL LEFT TO ϕ - 30°, $\dot{\theta}$ = -1°/SEC TO θ = -6°
5	2 15	12000	240	8	-6	AT ψ = 265° ROLL TO ϕ = 0
6	2 35	10000	265	6	-6	AT AS = 265 $\dot{\theta}$ = 1°/SEC TO θ = -2 TO HOLD AS = 270
7	2 45	9300	270	5	-2	ROLL LEFT TO ϕ = 30° TO LINE UP ON RUNWAY ψ = 175°
8	3 35	6000	270	5	-2	TURN COMPLETE HOLD AS = 270
9	4 55	900	270	5	-2	INITIATE PREFLARE
10	5 10	350	250	6	4	AT AS = 250, DEPLOY GEAR
11	5 30	0	175	11	11	T D AS < 220, $\dot{h}$ < 10 fps
12	5 45	0	100	--	--	AT AS = 100, GENTLE BRAKING TO AS = 80
13	6 00	0	50	--	--	AT AS = 50, ENGAGE NWS





WT = 150,000#
CG = 64 5 % (1070 24)



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FREE FLIGHT 2

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on - CSS FCS mode

SUMMARY

After separation, the Orbiter will accelerate to 295 KEAS (pitch = -10°). At 295 KEAS the Orbiter will pitch up to -3° to establish equilibrium glide conditions at 300 KEAS. Programmed test inputs (PTIS) and aerodynamic stick inputs (ASI) will be performed during this glide (35 seconds).

The Orbiter will pitch up to 3° and a roll left to a bank of 55° will be initiated. During the turn, a load factor of 1.8g will be maintained (note: the load factor will be released if alpha $\geq 13^{\circ}$).

After 135° of turn, the Orbiter will roll wings level and the airspeed will be reduced to 200 KEAS. At 200 KEAS, a pitch to 2° will be performed to maintain 200 KEAS for the execution of both PTIS and ASI. After the ASI, a roll left to 30° and a pitch down to -9° will be performed. The 30° banked turn will be controlled to line up on the runway.

At 260 KEAS, the speed brakes will be deployed to 50 percent and a pitch up to -7° will be performed. The resulting equilibrium glide conditions of 270 KEAS and -12° flight path angle will normally be maintained to 2000 ft AGL. However, the speed brakes may be modulated to control the touch down point. Also during this period ASI's will be made.

At 2000 ft AGL, the speed brakes will be retracted. The preflare maneuver will be initiated about 900 ft AGL. At 250 KEAS, the landing gear will be deployed and touch down will occur about 20 seconds later.

Nosewheel steering will be engaged at 90 KEAS to 60 KEAS with no braking. Below KEAS, low to moderate braking will be applied as required.

ALT FREE FLIGHT 2

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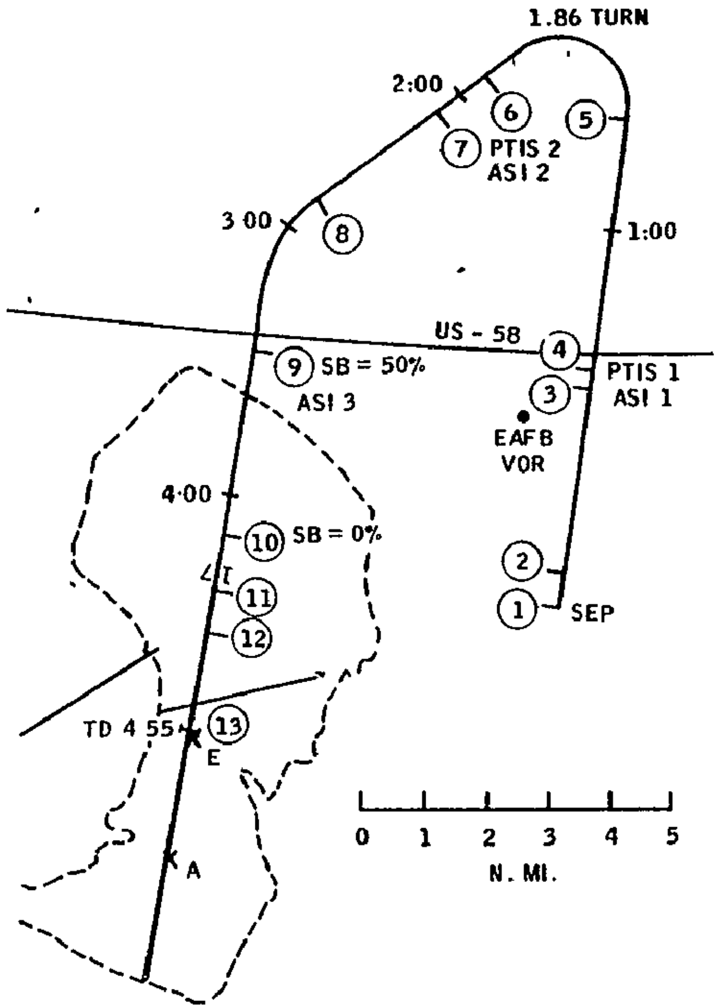
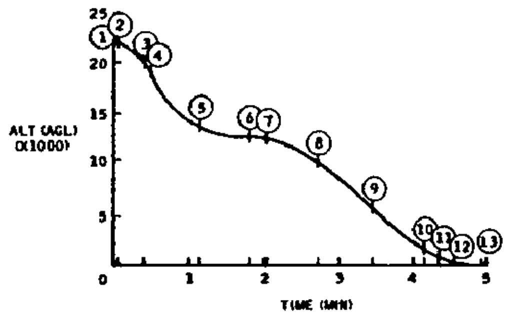
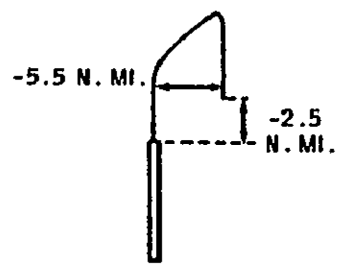
ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0.00	22100	260	10	.5	SEP; $\dot{\theta}$ = 2°/SEC, 3 SEC; $\dot{C}$ = 0, 2 SEC
2	0·05	21900	250	7	6.5	ROLL RIGHT φ = 20°, θ = -1°/SEC AT θ = -5° ROLL φ = 0, CONTINUE θ = -1°/SEC TO θ = -10
3	0 33	18200	295	5	-10	$\dot{\theta}$ = 2°/SEC TO θ = -3° TO HOLD AS = 300
4	0:35	17600	300	5	-3	PTIS; STICK INPUTS (TOTAL 35 SEC)
5	1:10	13600	300	5	-3	θ = 1°/SEC TO θ = 3; ROLL LEFT 55°; HOLD N_z = 1 8g (α < 13°) TURN TO ψ = 220°
6	1.50	12400	230	9	10	φ = 0; $\dot{\theta}$ = -1°/SEC TO θ = 2 HOLD AS = 200
7	2:05	12200	200	9	2	PTIS; STICK INPUTS (35 SEC)
8	2:40	10300	200	9	2	ROLL LEFT φ = 30°; $\dot{\theta}$ = -1°/SEC TO θ = -9° TURN TO ψ 175°
9	3:28	5500	260	5	-9	θ = 1°/SEC TO θ = -7°, SB = 50% HOLD AS = 270; STICK INPUTS (15 SEC)
10	4·08	2000	270	5	-7	SB → 0
11	4·20	900	270	5	-7	INITIATE PREFLARE
12	4:35	350	250	6	4	AT AS = 250, DEPLOY GEAR
13	4.55	0	175	11	11	T.D AS < 220; $\dot{h}$ < 10 fps
14	5.10	0	90	--	--	AT AS = 90, ENGAGE NWS
15	5.25	0	60	--	--	LOW TO MODERATE BRAKING AS REQUIRED WHEN AS < 60





WT = 150,000
CG = 64 4% (1070.24)



FREE FLIGHT 3

CONFIGURATION

150,000 pounds - 66.5% cg - tailcone on - CSS FCS mode

SUMMARY

After separation, the Orbiter will accelerate to 295 KEAS (pitch = -10°). The body flap will be lowered to 0°, and at 295 KEAS the Orbiter will pitch up to -3° to establish equilibrium glide conditions at 300 KEAS. Programmed test inputs (PTIS) and aerodynamic stick inputs (ASI) will be performed during this glide (35 seconds).

The Orbiter will pitch up to 3° and a roll left to a bank of 55° will be initiated. During the turn, a load factor of 1.8 g will be maintained (note: the load factor will be released if alpha $\geq 13^{\circ}$).

After 135° of turn, the Orbiter will roll wings level and the airspeed will be reduced to 200 KEAS. At 200 KEAS, a pitch to 2° will be performed to maintain 200 KEAS for the execution of both PTIS and ASI. After the ASI, a roll left to 30° and a pitch down to -9° will be performed. The 30° banked turn will be controlled to line up on the runway.

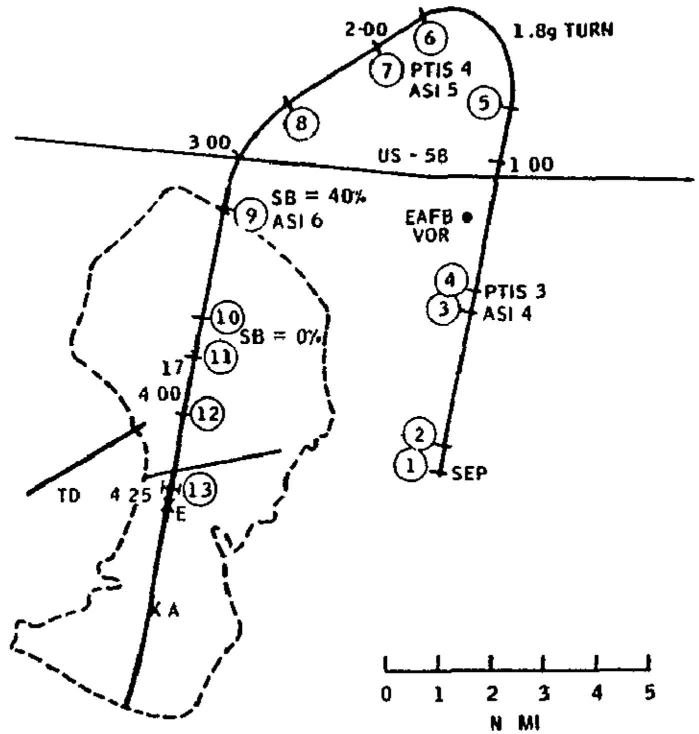
At 260 KEAS, the speed brakes will be deployed to 40 percent and a pitch up to -7° will be performed. The resulting equilibrium glide conditions of 270 KEAS and -12° flight path angle will normally be maintained to 2000 ft AGL. However, the speed brakes may be modulated to control the touch down point. Also during this period ASI's will be made.

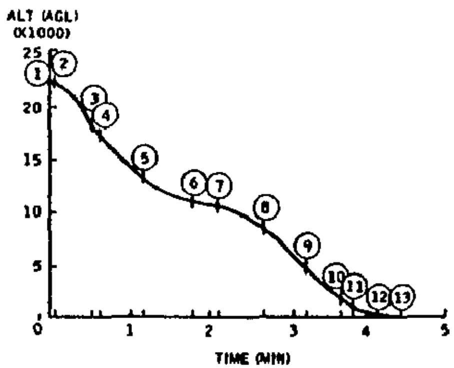
At 2000 ft AGL, the speed brakes and the body flap will be retracted. The preflare maneuver will be initiated about 900 ft AGL. At 250 KEAS, the landing gear will be deployed and touch down will occur about 20 seconds later.

Nosewheel steering will be engaged at 115 KEAS with no braking until speed is below 100 KEAS. Below 60 KEAS, moderate to hard braking will be applied as required.

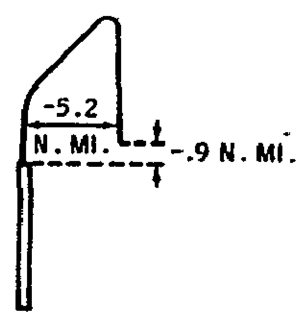
ALT FREE FLIGHT 3

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0:00	22100	260	10	.5	SEP; $\dot{\theta}$ = 2°/SEC, 3 SEC; $\dot{\theta}$ = 0, 2 SEC
2	0:05	21900	250	7	6.5	ROLL RIGHT φ = 20°; $\dot{\theta}$ = -1°/SEC AT θ = -5° ROLL φ = 0; CONTINUE θ = -1°/SEC TO θ = -10°; BF = 0
3	0:33	17700	295	5	-10	$\dot{\theta}$ = 2° SEC TO θ = -3 TO HOLD AS = 300
4	0:35	17000	300	5	-3	PTIS; STICK INPUTS (TOTAL 35 SEC)
5	1.10	13100	300	5	-3	$\dot{\theta}$ = 1°/SEC TO θ = 3, ROLL LEFT 55°; HOLD N_z = 1.8g (α < 13°) TURN TO ψ = 220°
6	1:50	10900	230	9	10	φ = 0, θ = -1°/SEC TO θ = 2 HOLD AS = 200
7	2.05	10700	200	9	2	PITS; STICK INPUTS (35 SEC)
8	2:40	8500	200	9	2	ROLL LEFT φ = 30°; $\dot{\theta}$ = -1°/SEC TO θ = -9° TURN TO ψ = 175°
9	3:14	4600	260	5	-9	θ = 1°/SEC TO θ = -7°; SB = 40% HOLD AS = 270; STICK INPUTS (15 SEC)
10	3:38	2000	270	5	-7	SB → 0; BF → -11.7
11	3:50	900	270	5	-7	INITIATE PREFLARE
12	4.05	350	250	6	4	AT AS - 250, DEPLOY GEAR
13	4.25	0	175	11	11	T. D. AS < 229; $\dot{h}$ < 10 fps
14	4:35	0	115	--	--	AT AS - 115 ENGAGE NWS
15	4:55					MODERATE TO HARD BREAKING AS REQUIRED WHEN AS < 60





WT = 150,000
CG = 66.5% (1096.05)



FREE FLIGHT 4

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on - CSS and Auto FCS modes

SUMMARY

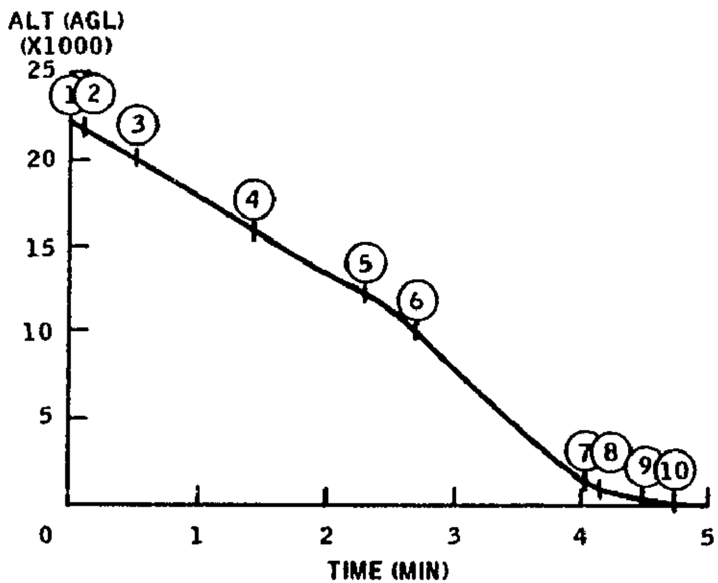
After separation the Orbiter will pitch down to -5°. After 20 seconds, a 30° banked turn will be executed for a heading change of 180°, during which the Orbiter will be accelerated to 270 KEAS. The crew will manually fly the Orbiter following the guidance error needles and speedbrake commands. When the guidance needles are centered, the auto guidance, including auto speed brakes, will be engaged and monitored. The auto guidance may not be engaged until the heading error is less than 45°. Prior to preflare, the auto guidance will be disengaged and the final approach to the lake bed will be controlled manually.

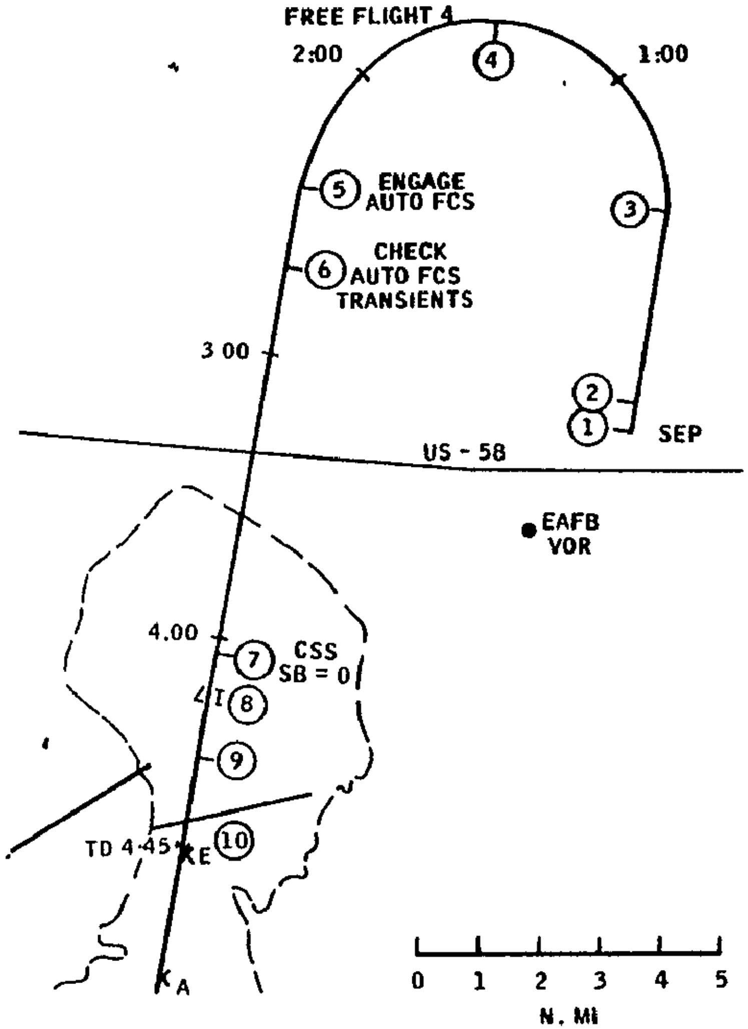
At 2000 ft AGL, the speed brakes will be retracted and the preflare maneuver will be initiated about 900 ft AGL. At 250 KEAS, the landing gear will be deployed and touchdown will occur about 20 seconds later.

With nosewheel steering disengaged, steering will be accomplished with differential braking. Heading changes of $\pm 6^{\circ}$ will also be performed using differential braking.

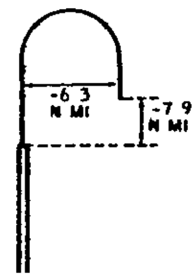
ALT FREE FLIGHT 4

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0:00	22100	260	10	.5	SEP; $\dot{\theta}$ = 2°/SEC, 3 SEC; $\dot{\theta}$ = 0, 2 SEC
2	0:05	21900	250	7	6.5	ROLL RIGHT φ = 20°; $\dot{\theta}$ = -1°/SEC TO θ = 0°, ROLL φ = 0.
3	0:30	20100	250	7	0	ROLL LEFT φ = 30°; HOLD AS = 250
4	1:25	16000	250	7	0	STEER VEHICLE TO LINE UP ON LOCALIZER (ψ = 175) AND GLIDE-SLOPE (θ = -5) WHEN ψ < 225° FLY GUIDANCE ERROR NEEDLES AND SPEEDBRAKE COMMANDS
5	2:20	12100	250	7	-5	WHEN THE GUIDANCE NEEDLES ARE CENTERED ENGAGE AUTO FCS AND SB
6	2:42	10000	270	6	-5	MONITOR AUTO GUIDANCE AND DISENGAGE AND ENGAGE
7	3.58	2000	270	6	-5	FCS → CSS, SB → 0
8	4.10	900	270	6	-5	INITIATE PREFLARE
9	4:25	350	250	6	5	AT AS = 250, DEPLOY GEAR
10	4:45	0	175	11	11	T D. AS < 220; ḣ < 10 fps
11	5:20	0	50	--	--	AT AS < 50, MAKE 6° HEADING CHANGES WITH DIFFERENTIAL BRAKING





WT = 150,000
CG = 64.5 % (1070.24)
BF = -11.7 ENTIRE FLIGHT
AUTO GUIDANCE GS = -12°



FREE FLIGHT 5

CONFIGURATION

150,000 pounds - 64.5% cg - tailcone on - CSS FCS mode

SUMMARY

After separation the Orbiter will accelerate to 270 KEAS (pitch = -10°). When established at equilibrium glide conditions for 270 KEAS (pitch = -2°) and at the proper position/energy relationship, a 30° banked left turn to the base leg will be performed.

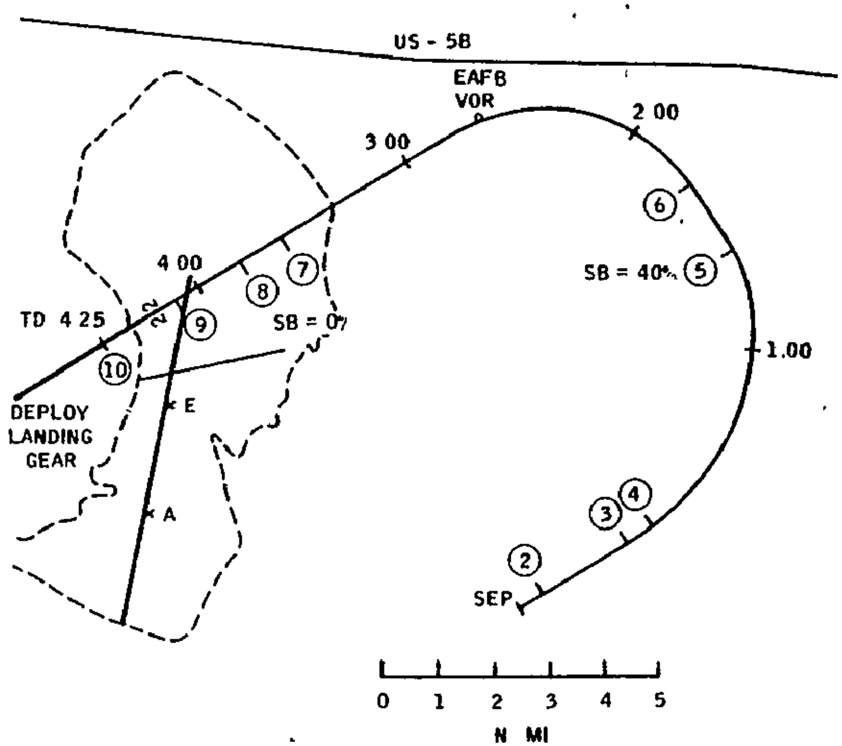
While on base leg, the speed brakes will be deployed to 40 percent to provide range modulation for a precision landing on the concrete runway. A 30° banked turn to the final approach leg will be performed to line up on the concrete runway.

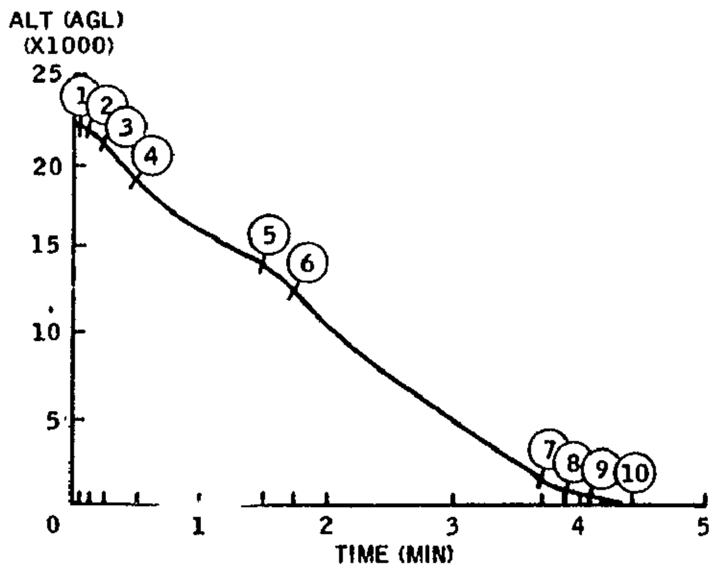
The speed brakes will be modulated by the crew to control the landing point. At 2000 ft AGL, the speed brakes will be retracted; and about 900 ft AGL the preflare maneuver will be initiated. At 250 KEAS, the landing gear will be deployed and touch down will occur about 20 seconds later.

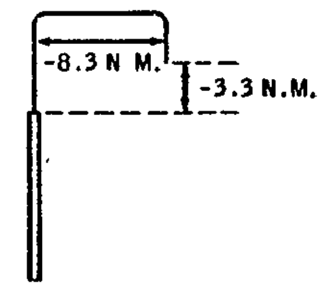
Three seconds after nose wheel touch down hard braking will be applied for 5 seconds. The brakes will be released for at least 5 seconds and hard braking will be applied for 5 seconds. Again the brakes will be released for at least 5 seconds after which braking will be applied as needed to control the rollout. Nose wheel steering will be engaged at 110 KEAS.

ALT FREE FLIGHT 5

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0:00	22100	260	10	.5	SEP; $\dot{\theta}$ = 2°/SEC, 3 SEC; $\dot{\theta}$ = 0, 2 SEC
2	0:05	21900	250	7	6.5	ROLL RIGHT ϕ = 20°; $\dot{\theta}$ = -1°/SEC AT θ = -5° ROLL ϕ = 0; CONTINUE $\dot{\theta}$ = -1°/SEC TO θ = -10°
3	0 18	20400	270	6	-10	AS = 265 $\dot{\theta}$ = 2°/SEC TO θ = -2 HOLD AS = 270
4	0.28	18900	270	6	-2	ROLL LEFT ϕ = 30°, HOLD AS = 270
5	1 28	14000	270	6	-2	AT ψ = 315° ROLL ϕ = 0° SB → 40% θ → -4 HOLD AS = 270
6	1:43	12600	270	6	-4	ROLL LEFT ϕ = 30 TO ψ = 225°
7	3·43	1500	270	6	-4	SB → 0
8	3·50	900	270	5	-9	INITIATE PREFLARE
9	4.05	350	250	6	4	AT AS = 250, DEPLOY GEAR
10	4·25	0	175	11	11	TD AS < 220, $\dot{h}$ < 10 fps
11	4 28	0	160	--	--	AT TD + 3 SEC, BRAKE HARD 5 SEC WAIT 5 SEC, BRAKE HARD 5 SEC WAIT 5 SEC
12	4.48	0	--	--	--	BRAKE AS REQUIRED







WT = 150,000
CG = 64 5% (1070 24)

FREE FLIGHT 6

CONFIGURATION

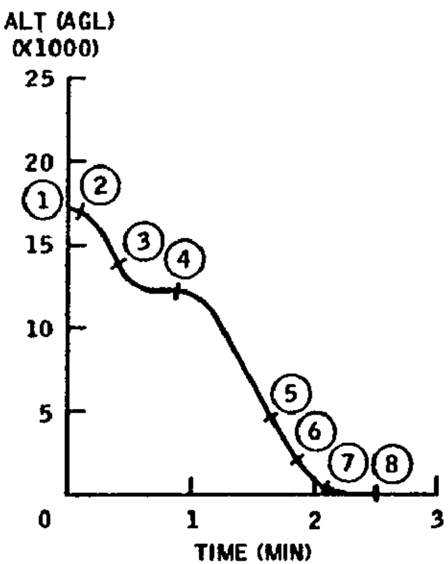
150,000 pounds - 65% cg - tailcone off - CSS FCS mode

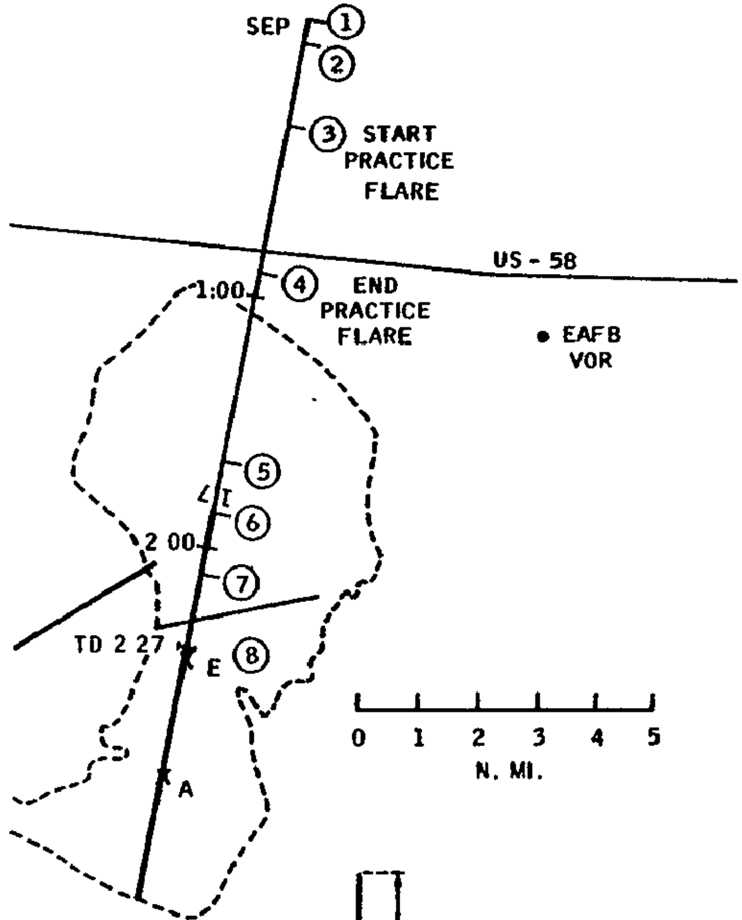
SUMMARY

After separation, the Orbiter will pitch down to -22° and accelerate to 255 KEAS. At 255 KEAS the crew will initiate a practice flare and simulated landing. During the deceleration of the flare, the altitude rate will be held to essentially zero while the crew evaluates the handling qualities. At 185 KEAS and an alpha approximately that of landing (about 11°), the Orbiter will pitch down to -22° and accelerate to 285 KEAS. At 285 KEAS, the crew will pitch up to -17° and establish equilibrium glide conditions at 290 KEAS. At 250 KEAS, the landing gear will be deployed and touch down will occur 20 seconds later.

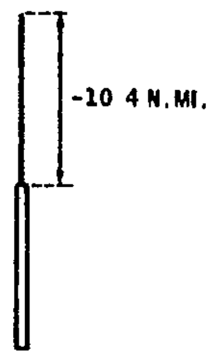
ALT FREE FLIGHT 6

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0:00	17200	260	10	.5	SEP, $\dot{\theta}$ = 2°/SEC, 3 SEC; θ = 0, 2 SEC
2	0·05	17000	244	8	6.5	ROLL RIGHT φ = 20°; $\dot{\theta}$ = -2°/SEC AT θ = -5° ROLL φ = 0; CONTINUE θ = -2°/SEC TO θ = -22°
3	0:23	14300	255	5	-22	AT AS = 255 INITIATE PRACTICE FLARE $\dot{\theta}$ = 2°/SEC, CONTINUE FLARE TO HOLD $\dot{h}$ = 0; AS = 185
4	0:55	12200	180	11	11	AT AS = 185; $\dot{\theta}$ = -2°/SEC TO θ = -22°
5	1 40	4600	285	4	-22	AT AS = 285 $\dot{\theta}$ = 1°/SEC TO θ = -17° TO HOLD AS = 290
6	1 52	2000	290	4	-17	INITIATE PREFLARE θ = 2°/SEC
7	2.07	350	250	6	3	AT AS = 250 DEPLOY GEAR
8	2.27	0	175	11	11	T.D. AS < 220, $\dot{h}$ < 10 fps
9	2:30	0	160	--	--	BRAKE AS REQUIRED





WT = 150,000
CG = 65% (1076.7)
TAILCONE OFF



FREE FLIGHT 7

CONFIGURATION

150,000 pounds - 65% cg - tailcone off - CSS FCS mode

SUMMARY

After separation, the Orbiter will pitch down to -22° and accelerate to 285 KEAS. At 285 KEAS, the speed brakes will be deployed to 45°. The crew will manually fly the Orbiter following the ADI auto-guidance needles including speed brake commands. Prior to preflare, the speed brakes will be retracted. At 2000 ft AGL, the preflare maneuver will be initiated and the landing gear will be deployed at 250 KEAS. Touchdown will occur about 20 seconds after the gear is deployed.

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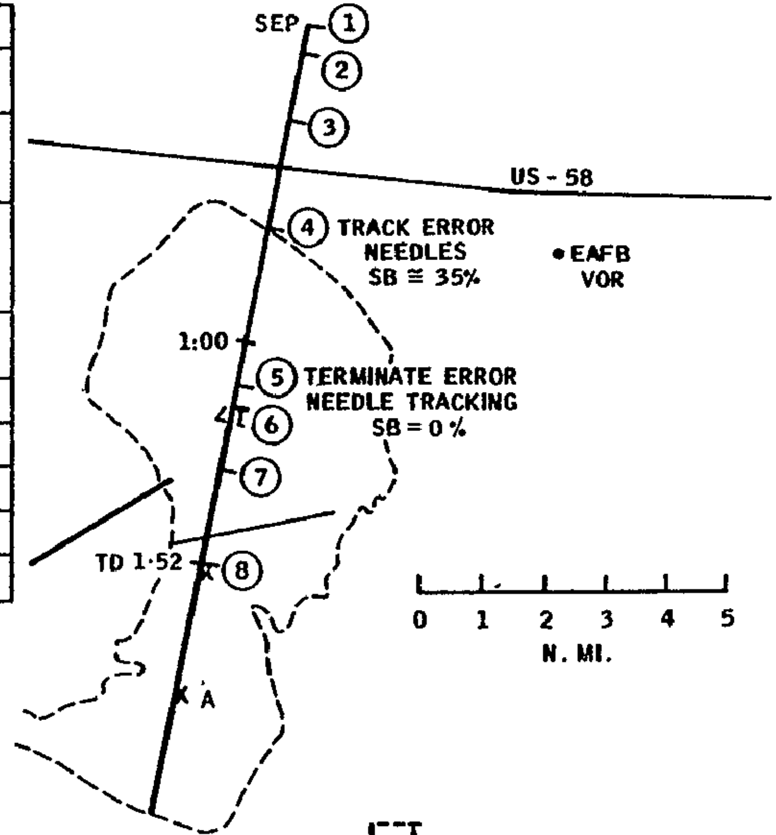
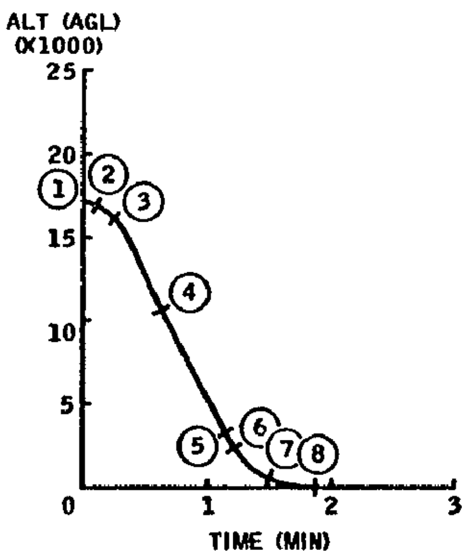
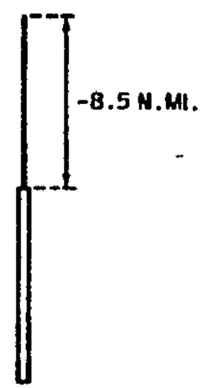
ALT FREE FLIGHT 7

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0:00	17200	260	10	.5	SEP; $\dot{\theta}$ = 2°/SEC, 3 SEC; $\dot{\theta}$ = 0, 2 SEC
2	0:05	17000	244	7	6.5	ROLL RIGHT ϕ = 20°; $\dot{\theta}$ = -2°/SEC AT θ = -5° ROLL ϕ = 0; CONTINUE $\dot{\theta}$ = -2°/SEC TO θ = -22°
3	0:18	15500	238	5	-22	$\dot{\theta}$ = 0; ACCELERATE TO 290, FLY GUIDANCE ERROR NEEDLES TO LINE UP ON LOCALIZER (ψ = 175) AND GLIDESLOPE (θ = -20.5)
4	0.38	10400	290	4	-20.5	FLY GUIDANCE ERROR NEEDLES AND SB BRAKE COMMANDS ≈ 35%
5	1:10	3100	290	4	-20.5	SB → 0
6	1.15	2000	290	4	-20.5	INITIATE PREFLARE θ = 2°/SEC
7	1.30	500	250	6	3	AT AS = 250, DEPLOY GEAR
8	1.52	0	175	11	11	TD AS < 220, $\dot{h}$ < 10 fps
9	1·55	0	160	--	--	BRAKE AS REQUIRED







WT = 150,000

CG = 65% (1076.7)

FREE FLIGHT 8

CONFIGURATION

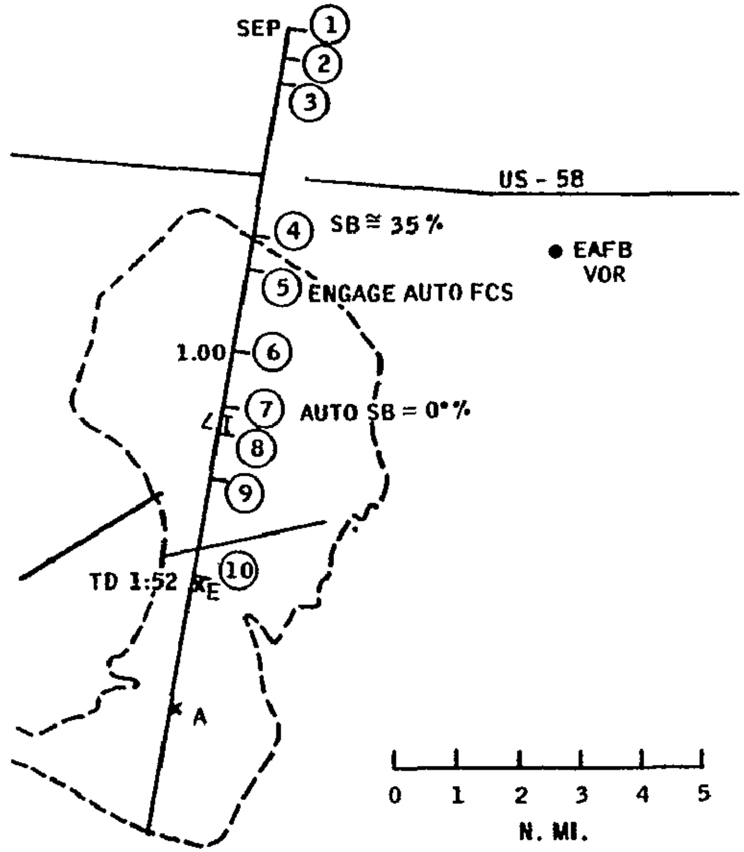
150,000 pounds - 65% cg - tailcone off - CSS and Auto FCS modes

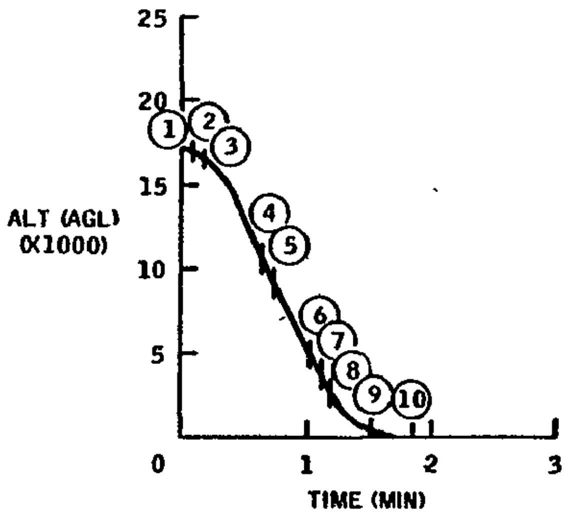
SUMMARY

After separation, the Orbiter will pitch down to -22° and accelerate to 285 KEAS. At 285 KEAS, the speed brakes will be deployed to 45°. The crew will manually fly the Orbiter, following the ADI auto-guidance needles. When the needles are centered, the auto guidance - including auto speed brakes - will be engaged and monitored. The auto guidance will be disengaged and engaged at altitude to determine any switching transients. The auto-guidance will then be allowed to control the flight to touchdown.

ALT FREE FLIGHT 8

ITEM	TIME	ALT (AGL)	KEAS	α	θ	ACTION
1	0:00	17200	260	10	.5	SEP; θ = 2°/SEC, 3 SEC, $\dot{\theta}$ = 0, 2 SEC
2	0:05	17000	250	7	6.5	ROLL RIGHT ϕ = 20°; $\dot{\theta}$ = -2°/SEC AT θ = -5° ROLL ϕ = 0; CONTINUE $\dot{\theta}$ = -2°/SEC TO θ = -22°
3	0:10	15500	238	5	-22	$\dot{\theta}$ = 0, ACCELERATE TO 290, FLY GUIDANCE ERROR NEEDLES TO LINE UP ON LOCALIZER (ψ = 175) AND GLIDESLOPE (θ = -20.5)
4	0:38	10400	290	4	-20.5	FLY GUIDANCE ERROR NEEDLES AND SB BRAKE COMMANDS ≈ 35%
5	0 44	9000	290	4	-20.4	WHEN THE GUIDANCE NEEDLES ARE CENTERED, ENGAGE AUTO FCS (WHICH INCLUDES AUTO SB)
6	1:00	5300	290	4	-20.4	CHANGE FCS TO CSS AND BACK TO AUTO (SET MAN SB TO CMDED PRIOR TO SWITCHING FCS MODES)
7	1:10	3100	290	4	-20.4	MONITOR AUTO SB RETRACTION
8	1:15	2000	290	4	-20.4	MONITOR PREFLARE
9	1.30	500	250	6	3	DEPLOY GEAR ON GEAR DEPLOY LITE OR 250 KEAS
10	1:52	0	175	11	11	MONITOR TD
11	1:55	0	160	--	--	BRAKE AS REQUIRED





WT = 150,000
CG = 65% (1076.7)