

STS-1

Operational Flight Profile

Volume II
Profile Summary - Cycle 3.3.2
(March 10, 1981 Launch Date)

Space Shuttle Program Office

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National Aeronautics and
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SHUTTLE PROGRAM

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STS-1 OPERATIONAL FLIGHT PROFILE

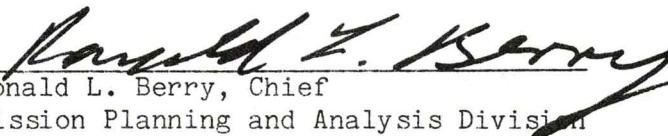
VOLUME II

PROFILE SUMMARY

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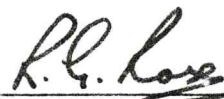
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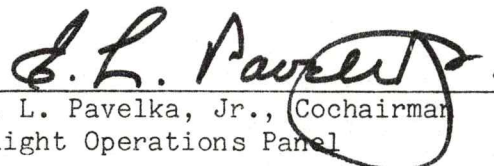


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SPECIAL NOTE

The data presented in this document reflect a total OMS load of 18 000 pounds and inert mass properties from the Shuttle Operational Data Submittal S575-ADD2, dated January 8, 1981. These data were not baselined in the Operational Flight Profile (OFP) Groundrules and Constraints (Volume I) for cycle 3.3.2.

REVISIONS

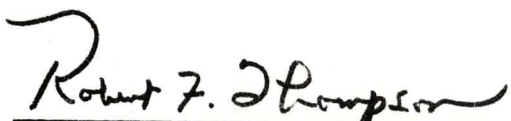
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		OFP Cycle 2 Baseline Issue (references PRCBD S04337, S05109, and S05431)	3/79
1		OFP Cycle 3 (reference PRCBD S05413A)	4/80
2		OFP Cycle 3.2.2 (reference PRCBD 14687)	11/80
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FOREWORD

This document, Volume II, contains the approved profile summary for the Space Shuttle flight-1 (STS-1) operational flight profile (OFP). Volumes II through VIII of the OFP (as defined in table I of this document) are based on the previously baselined groundrules and constraints. Hardware development, software verification, and crew training should be consistent with the data presented within Volumes I through VIII of the STS-1 OFP.

Volumes I and II (Profile Summary) of the STS-1 OFP are approved and controlled by the office of the Space Shuttle Program Manager (Level II). Volumes I and II were baselined using the standard Level II change process.

Document maintenance for all volumes is assigned to the Data Systems and Analysis Directorate (JSC/FA), Mission Planning and Analysis Division (JSC/FM).



Robert F. Thompson, Manager
Space Shuttle Program Office

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1.0 CHANGE CONTROL MANAGEMENT PROCEDURES FOR OPERATIONAL FLIGHT PROFILE DOCUMENTS

1.1 AUTHORITY

This volume is prepared under the authority of the Space Shuttle Program Manager as specified in the Space Shuttle Program Requirements Control Board Directive - Level II - No. S04337, dated February 10, 1978, and as amended by No. S04869, dated June 13, 1978. The profile summary for the STS-1 operational flight profile (OFP) is established in this volume.

1.2 PURPOSE

OFT flight design activity has progressed to the point where configuration control of the OFP design products and recognition by the various organizations that use these products are required. The major producers of the OFP products are the Data Systems and Analysis Directorate (JSC-FA) and the Flight Operations Directorate (JSC-CA). The activities of these directorates are coordinated under the auspices of the Flight Operations Panel (FOP) with this panel acting as the focal point for OFP design issue resolution, except for those issues that are appropriate for Level II disposition. The initial baselining and change control for the OFP Volume I (Groundrules and Constraints) and Volume II (Profile Summary) will be approved and controlled by the office of the Space Shuttle Program Manager.

1.3 SCOPE^a

The following documents normally comprise the OFP design products to be developed for each OFT flight:

- Volume I - Groundrules and Constraints
- Volume II - Profile Summary
- Volume III - Ascent
- Volume IV - Onorbit
- Volume V - Descent
- Volume VI - Abort
- Volume VII - OMS and RCS Consumables Analysis
- Volume VIII - Nonpropulsive Consumables Analysis

Volume I was evaluated through a Level II Change Request for initial baselining. Subsequent OFP documents (Volumes II through VIII) will reflect the content of the baselined Volume I. Volume II (Profile Summary) is baselined according to the procedures in JSC-07700, Volume IV, Appendix L (S04869). All changes to Volume I and Volume II are controlled according to the detailed procedures described in section 1.4.

^aFor Cycle 3.3.2 only; volumes I and II will be published.

1.4 CHANGE CONTROL PROCEDURES

1.4.1 Scope

All proposed changes to the Operational Flight Design Groundrules and Constraints and the Operational Flight Profile Summary baselined by the Level II PRCB will be controlled in accordance with the procedures prescribed herein. The processing flow is shown on page 4. The following paragraphs refer to this flow.

All proposed changes to the Operational Flight Design Groundrules and Constraints and the Operational Flight Profile Summary shall be documented on the Flight Design Change Request (FDCR) form, page 5. Proposed changes may be initiated at the Program (Level II), Project (Level III), or Design Activity levels. Change requests will be submitted to the organizational element responsible for coordinating change activity for the operational product being addressed.

1.4.2 Change Coordination, Assessment, and Categorization

The organizational element responsible for coordinating change requests for the operational product will log each change request, assign a completion date, and transmit the change request to the appropriate offices and/or working group(s). The recipients will review, analyze, and present evaluations, recommendations, and proposed change effectiveness to the organizational element responsible for establishing the content of the operational product. This organizational element will then categorize each proposed change into one of the following categories below.

- a. Approved
- b. Approved with modification
- c. Withdrawn
- d. Disapproved

All categorized change requests except those which are withdrawn or disapproved will be forwarded to the Level II office of primary responsibility for the operational product being addressed.

1.4.3 Manager of the Level II Office of Primary Responsibility

The manager of the Level II office of primary responsibility will sign approved change requests requiring no further Level II action, submit them to the Level II PRCB secretary for PRCBD preparation, and subsequently approve the completed PRCBD for distribution. Change requests disapproved by the manager of the Level II office of primary responsibility will be returned to the originator. Change Requests requiring further Level II review and disposition will be presented to the OFT manager for further action.

1.4.4 OFT Manager

Change requests disapproved by the OFT manager will be returned to the originator. The OFT manager will approve and sign a PRCBD for those change requests not requiring further Level II review and disposition. Change requests requiring consideration by the Program Manager will be forwarded to the Level II PRCB Secretary for review and disposition in accordance with Level II Configuration Management procedures.

1.5 APPROVED CHANGE IMPLEMENTATION

All changes that have been approved in accordance with the preceding paragraphs shall be provided to the organizational element responsible for publishing the affected operational product for implementation. A change history page showing the accumulative changes that have been made will be issued with each document change. This page shall be placed just behind the title page and will provide an up-to-date listing of all changes. Complete revisions of the product will be published as necessary and denoted by a revision number on the front cover. Changes will be made in accordance with the PRCBD.

1.6 OPERATIONAL PLANNING CHANGES AFFECTING PAYLOAD INTEGRATION PLANS (PIP's)

By participating in the Space Shuttle Program change review and disposition process, the Shuttle Payload Integration and Development Program Office (SPIDPO) will attempt to resolve conflicts between OFT operational documents or products and established PIP (or annex) requirements. When conflicts cannot be resolved in the course of this activity, SPIDPO will process a change request to the affected PIP as specified in JSC-13995 (Change Control Requirements and Procedures Manual), negotiating directly with the Space Shuttle Program Office prior to amending the payload agreement affected.

PAGE 1 OF ____	FLIGHT DESIGN CHANGE REQUEST		CR. NO. _____
APPLICABLE TO FLIGHT _____ DOCU. _____	INITIATOR _____	PHONE _____	DATE _____
ORGANIZATION _____			
CHANGE TITLE _____			
DESCRIPTION OF CHANGE			
REASON FOR CHANGE/IMPACT OF NONINCORPORATION			
_____ AUTHORIZED SIGNATURE/DATE			
FOP WORKING GROUP EVALUATION/RECOMMENDATION (INCLUDING EFFECTIVITY)			
_____ WORKING GROUP CHAIRMAN/DATE			
FOP DISPOSITION ☐ APPROVED ☐ APPROVED WITH MOD ☐ DISAPPROVED ☐ WITHDRAWN ☐ LEVEL II ACTION REQ _____ _____ DISPOSITIONING OPERATIONAL ELEMENT DATE ☐ ISSUE PRCBD ☐ FURTHER LEVEL II ACTION REQ. _____ _____ LEVEL II DATE			

2.0 INTRODUCTION

The orbital flight test (OFT) phase of the Shuttle Program consists of four orbital flights beginning in March 1981 and continuing through 1982. The major purpose of the OFT program is to demonstrate and verify Shuttle systems and flight capabilities by satisfying the OFT requirements as presented in reference 1.

This document presents a brief summary of all phases of the operational flight profile (OFP) for the first Space Transportation System-1 (STS-1) flight and supersedes the STS-1 flight profile information presented in reference 2. This summary document (volume II) defines the STS-1 OFP. This OFP summary document represents a combination of the STS-1 groundrules and constraints and the initialization data presented in reference 2 and the STS-1 flight requirements presented in reference 4. This document supersedes the Operational Flight Profile Summary, Cycle 3 (ref. 2).

The STS-1 flight activities described in this document reflect the trajectory, consumable, crew activity, and flight requirement baselines as of January 1, 1981.

Questions concerning the information presented in this document should be directed to Larry Davis (483-4401).

3.0 ACRONYMS

AOA	abort once around
APU	auxiliary power unit
ATO	abort to orbit
Btu/ft ²	heat load
Btu/ft ² / sec	heating rate
c.g.	center of gravity
CTPD	Crew Training and Procedures Division
delta-V	velocity increment
DTO	detailed test objective
EAFB	Edwards Air Force Base
EI	entry interface
EST	eastern standard time
ET	external tank
°F	degrees Fahrenheit
fps	feet per second
g	gravity
GET	ground elapsed time
GMT	Greenwich mean time
I-load	initialization load
IMU	inertial measurement unit
ISP	specific impulse
IOS	Indian Ocean Site (Air Force)
KSC	Kennedy Space Center
LOS	line of sight, loss of signal
MECO	main engine cutoff

max q	maximum dynamic pressure
MR	mixture ratio
O/F	oxidizer/fuel
OFP	operational flight profile
OFT	orbital flight test
OMS	orbital maneuvering system
PEG	powered explicit guidance
PRSD	power reactant supply and distribution
PST	Pacific standard time
psf	pounds per square foot
PTC	passive thermal control
RCS	reaction control system
RSS	root sum square
SRB	solid rocket booster
STS-1	Space Transportation System-1
SVDS	space vehicle dynamics simulation
TAEM	terminal area energy management
tig	time of ignition
Z-LV	Z-axis local vertical

4.0 FLIGHT DESCRIPTION

The STS-1 will be a 54.5-hour flight launched from Kennedy Space Center (KSC) on March 10, 1981 at 12:23 Greenwich mean time (GMT). The Orbiter will be inserted into a 130-n. mi. circular orbit with a 40.3-degree inclination. This orbit will be achieved by two orbital maneuvering system (OMS) maneuvers, OMS-1 (ground elapsed time (GET) = 00:10:32) and OMS-2 (GET = 00:44:00). The OMS-1 maneuver will occur shortly after external tank (ET) separation with the OMS-2 maneuver occurring at the apogee of the orbit resulting from OMS-1. The payload bay doors will be opened as early as possible on day 1. The Orbiter will transfer to 150-n. mi. circular orbit by performing two additional OMS maneuvers (OMS-3 and OMS-4) on the fifth orbit. The Orbiter will be placed in a Y-POP, Z-LV (tail forward into velocity vector) attitude for most of the STS-1 flight. This attitude will be maintained unless other requirements (flight test requirements, inertial measurement unit alinement, etc.) preclude this Z-LV attitude. Deorbit (GET = 53:27:52) will occur on March 12. Nominal landing will occur on runway 23 during a descending pass (orbit 37) to Edwards Air Force Base (EAFB). The GET for the nominal landing will be 54:28:00 (10:51 a.m. Pacific standard time (PST)).

A detailed sequence of events of all major events from lift-off through landing is presented in table I.

4.1 ASCENT

The Shuttle will be launched from KSC (pad 39A) at 12:23:00 GMT (7:23 a.m. eastern standard time (EST)) on March 10, 1981. This launch time corresponds to the opening of the window based on launching no earlier than sunrise + 45 minutes to satisfy the ascent photo-lighting requirement. The following constraints were considered in determining the closing of the launch window:

- a. All landings shall be no earlier than sunrise - 15 minutes or no later than sunset + 15 minutes.
- b. No landings will be scheduled to occur when the Sun azimuth is $\pm 10^\circ$ of the runway heading and 0° to 20° elevation.
- c. The end-of-mission beta must be less than 60° .

Table II summarizes the beta angles as a function of the launch date. For the nominal March 10 date, launch can occur as late as 11:05 EST (16:05 GMT) without violating the landing Sun azimuth-elevation constraint for rev 5 or the end-of-mission backup rev landing at EAFB. The landing Sun azimuth-elevation constraint precludes landings when the Sun azimuth is within $\pm 10^\circ$ of the runway's heading and when the Sun's elevation is between 0° and 20° . For the nominal March 10 launch, this Sun constraint determines the launch window closing time and the launch window duration of 3.7 hours. The resultant launch windows for each month of the year are summarized in table III.

The ascent trajectory for STS-1 was generated using the space vehicle dynamics simulation computer program. The six-degrees-of-freedom simulation incorporates (1) trajectory shaping (lofting), (2) main-engine throttling, and (3) wind

biasing to reduce aerodynamic loads and maintain a maximum dynamic pressure (max q) of approximately 580 lb/ft².

The launch azimuth is 66.96°, measured positive clockwise from the north.

Lift-off from KSC occurs at 0.3 second after solid rocket booster (SRB) ignition, after which a vertical rise to tower clearance phase is initiated, ending at a relative velocity of 107 fps (GET = 7.5 seconds). After tower clearance, a controlled pitchover program is initiated to achieve main engine cutoff (MECO) targets while reducing aerodynamic loads. A max q of 579.6 lb/ft² is achieved at a GET of 52.8 seconds (geodetic altitude 24 335 feet, alpha -3.8, beta 0.1, Earth-relative velocity 1036.2 fps). An SRB separation sequence is initiated at 132.0 seconds GET. After SRB staging, the main engines continue at 100 percent rated thrust level until an acceleration of 3g is attained, after which the engines are throttled to maintain a constant 3g acceleration. Closed-loop steering, using the powered explicit guidance (PEG) simulation, is initiated after SRB staging and is targeted to an inclination of 40.3°, a radius of 21 290 308 feet (60 n. mi. above a spherical Earth with a radius of 3443.9336 n. mi.), a velocity of 25 668 fps, a flightpath angle of 0.5°, and a descending node of 142.0° E. At 18.0 seconds after MECO command, structural separation from the ET occurs. A reaction control system (RCS) -Z translation separation maneuver is initiated 0.16 seconds prior to separation. This maneuver takes 6 seconds and results in a -Z delta-V component of approximately 4 fps. Relative motion between the Orbiter and ET from structural separation through 10 seconds of the OMS-1 maneuver is presented in a target-centered curvilinear coordinate system in figure 1.

The ET is jettisoned on a suborbital trajectory that results in a nominal impact in the Indian Ocean.

Two seconds after the -Z translation maneuver is complete, a +Y translational evasive maneuver is initiated. This maneuver is 24 seconds long and results in a +Y delta-V component of approximately 4 fps.

OMS-1 ignition occurs 102.0 seconds (GET = 00:10:32) after structural separation of the ET. The PEG model is targeted inplane to an orbit with apogee altitude of 130 n. mi.

Upon completion of the 165 fps OMS-1 burn, the resultant orbit has an apogee altitude of 130 n. mi. and a perigee altitude of approximately 57 n. mi. relative to an oblate Earth.

The second OMS ignition occurs near orbital apogee at 00:44:00 GET. The 137 fps delta-V burn places the Orbiter into a near-circular orbit of approximately 130 n. mi. above the spherical Earth radius.

Major ascent events during the first orbit of the nominal STS-1 flight are presented in table IV and figure 2. Maneuver summary tables for the nominal OMS-1 and OMS-2 maneuvers are presented in table V.

First-stage time histories for SSME thrust, dynamic pressure, angle of attack, angle of sideslip, bank angle, and SRB thrust are presented in figures 6 through 11, respectively.

Second-stage time histories of g level and altitude are presented in figures 12 and 13.

4.2 SRB AND ET DISPOSAL

A brief description of the SRB and ET disposal phases of the flight is summarized in this section.

4.2.1 SRB Disposal

The left and right SRB's are jettisoned after burnout (ignition + 131.9 seconds) on tumbling free-fall trajectories. At 74.8 seconds after separation (nominal apogee), the nozzle extension on each SRB is jettisoned. During the descending portion of the trajectory, the SRB's achieve a nose-up trim condition. At an altitude of 17 000 feet, the nosecap on each SRB is jettisoned, beginning the parachute deployment sequence. This culminates at 7000 feet with the deployment of three main parachutes on each SRB. Table VI presents the sequence of significant events during the trajectory from separation to impact. The altitude time histories of both the left and right SRB's are illustrated in figure 3.

The right SRB impacts in the Atlantic Ocean 300.5 seconds after separation, 138.9 n. mi. from the launch site. The coordinates of the nominal impact point are 29.793° N latitude, 78.332° W longitude. The left SRB impacts approximately 0.5 n. mi. right crossrange of the right SRB, 301.2 seconds after separation. This is 138.9 n. mi. from the launch site, at 29.786° N latitude, 78.328° W longitude. Figure 4 shows the location and size of the composite footprint containing all elements of both SRB's. The composite footprint is 16.9 n. mi. long and 8.4 n. mi. wide.

Because the RTLS abort region extends beyond, and the AOA and ATO regions occur after nominal SRB cutoff and separation, the SRB impact areas defined for the nominal missions apply for these conditions. Only for an engine-out RTLS abort occurring between lift-off and nominal SRB cutoff is the SRB impact footprint changed from the nominal planned.

4.2.2 ET Disposal

The intact ET impact location for the nominal mission is 31.0° S latitude and 93.2° E longitude in the Indian Ocean. Trajectory, drag, rotational lifting effect, and atmospheric uncertainties, together with the debris breakup scatter during entry result in an ET impact footprint of 1077 n. mi. uprange and 1033 n. mi. downrange from the nominal impact point. There is also a crossrange deviation of ± 31 n. mi. about the groundtrack. The ET breakup occurs during entry at an altitude of 193 000 feet for tumbling drag. Figure 5 presents the ET ground-track and the footprint dispersion area. The uprange footprint boundary is 21.4° S latitude and 77.3° E longitude. The downrange footprint is 37.3° S latitude and 111.4° E longitude. The crossrange boundary is $\pm 0.5^{\circ}$ in width. Figure 5 shows that the ET footprint does not violate the constraint of impacting closer than 200 n. mi. from a landmass.

4.3 ONORBIT

The STS-1 orbital operations phase is initiated at the completion of the OMS-2 maneuver (GET = 00:44:53) and terminates at deorbit ignition (GET = 53:27:52).

Day 1 of the STS-1 flight is concerned primarily with configuring the vehicle for onorbit operation (i.e., opening payload bay doors, reconfiguring software, IMU alinements). Also, following verification of critical vehicle systems, the Orbiter is transferred to a 150-n. mi. circular orbit by means of two OMS engine maneuvers (OMS-3 and OMS-4). The OMS-3 maneuver occurs in orbit 5 (at GET = 6:20:41) and raises the apogee to 150 n. mi. The OMS-4 maneuver is performed approximately one-half an orbit later (GET = 7:05:31) and circularizes the orbit to 150 n. mi. The primary activity schedule for day 2 is to accomplish a series of flight test objectives (RCS test, control system test, etc.).

The final day of flight is concerned with preparations for deorbit and landing. Several detailed test objectives (DTO) are scheduled for completion during the orbital phase of STS-1. However, the detail scheduling of these and other crew-related activities is not presented in this document since the crew activity plan to be published by the Crew Training and Procedures Division (CTPD) in January 1981 is the official source for these types of data.

Deorbit opportunities to EAFB and five contingency landing sites (crossrange less than or equal to 700 n. mi.) are shown in table VII. Detailed maneuver tables for OMS-3 and OMS-4 are provided in table VIII. The flight groundtracks with major events noted are shown in figure 14. The consumables budgets are summarized in this document. The OMS and RCS budgets are presented in table IX, X, XI, and XII. Nonpropulsive consumables budgets are presented in tables XIII through XX.

Detailed tabular trajectory and GSTDN data with masking (super tape printout) are provided in appendix A (published separately in December 1980). Detailed trajectory and attitude data are provided in appendix B (to be published in March 1981). Detailed propulsive consumables data are provided in appendix C (to be published in February 1981). Detailed nonpropulsive consumables data are provided in appendix D (to be published in February 1981).

4.4 DESCENT

The deorbit maneuver is initiated at 53 hours 27 minutes 52 seconds GET during the 36th orbit, with subsequent landing on runway 23 at EAFB at 10:51 local time. The 36th orbit was selected for deorbit because it provides the best combination of predeorbit and postdeorbit tracking and communication. A backup deorbit opportunity occurs during the 37th orbit with degraded postdeorbit tracking and communication and with no coverage during the last orbit through the Ascension tracking station.

The deorbit maneuver is normally performed using two OMS engines; however, deorbit targeting and OMS propellant loading provide the capability to deorbit with either one OMS engine or RCS engines using OMS propellant and achieve the nominal entry conditions. In addition, sufficient OMS and RCS propellant is

loaded and budgeted to provide a deorbit capability with a minimum deorbit velocity increment that achieves entry interface (EI) conditions satisfactory for atmospheric capture and a safe entry for a systems failure that prevents use of propellant from one set of OMS propellant tanks.

This OMS loading makes it necessary to use excess OMS propellant for nominal deorbit to achieve the desired entry longitudinal center-of-gravity (c.g.) position of 66.7 percent at Mach = 3.0. This propellant wasting is accomplished by an out-of-plane deorbit maneuver component resulting in a total deorbit velocity increment (ΔV) of 299.1 fps, with a thrust duration of 2 minutes 35 seconds and a 25-minute 42-second free-fall time between thrust termination and EI. A maneuver summary table for the nominal deorbit is presented in table XXI. Nominal conditions at EI of 400 000 feet altitude are 4392 n. mi. range-to-go, 25 750 fps inertial velocity, and -1.2° inertial flightpath angle, with an Orbiter weight of 196 288 pounds. The deorbit through landing groundtrack is presented in figure 15.

A 40° angle of attack is maintained during the early part of atmospheric descent to minimize the aerodynamic heating environment. This angle of attack is maintained until the aerodynamic heating is reduced to a relatively low level with pitchover to a lower angle of attack beginning at an Earth-relative speed of 14 500 fps. This pitchover continues until an angle of attack of 14.0° is reached at the entry/terminal area energy management (TAEM) interface at 2500 fps Earth-relative speed. The nominal entry profile results in a maximum surface temperature of 2683°F on the reinforced carbon carbon material, with the most critical location being on the wing leading edge. The heat load and maximum reference heating rate on this trajectory is $54\,522\text{ Btu/ft}^2$ and $61.2\text{ Btu/ft}^2/\text{sec}$, respectively. The nominal thermal constraints boundaries are presented in figure 16.

At entry/TAEM interface (2500 fps relative velocity), the dynamic pressure is 210 psf at an attitude of 84 200 feet and range-to-go of 59.7 n. mi., which provides adequate maneuverability margins to accommodate worst case error sources for achieving approach-and-landing interface. The TAEM profile is shaped to produce a dynamic pressure profile, which is reduced to 162 psf near Mach 1 to achieve an angle-of-attack corridor that will avoid the $C_{Y\beta}$ dynamic stability boundary on a 3-sigma basis. The dynamic pressure is ramped in the subsonic region to the 265 psf required at approach-and-landing interface, which provides a low angle-of-attack profile to minimize the effects of rolloff and noseslice tendencies and buffet onset in the transonic area.

The approach-and-landing phase was simulated with two modifications to the FSSR autoland guidance, referred to as the Ames mods. The basic geometry consists of a 20° outer glideslope followed by a preflare maneuver to a 1.5° inner glideslope. A dynamic pressure of 265 psf is used on the outer glideslope to provide speedbrake settings that can account for dispersions and to provide enough energy for 5 seconds of flight on the inner glideslope and an energy reserve at touchdown corresponding to at least 4 seconds of flight time. The preflare maneuver is designed to result in normal accelerations less than $1.5g$'s.

Following a final flare maneuver, touchdown occurs at 188 knots equivalent airspeed with a 1.5-fps descent rate. The landing gear deployment starts when the

equivalent airspeed decreases through 270 knots. A nominal gear deployment time of 7.5 seconds was used and resulted in the gear being down-and-locked 11 seconds prior to touchdown.

4.5 ASCENT ABORTS

Intact abort capability is provided for the STS-1 launch to return the crew and Orbiter safety to a primary landing site following the loss of a single SSME or a time-critical failure requiring an immediate return. During ascent, the abort capability is subdivided into two regions: (1) return-to-launch site (RTLS) abort capability that is available for failures up to approximately 260 seconds flight time, and (2) a press to MECO capability that is planned for use during main-engine failures after approximately 260 seconds. These abort types are presented in figure 17.

An RTLS abort is initiated approximately 20 seconds after SRB staging for failures in first stage or approximately 20 seconds after the failure for failures in second stage.

RTLS is subdivided into several unique flight phases. A typical RTLS profile is shown in figure 18. The powered flight (PRTLS) consists of a fuel dissipation phase to an exoatmospheric pitcharound maneuver, followed by a closed loop guidance phase to set up the ET separation and the Orbiter glide potential. Mated coast is the next phase which includes the approximately 14 seconds coast from MECO to ET separation. This phase consists of blended aerodynamic and RCS control of the combined Orbiter/ET mated configuration. The ET separation phase utilizes a minus-Z RCS translation maneuver to separate the Orbiter from the ET. Once the Orbiter has achieved aerodynamic flight, glide phase (GRTLS) is initiated.

The GRTLS consists of an alpha recovery and load relief phase followed by a transition to the automatic TAEM entry guidance to return the Orbiter to the KSC Shuttle runway. Landing will occur approximately 22 minutes after lift-off.

The press-to-MECO concept is to continue normal ascent after the failure occurs. This allows the actual abort decision to be postponed until after MECO. Based on the actual MECO state achieved and the status of the vehicle, the decision to continue the normal mission, abort to orbit (ATO), or abort once around (AOA) will be made. The press-to-MECO abort boundary is designed to guarantee at least an AOA capability for minimum performance following the failure. Failures beyond the abort boundary or better performance could result in ATO or normal mission capability.

The AOA consists of two OMS maneuvers to set up a one-revolution return to Northrup strip, the prime landing site for AOA. The AOA entry is planned to be near nominal but could utilize up to a 700-n. mi. crossrange capability. Landings will occur approximately 107 minutes after lift-off. A typical AOA profile is shown in figure 19.

The ATO consists of two OMS maneuvers inserting the Orbiter into a 105-n. mi. circular orbit. A typical ATO profile is shown in figure 20. Based on the OMS performance available and vehicle status after orbit insertion, the orbit will be increased as close to the normal 150-n. mi. altitude as possible. Full mission duration is planned except for time-critical failures requiring an earlier return.

The abort I-loads have been developed in accordance with the baselined ground-rules and constraints for STS-1, cycle 3.2.2. In addition, several design preferences have been established that influence the abort profiles and the associated I-loads. Some of these key preferences include:

- a. Minimizing attitude transition between the SSME out attitude and that attitude required for RTLS fuel dissipation thrusting
- b. Constraining the AOA OMS-1 apogee target to be the same altitude as the ATO circular orbit to allow a common AOA/ATO OMS-1 target
- c. Optimizing AOA and ATO targets for underspeed MECO conditions
- d. Accommodating at least a 2-minute OMS-1 ignition delay

5.0 ASSESSMENT OF FLIGHT REQUIREMENTS COMPLETION

The STS-1 flight profile presented in this document was developed to satisfy the tests specified in the flight requirements document for STS-1 (ref. 4). It is realized that only the subsystem manager or initiator of a test can give a complete evaluation. However, assuming that the data collection specified in the various DTO's can be satisfied, then all the STS-1 tests can be accomplished with the current profile.

6.0 REFERENCES

1. Shuttle Master Verification Plan. JSC-007700-10-MVP-11.
2. Mission Planning and Analysis Division: STS-1 Operational Flight Profile, Volume II - Profile Summary, Cycle 3. JSC-14483, April 1980.
3. Mission Planning and Analysis Division: STS-1 Operational Flight Profile, Volume I - Groundrules and Constraints, Cycle 3.3.2. JSC-17023, December 1980.
4. Space Transportation System Flight Requirement Document: Space Shuttle Orbital Flight Test (STS-1). JSC-10780, Basic, Rev. D, May 1980.

TABLE I.- STS-1 FLIGHT SEQUENCE OF EVENTS

GMT of STS-1 launch: March 10, 1981 12:23:00 (7:23 a.m. EST)		
Inclination = 40.3°		
Event	Mission elapsed time, hr:min:sec	Comments
SRB ignition	0:00:00	
Lift-off	0:00:00.3	
Pitchover	0:00:08	
Max q	0:00:53	
SRB separation	0:02:12	
MECO	0:08:32	Orbit = 13/80
ET separation	0:08:50	
OMS-1 ignition	0:10:32	
OMS-1 cutoff	0:12:01	Orbit = 57/130 $\Delta V = 165$ fps
OMS-2 ignition	0:44:00	
OMS-2 cutoff	0:45:15	Orbit = 130/130 $\Delta V = 137$ fps
OMS-3 ignition	6:20:41	
OMS-3 cutoff	6:21:20	Orbit = 130/150 $\Delta V = 36.5$ fps
OMS-4 ignition	7:05:31	
OMS-4 cutoff	7:06:11	Orbit = 150/150 $\Delta V = 37.5$ fps
Deorbit ignition	53:27:52	
Deorbit cutoff	53:30:27	Orbit = 2/149 $\Delta V = 299.$ fps
Entry interface	53:56:09	
TAEM	54:21:30	
Landing	54:27:49	

TABLE II.- STS-1 BETA ANGLE AS A FUNCTION OF LAUNCH TIME

Launch date	Lift-off EST, hr:min (a.m.)	Launch beta, deg	End-of- mission beta, deg
March 10	7:23	-39	-30
March 31	6:59	-30	-21
April 30	6:28	-17	-9
May 31	6:10	-9	-1
June 30	6:11	-8	0
July 31	6:27	-13	-5
August 31	6:44	-24	-16
September 30	7:00	-38	-30
October 31	7:18	-50	-43
November 30	7:42	-59	-51
December 31	8:00	-61	-52
January 31	7:57	-54	-46
February 28	7:33	-43	-34

TABLE III.- STS-1 LAUNCH WINDOW SUMMARY

Launch date	Lift-off GMT, hr:min (a.m.)	Lift-off EST, hr:min (a.m.)	Nominal landing PST, hr:min (a.m.)	Launch window duration, hr	Closing constraint code ^a
March 10 ^b	12:23	7:23	10:51	3.7	2
March 31 ^b	11:59	6:59	10:27	6.4	3
April 30 ^b	11:28	6:28	9:56	7.3	3
May 31 ^b	11:10	6:10	9:38	8.0	3
June 30 ^b	11:11	6:11	9:39	8.1	3
July 31 ^c	11:27	6:27	9:55	7.6	3
August 31 ^c	11:44	6:44	10:12	6.7	3
September 30 ^c	12:00	7:00	10:28	4.1	2
October 31	12:18	7:18	10:46	3.2	2
November 30	12:42	7:42	11:10	1.3	1
December 31	13:00	8:00	11:28	1.1	1
January 31	12:57	7:57	11:25	2.6	2
February 28 ^b	12:33	7:33	11:01	3.3	2

^aCodes:

- 1 = Window closing due to end-of-mission beta = 60°.
- 2 = Window closing due to Sun-runway azimuth/elevation (backup landing opportunity or rev 5 landing).
- 3 = Window closing due to sunset + 15 landing (backup landing opportunity or rev 5 landing).

^bDesirable to land prior to 10:00 a.m. PST at EAFB.^cDesirable to land prior to 12:00 noon PST at EAFB.

TABLE IV.- STS-1 ASCENT MAJOR EVENTS

		GET, min:sec	Range, n. mi.	Altitude/orbit, n. mi.
	Lift-off	0:00	0.	0.
1	Throttle for dynamic pressure	0:34	.4	1.7
	Maximum dynamic pressure	0:53	1.7	4.4
2	SRB separation	2:12	21.	27.
3	MECO (ET separation)	8:32	740.	13/80
4	OMS-1 ignition	10:32	---	
5	OMS-1 cutoff	12:01	---	57/130
6	OMS-2 ignition	44:00	---	
7	OMS-2 cutoff	45:15	---	130/130

TABLE V.- STS-1 MANEUVER SUMMARY TABLE

(a) Nominal OMS-1

Parameter	Value	Unit
OMS pitch	0.3	deg
OMS left yaw	-6.4	deg
OMS right yaw	6.4	deg
WT	213428.	lb
GET ignition	0:00:10:32.4	d:h:m:s
GMT ignition	10:12:33:32.4	d:h:m:s
C1	0	fps
C2	0	---
HT	130.017	n. mi.
OT	160.027	deg
PRPLT	0	lb
DVX)	162.5	fps
DVY) LVLH	0.0	fps
DVZ)	11.9	fps
RI)	319.9	deg
PI) INRTL	53.1	deg
YI) RELMAT	1.3	deg
RR)	181.7	deg
PR) REF	318.4	deg
YR) RELMAT	0.	deg

TABLE V.- Continued

(a) Concluded

Parameter		Value	Unit
RH	LVLH	180.	deg
PH		340.2	deg
YH		0.	deg
HA		130.	n. mi.
HP		80.	n. mi.
DVT		165.	fps

TABLE V.- Continued

(b) Nominal OMS-2

Parameter	Value	Unit
OMS pitch	0.3	deg
OMS left yaw	-6.4	deg
OMS right yaw	6.4	deg
WT	209880.	lb
GET ignition	0:00:44:00	d:h:m:s
GMT ignition	10:13:07:00	d:h:m:s
C1	0	fps
C2	0	---
HT	137.012	n. mi.
OT	340.050	deg
PRPLT	0	lb
DVX	N/A	fps
DVY	N/A	fps
DVZ	N/A	fps
RI	28.	deg
PI	190.	deg
YI	330.	deg
RR	80.	deg
PR	88.	deg
YR	358.	deg

TABLE V.- Concluded

(b) Concluded

Parameter		Value	Unit
RH	LVLH	180.	deg
PH		347.	deg
YH		360.	deg
HA		130	n. mi.
HP		130	n. mi.
DVT		137	fps

TABLE VI.- STS-1 SRB DISPOSAL SEQUENCE OF EVENTS

Event	Time, sec	Altitude, ft
SRB separation (lift-off +131.9 sec)	0	163 004
Terminate separation motor burn	2.0	167 547
Jettison nozzle extension	74.8	248 951
Jettison nose cap and deploy pilot chute	226.2	17 000
Deploy drogue chute	227.2	16 482
Jettison frustum and deploy three main parachutes	249.1	7 000
SRB impact	300.5	0
Nose cap impact	347.1	0
Frustum impact	356.3	0
Nozzle extension impact	395.2	0

TABLE VII- DEORBIT OPPORTUNITIES

(Crossrange $\leq$ 700 n. mi.)

(a) EAFB

Deorbit orbit	Crossrange, n. mi. ^a	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit $\rightarrow$ EI)	Lighting condition at landing ^b
2	136 N	2:22	2:46	3:16	ORR	Daylight
3	242 S	3:56	4:20	4:50	ORR	Daylight
4	320 S	5:30	5:54	6:24	WINU	Daylight
5	82 S	7:03	7:28	7:58	GWM	Daylight
6	535 N	8:38	9:03	9:33	--	Daylight
17	541 N	24:42	25:12	25:42	ORR	Daylight
18	14 S	26:16	26:46	27:16	ORR	Daylight
19	303 S	27:51	28:21	28:51	WINU	Daylight
20	274 S	29:26	29:56	30:26	WINU	Daylight
21	67 N	31:01	31:31	32:01	GWM	Daylight
22	660 N	32:35	33:05	33:35	--	Daylight
33	327 N	48:44	49:14	49:44	ORR	Daylight
34	145 S	50:19	50:49	51:19	ORR	Daylight
35	330 S	51:54	52:24	52:54	WINU	Daylight
36	191 S	53:28	53:58	54:28	GWM	Daylight
37	244 N	55:02	55:34	56:02	GWM	Daylight
49	139 N	72:47	73:17	73:47	ORR	Daylight
50	243 S	74:22	74:52	75:22	ORR	Daylight
51	319 S	75:57	76:27	76:57	WINU	Daylight
52	73 S	77:32	78:02	78:32	GWM	Daylight
53	447 N	79:06	79:36	80:06	--	Daylight
64	528 N	95:15	95:45	96:15	--	Dark
65	22 S	96:50	97:20	97:50	ORR	Daylight
66	305 S	98:24	98:54	99:24	ORR	Daylight
67	270 S	99:59	100:29	100:59	WINU	Daylight
68	76 N	101:34	102:04	102:34	GWM	Daylight
69	674 N	103:09	103:39	104:09	--	Daylight

^a"N" means Orbiter must fly north of groundtrack to reach landing site and "S" means Orbiter must fly south of groundtrack to reach landing site.

^b"Daylight" is defined as later than "sunrise minus 15 minutes" and earlier than "sunset plus 15 minutes".

TABLE VII.- Continued
 (Crossrange $\leq$ 700 n. mi.)

(b) KSC

Deorbit orbit	Crossrange, n. mi. ^a	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit $\rightarrow$ EI)	Lighting condition at landing ^b
1	495 S	0:54	1:19	1:49	ORR	Daylight
3	571 S	4:03	4:28	4:58	HAW	Daylight
4	118 S	5:37	6:02	6:32	WINU	Daylight
5	568 N	7:11	7:36	8:06	GWM	Daylight
15	514 N	21:39	22:09	22:39	ORR	Sunrise - 36 min
16	164 S	23:14	23:44	24:14	ORR	Daylight
17	597 S	24:49	25:19	25:49	ORR	Daylight
19	454 S	28:00	28:30	29:00	HAW	Daylight
20	92 N	29:34	30:04	30:34	WINU	Daylight
31	262 N	45:42	46:12	46:42	ORR	Sunrise - 33 min
32	343 S	47:16	47:46	48:16	ORR	Daylight
33	672 S	48:52	49:22	49:52	ORR	Daylight
34	656 S	50:27	50:57	51:27	ORR	Daylight
35	297 S	52:02	52:32	53:02	HAW	Daylight
36	329 N	53:37	54:07	54:37	GWM	Daylight
47	31 N	69:44	70:14	70:44	ORR	Sunrise - 31 min
48	491 S	71:19	71:49	72:19	ORR	Daylight
50	570 S	74:30	75:00	75:30	ORR	Daylight
51	110 S	76:05	76:35	77:05	HAW	Daylight
52	586 N	77:40	78:10	78:40	GWM	Daylight
62	499 N	92:12	92:42	93:12	--	Dark
63	175 S	93:47	94:17	94:47	ORR	Sunrise - 28 min
64	602 S	95:22	95:52	96:22	ORR	Daylight
66	446 S	98:33	99:03	99:33	ORR	Daylight
67	105 N	100:08	100:38	101:08	HAW	Daylight

^a"N" means Orbiter must fly north of groundtrack to reach landing site and "S" means Orbiter must fly south of groundtrack to reach landing site.

^b"Daylight" is defined as later than "sunrise minus 15 minutes" and earlier than "sunset plus 15 minutes".

TABLE VII.- Continued
 (Crossrange $\leq$ 700 n. mi.)
 (c) Northrup Strip

Deorbit orbit	Crossrange, n. mi. ^a	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit $\rightarrow$ EI)	Lighting condition at landing ^b
1	316 N	0:49	1:14	1:44	ORR	Daylight
2	202 S	2:23	2:48	3:18	ORR	Daylight
3	441 S	3:57	4:22	4:52	WINU	Daylight
4	355 S	5:32	5:57	6:27	HAW	Daylight
5	39 N	7:06	7:31	8:01	GWM	Daylight
6	680 N	8:40	9:05	9:35	--	Daylight
17	130 N	24:44	25:14	25:44	ORR	Daylight
18	312 S	26:18	26:48	27:18	ORR	Daylight
19	449 S	27:54	28:24	28:54	WINU	Daylight
20	254 S	29:29	29:59	30:29	WINU	Daylight
21	235 N	31:03	31:33	32:03	GWM	Daylight
32	553 N	47:12	47:42	48:12	ORR	Sunrise - 47 min
33	50 S	48:46	49:16	49:46	ORR	Daylight
34	396 S	50:20	50:51	51:21	ORR	Daylight
35	420 S	51:26	52:26	52:56	WINU	Daylight
36	117 S	53:31	54:01	54:31	GWM	Daylight
37	454 N	55:06	55:36	56:06	GWM	Daylight
64	119 N	95:17	95:47	96:17	ORR	Sunrise - 42 min
65	318 S	96:52	97:22	97:52	ORR	Daylight
66	449 S	98:27	98:57	99:27	ORR	Daylight
67	247 S	100:02	100:32	101:02	WINU	Daylight
68	247 N	101:37	102:07	102:37	GWM	Daylight

^a"N" means Orbiter must fly north of groundtrack to reach landing site and "S" means Orbiter must fly south of groundtrack to reach landing site.

^b"Daylight" is defined as later than "sunrise minus 15 minutes" and earlier than "sunset plus 15 minutes".

TABLE VII.- Continued
 (Crossrange $\leq$ 700 n. mi.)

(d) Hickam

Deorbit orbit	Crossrange, n. mi. ^a	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit $\rightarrow$ EI)	Lighting condition at landing ^b
3	77 S	3:45	4:10	4:40	WINU	Daylight
8	52 S	11:36	12:06	12:36	IOS	Daylight
18	473 N	26:06	26:36	27:06	ORR	Dark
19	314 S	27:41	28:11	28:41	WINU	Daylight
23	516 S	34:04	34:34	35:04	IOS	Daylight
24	218 N	35:39	36:09	36:39	IOS	Daylight
34	189 N	50:09	50:39	51:09	ORR	Dark
35	539 S	51:41	52:14	52:44	WINU	Daylight
39	288 S	58:07	58:37	59:07	IOS	Daylight
40	504 N	59:41	60:11	60:41	IOS	Daylight
50	80 S	74:12	74:42	75:12	ORR	Dark
55	37 S	82:09	82:39	83:09	IOS	Daylight
65	456 N	96:40	97:10	97:40	--	Dark
66	328 S	98:14	98:44	99:14	ORR	Dark
70	504 S	104:37	105:07	105:37	IOS	Daylight
71	234 N	106:12	106:42	107:12	IOS	Daylight

^a"N" means Orbiter must fly north of groundtrack to reach landing site and "S" means Orbiter must fly south of groundtrack to reach landing site.

^b"Daylight" is defined as later than "sunrise minus 15 minutes" and earlier than "sunset plus 15 minutes".

TABLE VII.- Continued
 (Crossrange $\leq$ 700 n. mi.)
 (e) Kadena

Deorbit orbit	Crossrange, n. mi. ^a	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit $\rightarrow$ EI)	Lighting condition at landing ^b
6	353 N	8:12	8:38	9:08	--	Dark
7	326 S	9:43	10:13	10:43	--	Dark
10	554 S	14:30	15:00	15:30	ACN	Daylight
11	24 N	16:04	16:34	17:04	ACN	Daylight
22	100 N	32:10	32:40	33:10	--	Dark
23	504 S	33:46	34:16	34:46	BOTU	Dark
26	386 S	38:32	39:02	39:32	ACN	Daylight
27	270 N	40:07	40:37	41:07	ACN	Daylight
37	608 N	54:39	55:09	55:39	--	Dark
38	132 S	56:14	56:44	57:14	--	Dark
39	648 S	57:49	58:19	58:49	BOTU	Dark
41	680 S	61:00	61:30	62:00	--	Sunrise - 20 min
42	188 S	62:35	63:05	63:35	ACN	Daylight
43	536 N	64:10	64:40	65:10	ACN	Daylight
53	337 N	78:42	79:12	79:42	--	Dark
54	337 S	80:16	80:46	81:16	--	Dark
57	545 S	85:03	85:33	86:03	BOTU	Sunrise - 17 min
58	37 N	86:38	87:08	87:38	--	Daylight

^a"N" means Orbiter must fly north of groundtrack to reach landing site and "S" means Orbiter must fly south of groundtrack to reach landing site.

^b"Daylight" is defined as later than "sunrise minus 15 minutes" and earlier than "sunset plus 15 minutes".

TABLE VII.- Concluded
 (Crossrange $\leq$ 700 n. mi.)

(f) Rota

Deorbit orbit	Crossrange, n. mi. ^a	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit $\rightarrow$ EI)	Lighting condition at landing ^b
1	443 N	1:05	1:35	2:05	TUL	Daylight
13	142 N	18:45	19:15	19:45	--	Daylight
14	184 S	20:20	20:50	21:20	QUI	Daylight
15	204 S	21:55	22:25	22:55	--	Daylight
16	87 N	23:30	24:00	24:30	TUL	Daylight
17	636 N	25:04	25:34	26:04	BDA	Daylight
28	499 N	41:14	41:44	42:14	AGO	Daylight
29	1 S	42:48	43:18	43:48	--	Daylight
30	227 S	44:23	44:53	45:23	QUI	Daylight
31	138 S	45:58	46:28	46:58	MIL	Daylight
32	248 N	47:32	48:02	48:32	TUL	Daylight
44	303 N	65:16	65:46	66:16	AGO	Daylight
45	111 S	66:51	67:21	67:51	--	Daylight
46	232 S	68:26	68:56	69:26	--	Daylight
47	38 S	70:00	70:30	71:00	MIL	Daylight
48	436 N	71:35	72:05	72:35	TUL	Daylight
60	133 N	89:19	89:49	90:19	--	Daylight
61	187 S	90:53	91:23	91:53	--	Daylight
62	201 S	92:28	92:58	93:28	--	Daylight
63	95 N	94:03	94:33	95:03	MIL	Daylight
64	649 N	95:37	96:07	96:37	TUL	Daylight

^a"N" means Orbiter must fly north of groundtrack to reach landing site and "S" means Orbiter must fly south of groundtrack to reach landing site.

^b"Daylight" is defined as later than "sunrise minus 15 minutes" and earlier than "sunset plus 15 minutes".

TABLE VIII.- DETAILED MANEUVER TABLE

(a) OMS-3

GMT 1981 3 10 18 43 40.6									
CODE	ORSD1FCT				PAD				
GMTI	0	18	43	40.6	G HRS	18			GMTR 0 12 23 .0
PETI	0	6	20	40.6	M MIN	43			OUTOUT MAT 1
DVM	36.5	DT B	0	38.8	T SEC	4062			OSTAID VEH10RB
		DT RCS	0	.0	P HRS	6			GMTV 0 13 11 .0
VX	5.35	R	331.16		E MIN	20			PETV 0 0 48 .0
VY	33.51	P	102.19		T SEC	4062			DEPH 1
VZ	-13.44	Y	340.23		VX	364			TSTAID VEH2VH2
VXB	34.31	YH	347.82		VY	0			GMTV 0 0 0 .0
VYB	-7.65	PH	342.73		VZ	8			PETV 0-12-23 .0
VZB	9.84	RH	180.29		R	331			TEPH 1
					P	102			FSTAID VEH10RB
DVTO	.09	TVR	180.00		Y	340			GMTV 0 13 11 .0
DTTO	.10	ULL	.00		C1	0			PETV 0 0 48 .0
					C2	0			
HA	150.10	HBI	128.9		HT	0			WINIT 208904.00
HP	128.90	PBI	32 42 N		THETAT	0			WOMS .00
L AN	129 10 E	LBI	85 1 W		PRPLT	0			WRCS .00
WP	120.55	FBI	29.70		BT	0			WFNL N/A
I	40.17								
E	.003324								DVREMPRI -36.50
A	3584.8								DVREMSEC .00
					ADI				
					INRTL +X LVLH +X				ORB TRIMS
27 47.0	DH	.00			R 331.2 R 176.6				L R
UNTIL	THETA	.00			P 102.2 P 342.4				P -16.00 -16.00
DARK	THETA DOT	.00			Y 340.2 Y 348.4				Y 12.10 -12.10
					REL MAT-- M50 TO ADI				
					1.00000000 .00000000 .00000000				
					.00000000 .00000000 1.00000000				
					.00000000 -1.00000000 .00000000				
					GIMBAL ANGLES				
					REFSMAT- M50 TO IMU PLATFORM				
YIMU	347.818				.16587434 .91957210 -.35619218				
PIMU	342.726				.51473017 -.38882393 -.76411309				
RIMU	180.286				-.84115312 -.05659611 -.53782741				

TABLE VIII.- Concluded

(b) OMS-4

GMT 1981 3 10 19 28 31.2												
CODE OLS02FCT				PAD								
GMTI	0	19	28	31.2	G HRS	19		GMTR	0	12	23	.0
PETI	0	7	5	31.2	M MIN	28		OUTOUT MAT				2
DVM	37.5	DT B	0	39.7	T SEC	3116		OSTAID				VEH10RB
		DT RCS	0	.0	P HRS	7		GMTV	0	13	11	.0
VX	-2.15	R		25.44	E MIN	5		PETV	0	0	48	.0
VY	-33.90	P		287.97	T SEC	3116		DEPH	2			
VZ	15.89	Y		22.33	VX	371		TSTAID				VEH2VH2
VXB	35.25	YH		12.66	VY	0		GMTV	0	0	0	.0
VYB	7.86	PH		336.85	VZ	47		PETV	0-12-23			.0
VZB	10.11	RH		178.34	R	25		TEPH	2			
					P	288		FSTAID				VEH10RB
DVTO	.09	TVR		180.00	Y	22		GMTV	0	13	11	.0
DTTO	.10	ULL		.00	C1	0		PETV	0	0	48	.0
					C2	0						
HA	150.53	HBI		150.1	HT	0		WINIT		208	108.00	
HP	150.09	PBI		32 37 S	THETAT	0		WOMS				.00
L AN	129 10 E	LBI		83 46 E	PRPLT	0		WRCS				.00
WP	-51.28	FBI		175.64	BT	0		WFNL				N/A
I	40.17											
E	.000356							DVREMPRI				-73.99
A	3595.3							DVREMSEC				.00
					ADI							
					INRTL	+X	LVLH	+X	ORB	TRIMS		
17 23.1		DH		.00	R	25.4	R	183.4	L	R		
UNTIL		THETA		.00	P	288.0	P	336.3	P	-16.00		-16.00
DAY		THETA DOT		.00	Y	22.2	Y	11.6	Y	12.10		-12.10
REL MAT-- M50 TO ADI												
					1.00000000	.00000000		.00000000				
					.00000000	.00000000		1.00000000				
					.00000000	-1.00000000		.00000000				
GIMBAL ANGLES REFS MAT- M50 TO IMU PLATFORM												
YIMU	12.658				-.16600719	-.91876137		.35821664				
PIMU	336.850				.51333171	-.39067179		-.76411133				
RIMU	178.336				.84198110	.05703599		.53648367				

TABLE IX.- STS-1 PROPULSIVE CONSUMABLES FLIGHT REQUIREMENTS

(a) OMS

Event/item	Propellant used, lb
OMS-1	3 546
OMS-2	2 872
OMS-3	753
OMS-4	771
Interconnect	752
Nominal deorbit	5 673
Total flight requirement	14 367
Nav dispersions (amount > OMS-3/OMS-4)	562
OMS for RCS deorbit (amount > nom deorbit)	527
Ballast	826
Dispersions	279
Contingencies	548
Trapped	891
Total load	18 000

TABLE IX.- Continued

(b) Aft RCS

Event/item	Propellant used, lb
Launch to entry interface	1067
Entry interface to landing	790
Total flight requirement	1857
Reserved for entry dispersion (above nominal)	1572
Dispersion/contingencies	442
Trapped	748
24-hour extension	15
Pod failure (-X 39 fps)	215
Margin	575
Total load	5424

TABLE IX.- Concluded

(c) Fwd RCS

Event/item	Propellant used, lb
Flight requirement	548
Dispersion/contingencies	204
Trapped	392
24-hour extension	82
Pod failure (-X 39 fps)	884
Margin	354
Total load	2464

TABLE X.- STS-1 OMS PROPELLANT SUMMARY

	Oxidizer	Fuel	Total
Insertion burn (163.2 fps)	2 208	1338	3 546
OnOrbit	2 737	1659	4 396
Deorbit (299.1 fps)	3 532	2141	5 673
Total usage	(8 477)	(5138)	(13 615)
Dispersions and contingencies			
ISP (-3 sec)	60	36	---
MR allowance	61	65	---
Loading accuracy	78	47	---
RSS subtotal	116	88	204
OMS engine failure during burn	67	56	123
Gaging error	265	160	425
Total dispersion contingency	(448)	(304)	(752)
Trapped in lines	160	86	246
Trapped in tanks	360	219	579
Vapors	64	2	66
Total trapped	(584)	(307)	(891)
Total required for RCS	463	289	752
Total RCS disp. and cont.	46	29	75
Total required	10 018	6067	16 085
Total loaded	11 208	6792	18 000

TABLE XI.- STS-1 AFT RCS PROPELLANT SUMMARY

	Oxidizer	Fuel	Total
Nominal required	1143	714	1857
Total usage	(1143)	(714)	(1857)
Dispersions and contingencies			
ISP variation	23	15	--
O/F variation	23	14	--
Loading accuracy	30	19	--
RSS subtotal	44	28	72
Flight uncertainty	114	71	135
Inflight gaging error	152	68	220
One failed OMS during burn	46	28	74
Total dispersion contingency	(356)	(195)	(551)
Trapped in lines	118	78	196
Trapped in tanks	333	208	541
Vapors	11	0	11
Total trapped	(462)	(286)	(748)
Total required	1961	1195	3156
Total loaded in aft RCS	3372	2052	5424

TABLE XII.- STS-1 FORWARD RCS PROPELLANT SUMMARY

	Oxidizer	Fuel	Total
Nominal required	337	211	548
Total usage	(337)	(211)	(548)
Dispersions and contingencies			
ISP variation	5	3	--
O/F variation	7	4	--
Loading accuracy	15	9	--
RSS subtotal	17	10	27
Flight uncertainty	34	21	55
Inflight gaging error	76	34	110
One failed OMS during burn	7	5	12
Total dispersion contingency	(134)	(70)	(204)
Trapped in lines	38	21	59
Trapped in tanks	202	126	328
Vapors	5	0	5
Total trapped	(245)	(147)	(392)
Total required	716	428	1144
Total loaded	1515	949	2464

TABLE XIII.- STS-1 GASEOUS O₂ BUDGET

	<u>Gaseous O₂, lbm</u>
Total loaded	66.0
Prelaunch requirement	.0
Launch load	66.0
Unusables: residual	11.0
Reserves:	
Measurement error	4.7
Dispersion/flight planning uncertainty	.0
Contingency requirements (cabin puncture)	41.7
Available for nominal mission	8.6
Flight requirement	.0
Margin, lb	8.6

TABLE XIV.- STS-1 GASEOUS N₂ BUDGET

	<u>Gaseous N₂, lbm</u>
Total loaded	262.2
Prelaunch requirement	.0
Launch load	262.2
Unusables: residual	26.0
Reserves:	
Measurement error	16.2
Dispersion/flight planning uncertainty	1.4
Contingency requirements (cabin puncture)	96.5 ± 1.1
Available for nominal mission	120.9
Flight requirement	14.1
Margin, lb	106.8

TABLE XV.- STS-1 WASTE H₂O BUDGET

	<u>H₂O, lbm</u>
Max loaded capability (1 tank)	168.3
Prelaunch requirement	1.0
Ullage	3.3
Offload	19.0
Launch load (95 percent)	145.0
Reserves:	
Measurement error	8.3
Unusable: Residual	3.3
Dispersion/flight planning uncertainty	4.2
Dumped	31.8
Available for nominal mission	97.4
Flight generation	29.5
Margin, lb	17.3

TABLE XVI.- STS-1 POTABLE H₂O BUDGET

	Potable H ₂ O, <u>lb</u>	Potable H ₂ O <u>(cumulative), lb</u>
Mission load:		
Volume capacity - 6 tanks	1009.8	
Less offload	99.8	
Total loaded	910.0	
Residual	19.8	
Prelaunch F/C H ₂ O	20.8	
Total usable at lift-off	911.0	
Mission F/C H ₂ O generated	<u>787.9</u>	
H ₂ O available for the mission	1698.9	1698.9
Mission requirement:		
Flash evaporator		
Ascent 224.9		
Onorbit 524.9	1104.4	
Descent 354.6		
Metabolic	<u>38.1</u>	
Total mission requirement	1142.9	1142.9
Onorbit H ₂ O management		
Dump twice a day if required	0.0	
Reserves:		
Measurement error	49.8	
Dispersion/flight planning		
uncertainty	138.8	
Contingency: Earliest PLBD EVA		
closure @ Tig -7.5 hr	<u>419.2</u>	(130.0)
One orbit backup deorbit		
(waste tank used)	607.8	<u>607.8</u>
Margin: (Tanks A - F)		-51.8 ^a

^aThis negative margin is based on the 12/30/80 crew activity timeline. Expected changes to this timeline will make a positive margin for the nominal mission.

TABLE XVII.- STS-1 AMMONIA BUDGET

	<u>Nominal NH₃, lbm</u>
Total loaded	97.6
Prelaunch requirement	0
Launch load	97.6
Unusable: residual	2.0
Reserves:	
Measurement error	5.4
Dispersion/flight planning uncertainty (5%)	7.5
Contingency requirements	0
Total	12.9
Available for nominal mission	82.7
Flight requirement	
From 120 000 ft	75.4
Margin, lb	^a 7.3

^aFor the nominal timeline, this 7.3-pound ammonia margin will provide approximately 17 minutes of postlanding environmental cooling.

TABLE XVIII.- STS-1 APU FUEL BUDGET

	Fuel, lb		
	<u>Sys-1</u>	<u>Sys-2</u>	<u>Sys-3</u>
Total loaded	350.0	350.0	350.0
Loading uncertainty	4.0	4.0	4.0
Unusable	<u>5.4</u>	<u>5.4</u>	<u>5.4</u>
Available for mission planning	340.6	340.6	340.6
Flight Requirements			
Ascent	55.1	54.1	52.8
Onorbit	25.4	--	--
Descent	<u>145.4</u>	<u>146.1</u>	<u>134.7</u>
Total	225.9	200.2	187.5
Reserve requirements	<u>103.7</u>	<u>103.7</u>	<u>94.2</u>
Total	329.6	303.9	281.7
Margin	11.0	36.7	48.9

TABLE XIX.- STS-1 APU/HYD WATER BUDGET

	Water, lbm		
	<u>Sys-1</u>	<u>Sys-2</u>	<u>Sys-3</u>
Total loaded:			
Water tank	141.4	141.4	141.4
Boiler Section	<u>5.0</u>	<u>5.0</u>	<u>5.0</u>
Total	146.4	146.4	146.4
Loading uncertainty	0.0	0.0	0.0
Unusables:			
Water tank	2.8	2.8	2.8
Boiler section	<u>8.0</u>	<u>8.0</u>	<u>8.0</u>
Total	10.8	10.8	10.8
Available for flight planning	135.6	135.6	135.6
Flight requirements:			
Ascent	7.9	7.9	7.9
Onorbit checkout	0.0	0.0	0.0
Descent	<u>38.1</u>	<u>35.2</u>	<u>32.8</u>
Total	46.1	43.1	40.7
Reserve requirements ^a	TBD	TBD	TBD
Margin	TBD	TBD	TBD

^aThe APU and hydraulic system consumables reserve requirements and margins have not been determined pending resolution and completion of the following:

- Finalization of the flight rules
- Design modification and subsequent simulation of the entry flight control system.
- APU/hydraulic system performance analysis and assessment of the Orbiter control loop dynamic stability test results.

TABLE XX.- STS-1 PRSD CRYOGENIC O₂ AND H₂ BUDGET (CYCLE 3.3.2)NOMINAL MISSION - 55.2 HOURS^a

	<u>O₂, lbm</u>	<u>H₂, lbm</u>	<u>kWh</u>
Total loaded	1562.0	184.0	
Prelaunch requirement	18.3	5.1	
Launch load	1543.7	178.9	
Unusables: Residuals	46.8	4.6	
Reserves:			
Measurement error	42.6	5.1	
Dispersion/flight planning uncertainty	69.3	8.6	98
Contingency requirements			
24-hour launch hold	10.7	3.0	
1-day mission extension ^b (25 ^h 26 ^m)	318.0	39.3	449
Available for nominal mission	1056.3	118.3	
Flight requirement	602.7	85.6	977
Margin	453.6	32.7	^c 373

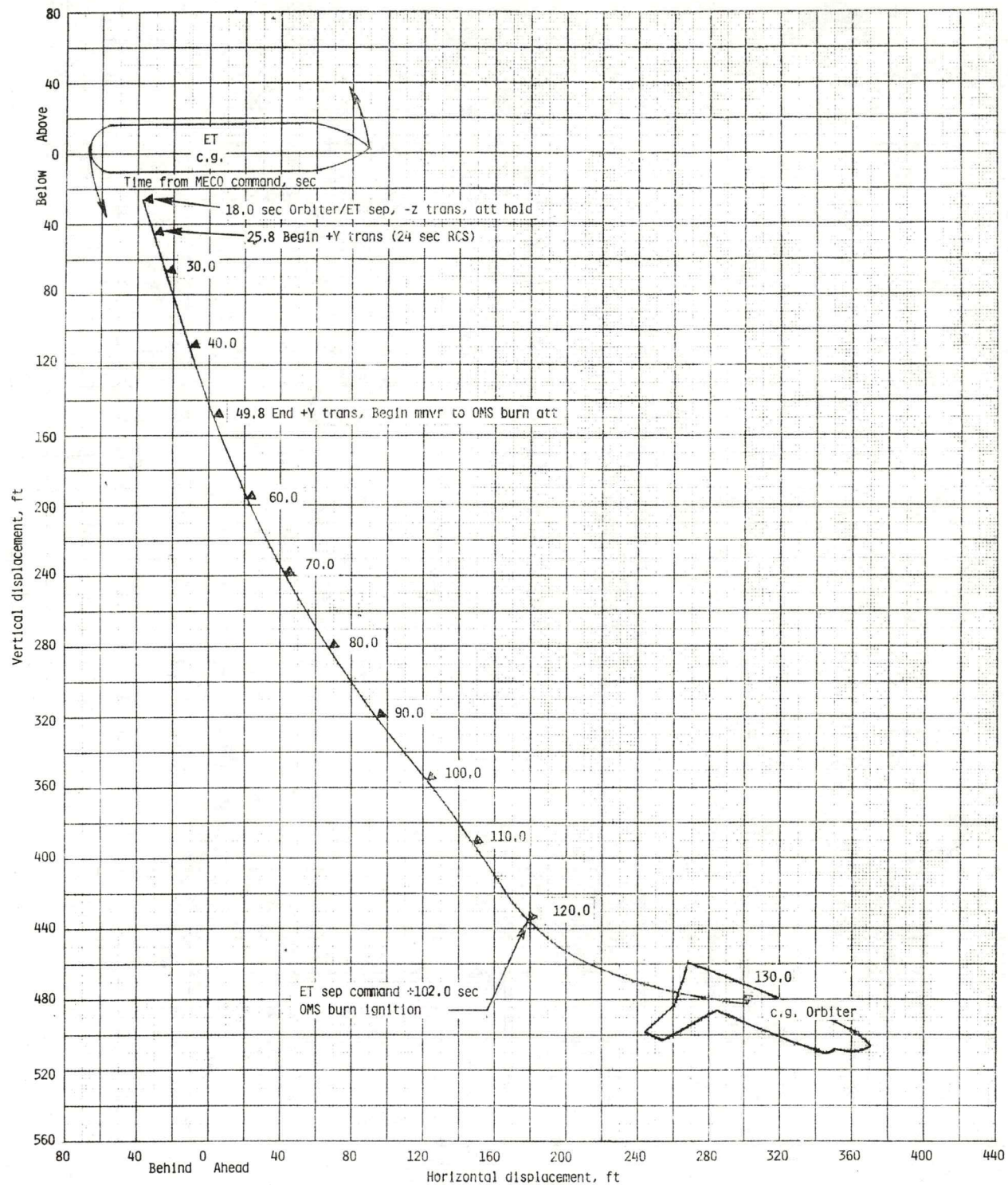
^aIncludes a 40-minute postlanding requirement.^bCovers all acceptable crossrange deorbit opportunities (through orbit 53) as shown in reference 2.^cEstimated energy equivalent of hydrogen quantity margin biased on average flight usage.

TABLE XXI.- STS-1 MANEUVER SUMMARY TABLE FOR NOMINAL DEORBIT

Parameter	Value	Unit
OMS pitch	+ .1	deg
OMS left yaw	-6.5	deg
OMS right yaw	+6.5	deg
Weight	205652.	lb
GET ignition	53:27:52	d:h:m:s
GMT ignition	71:17:50:52	d:h:m:s
C1	15510.	fps
C2	-0.6236	---
HT	65.832	n. mi.
OT	113.543	deg
PRPLT	+5925.	lb
DVX	-254.6	fps
DVY PEG-7	-91.2	fps
DVZ	-127.8	fps
RI	139.	deg
PI INRTL RELMAT	66.	deg
YI	4.	deg
RR	359.	deg
PR REF RELMAT	135.	deg
YR	350.	deg

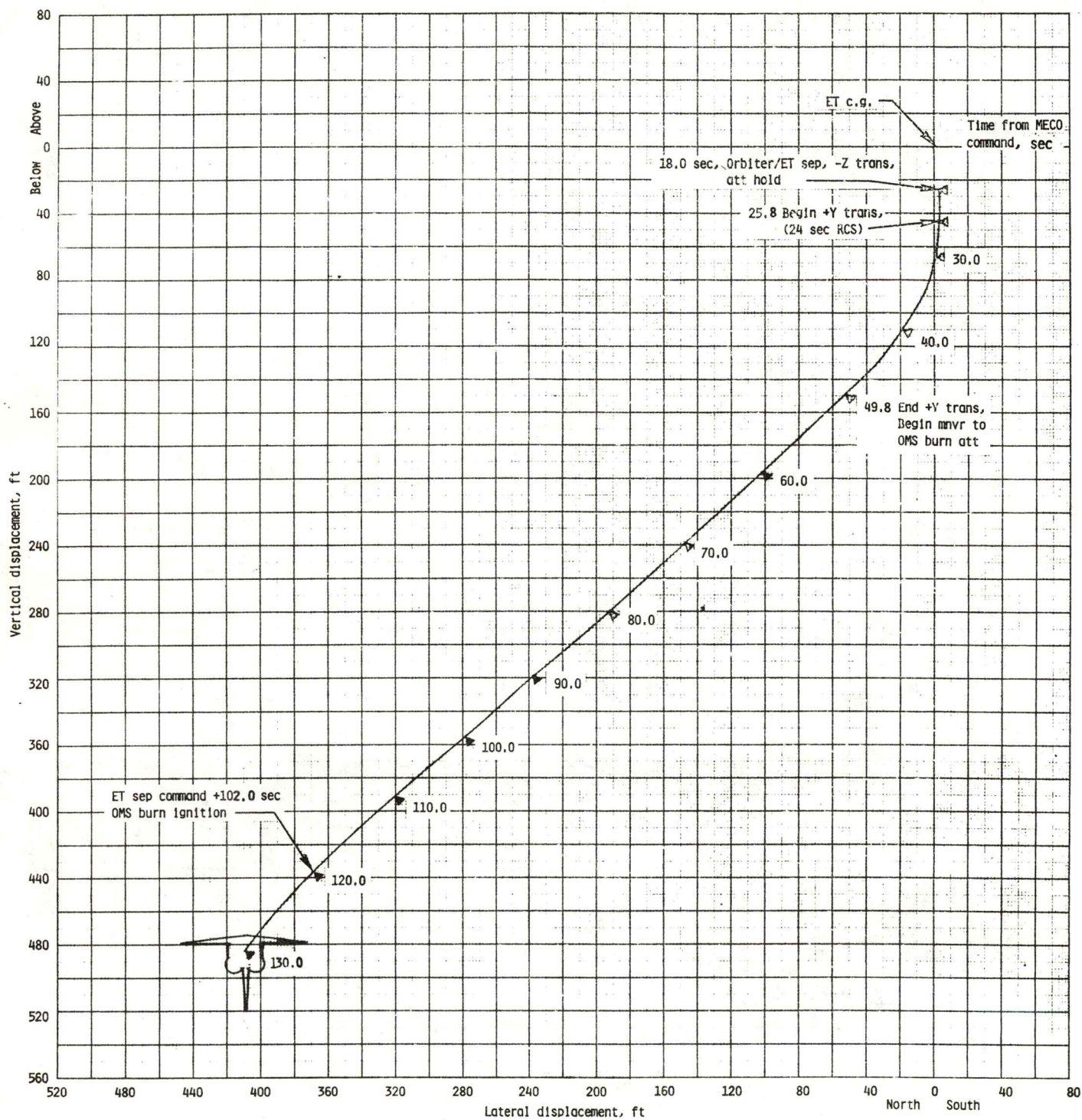
TABLE XXI.- Concluded

Parameter		Value	Unit
RH		357.	deg
PH	LVLH	170.	deg
YH		341.	deg
HA		151.	n. mi.
HP		2.	n. mi.
TFF		25:42	m:s
REI		4392.	n. mi.
DVT		299.1	fps
TGO		2:35	m:s
VGOX		288.02	fps
VGOY	Body	-0.56	fps
VGOZ		80.79	fps
RI		204	deg
PI	EI-5 INRTL	274	deg
YI		37	deg
RLVLH		1	deg
PLVLH	EI-5 LVLH	39	deg
YLVLH		358	deg



(a) Vertical and horizontal displacement.

Figure 1.- Nominal Orbiter/ET relative motion for the separation maneuver.



(b) Vertical and lateral displacement.

Figure 1.- Concluded.

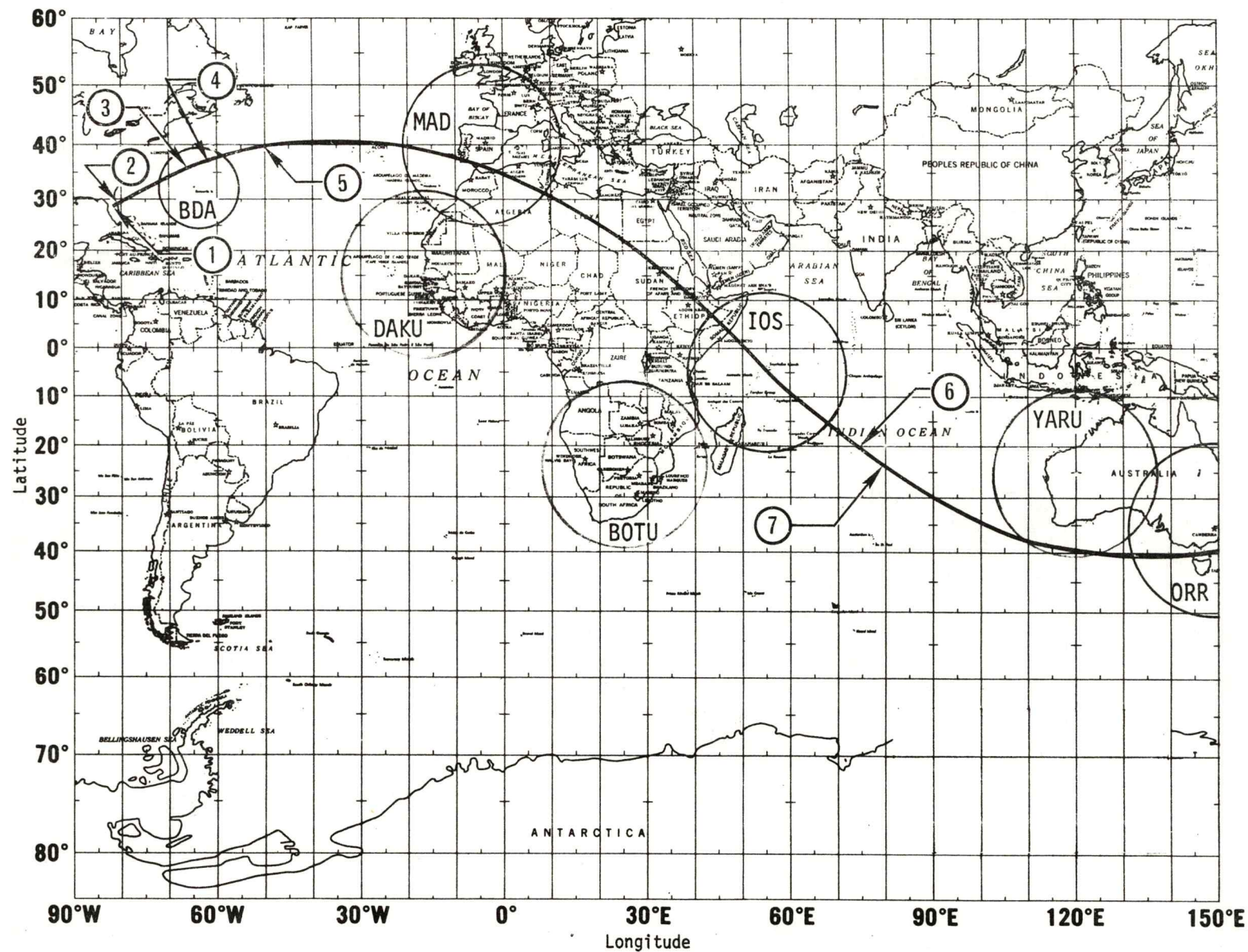


Figure 2.- STS-1 ascent groundtrack and post-MECO communication coverage.

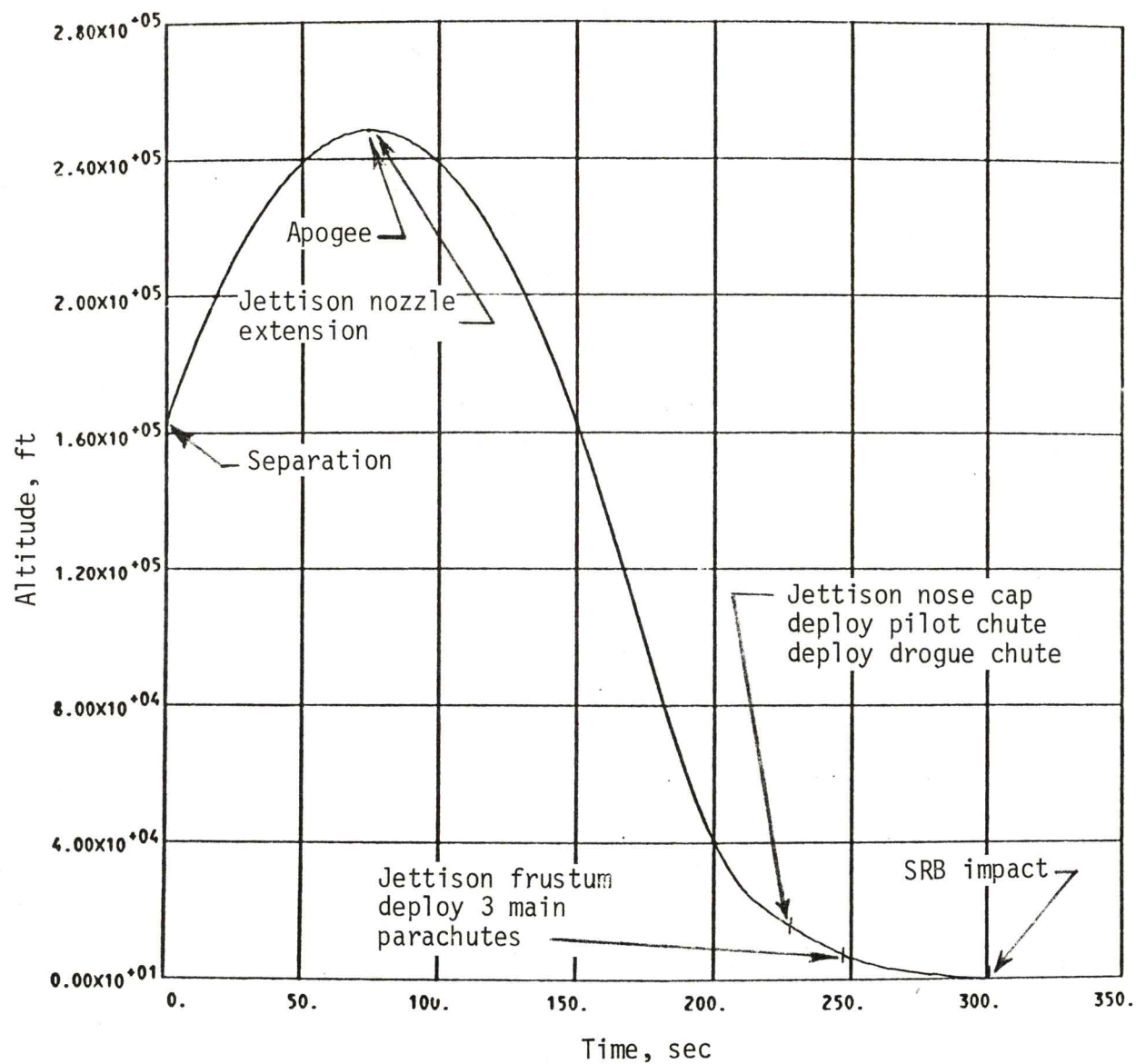


Figure 3.- Left and right SRB altitude time histories.

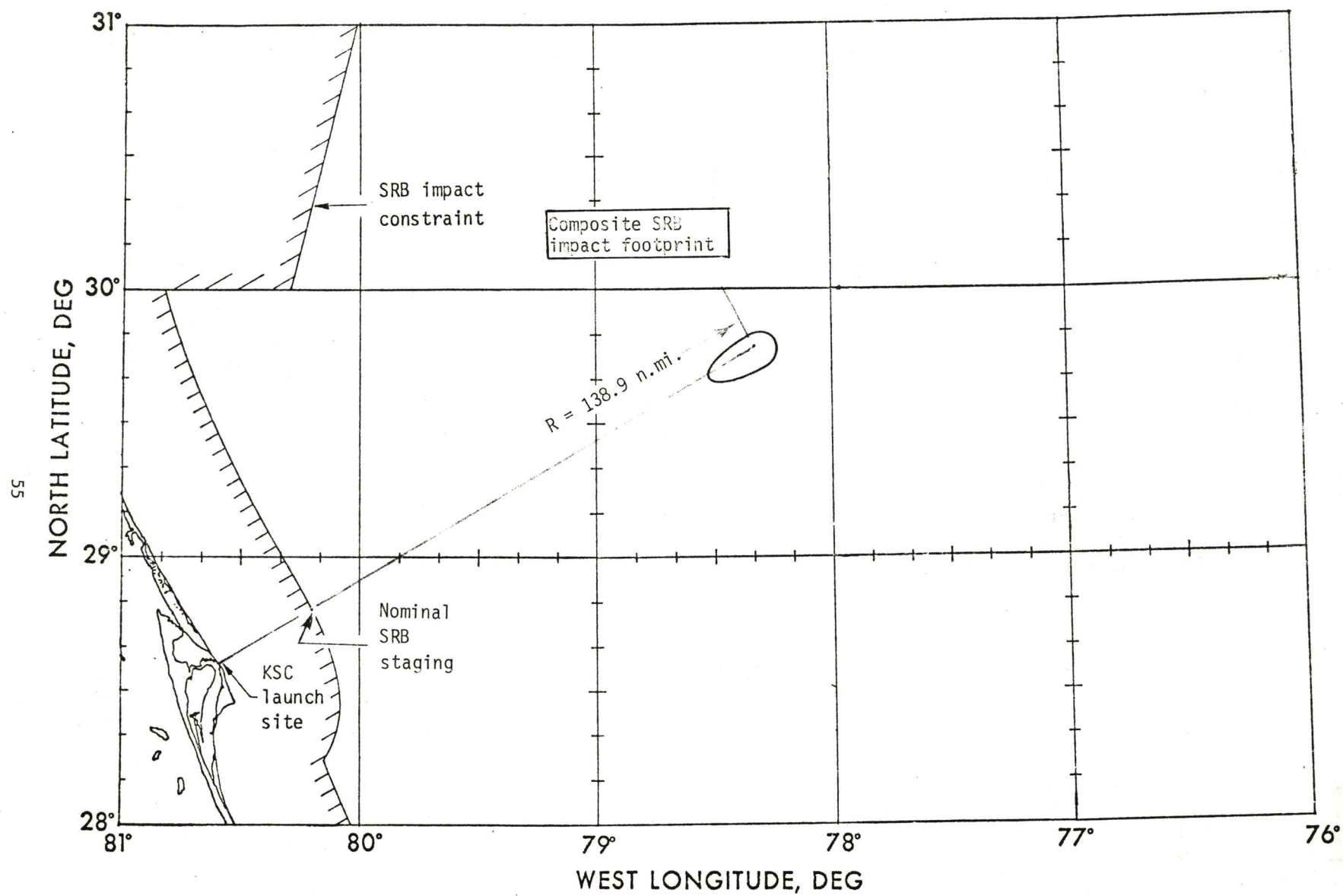


Figure 4.- STS-1 SRB impact footprint.

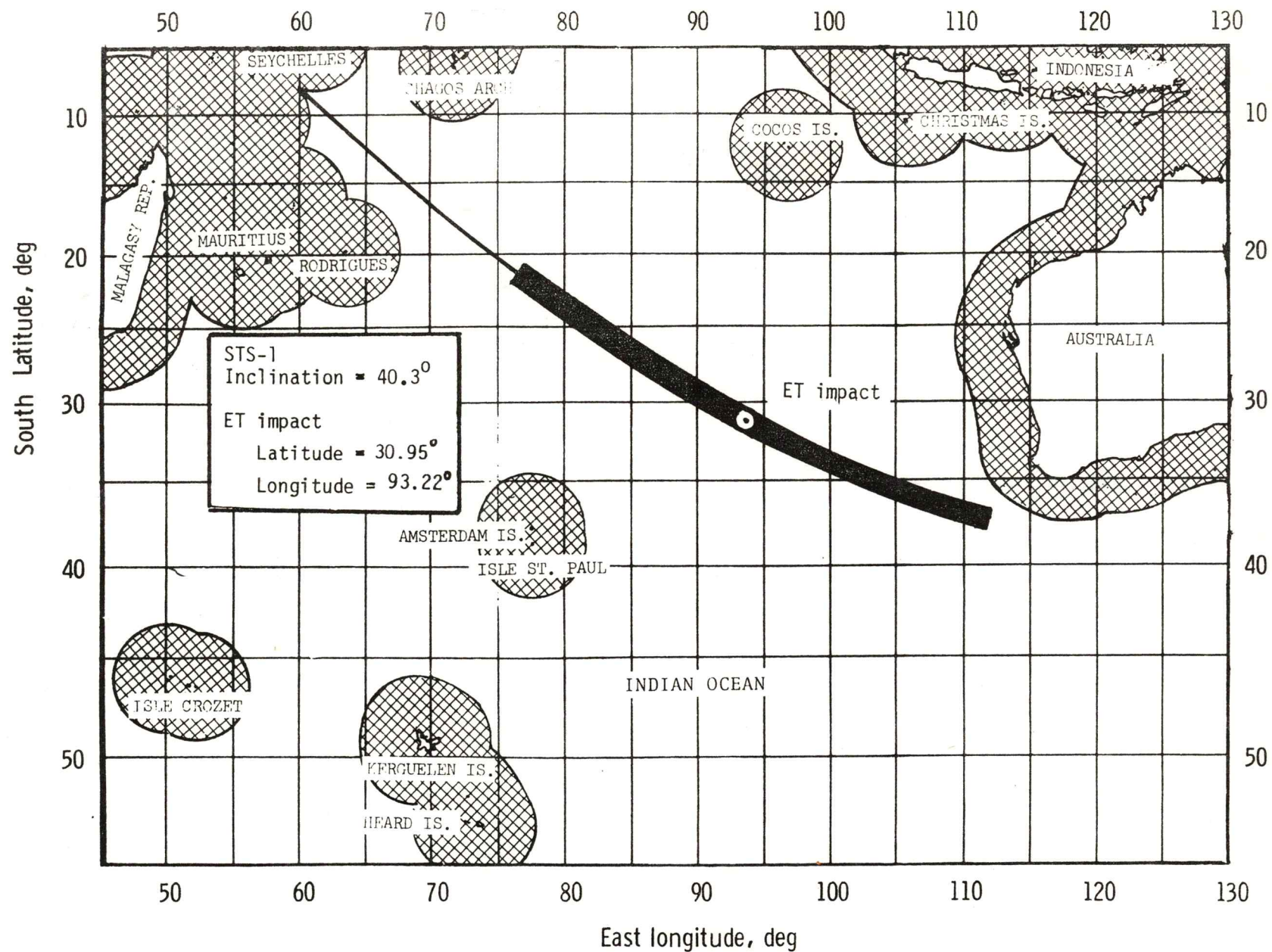


Figure 5.- STS-1 nominal ET footprint.

K-11

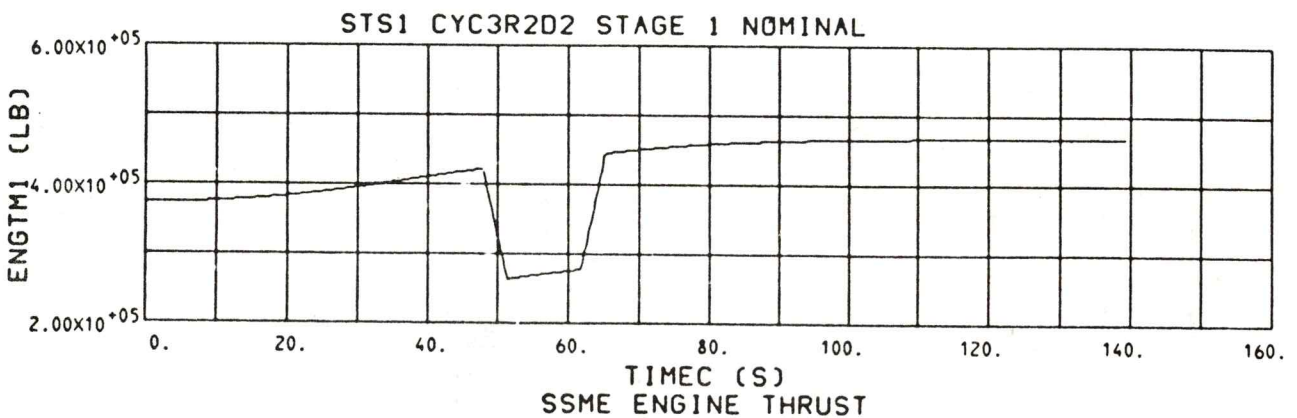
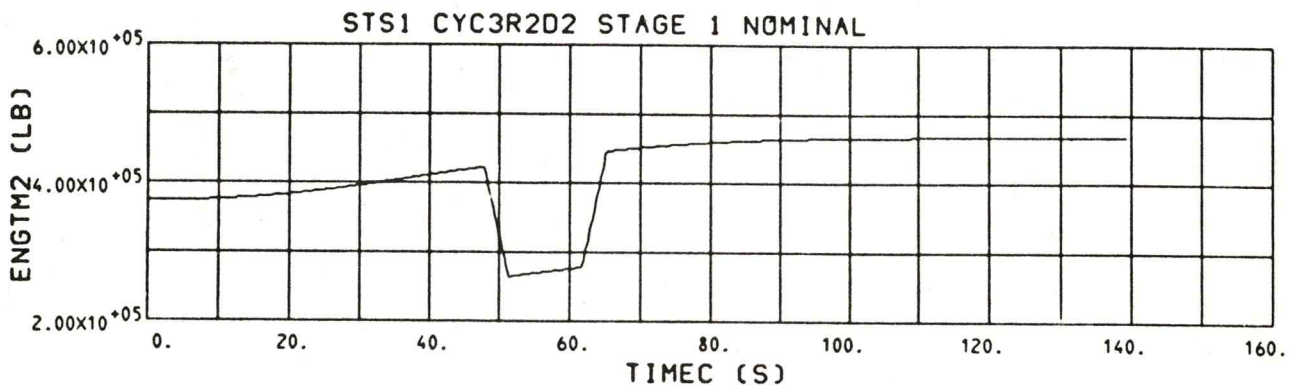
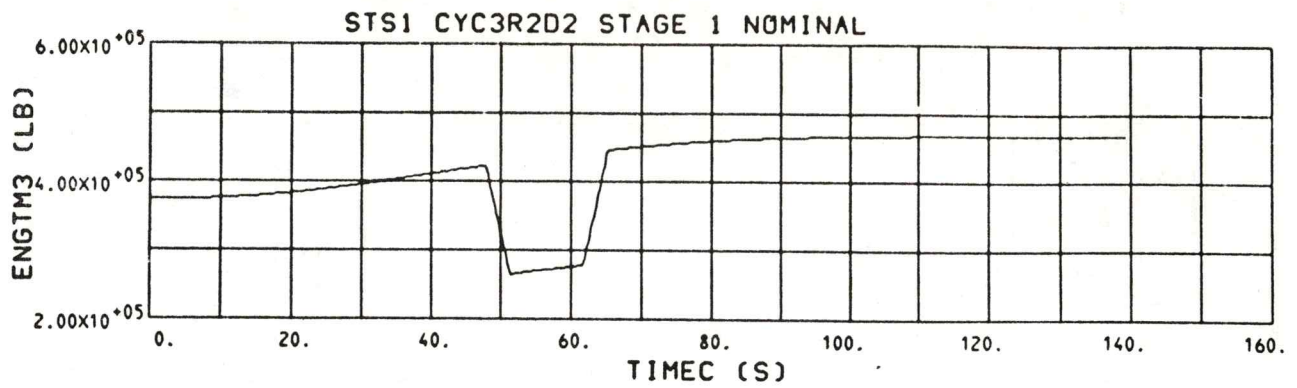


Figure 6.- Time history of SSME engine thrust.

- C322/MAR MEAN/63.31SRB/NOM CHK

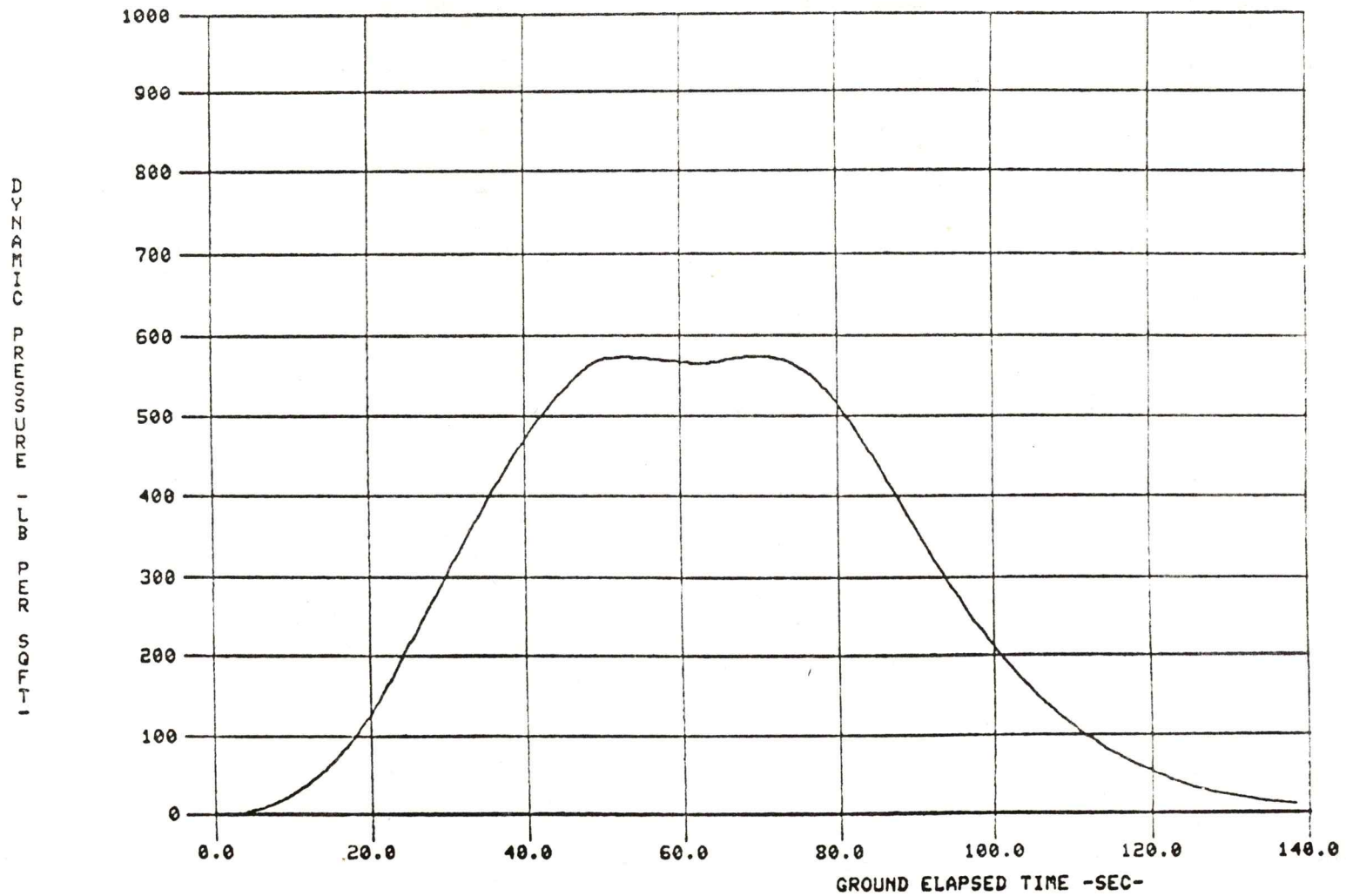


Figure 7.- Time history of dynamic pressure.

- C322/MAR MEAN/63.31SRB/NOM CHK

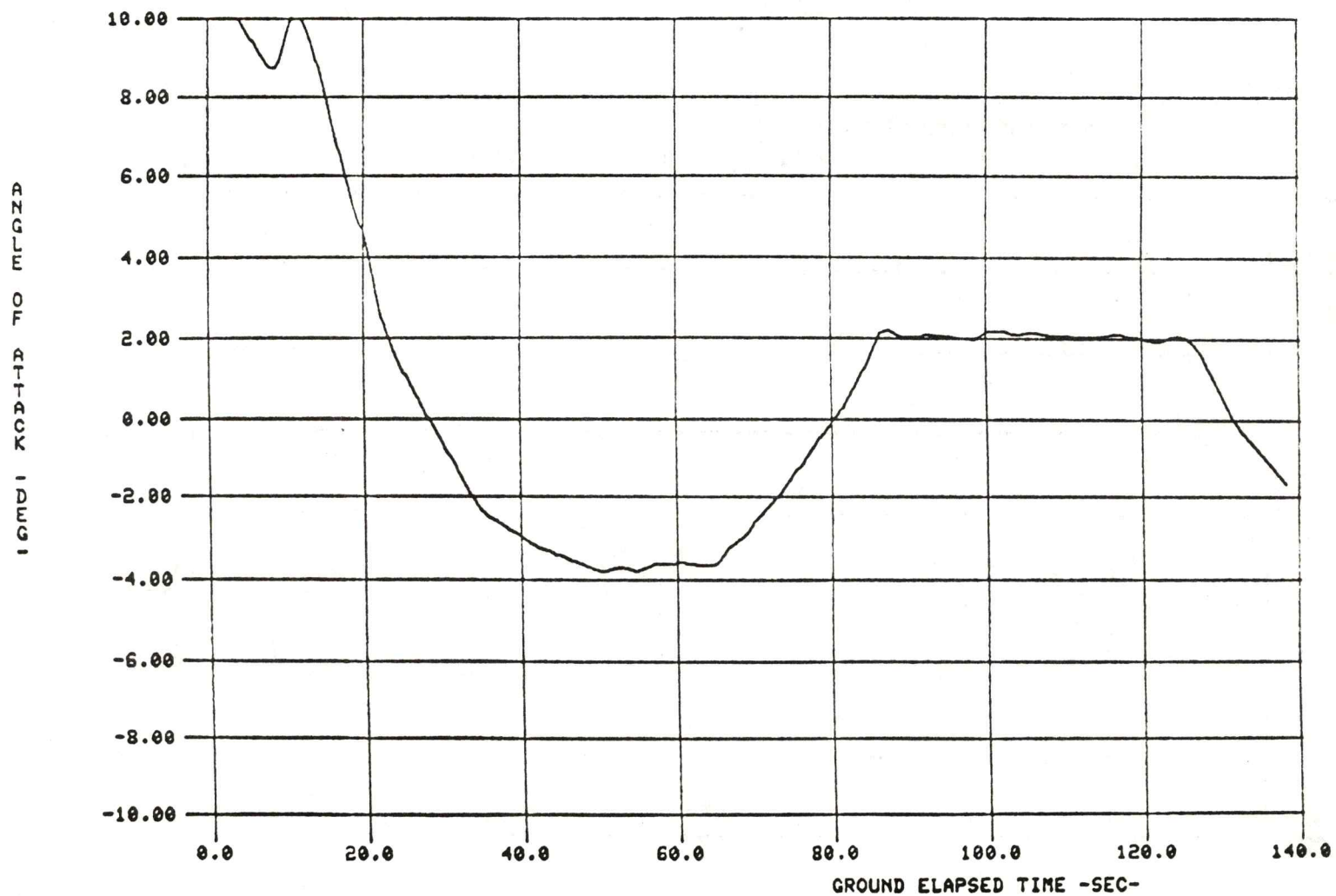


Figure 8.- Time history of angle of attack.

ANGLE OF SIDESLIP

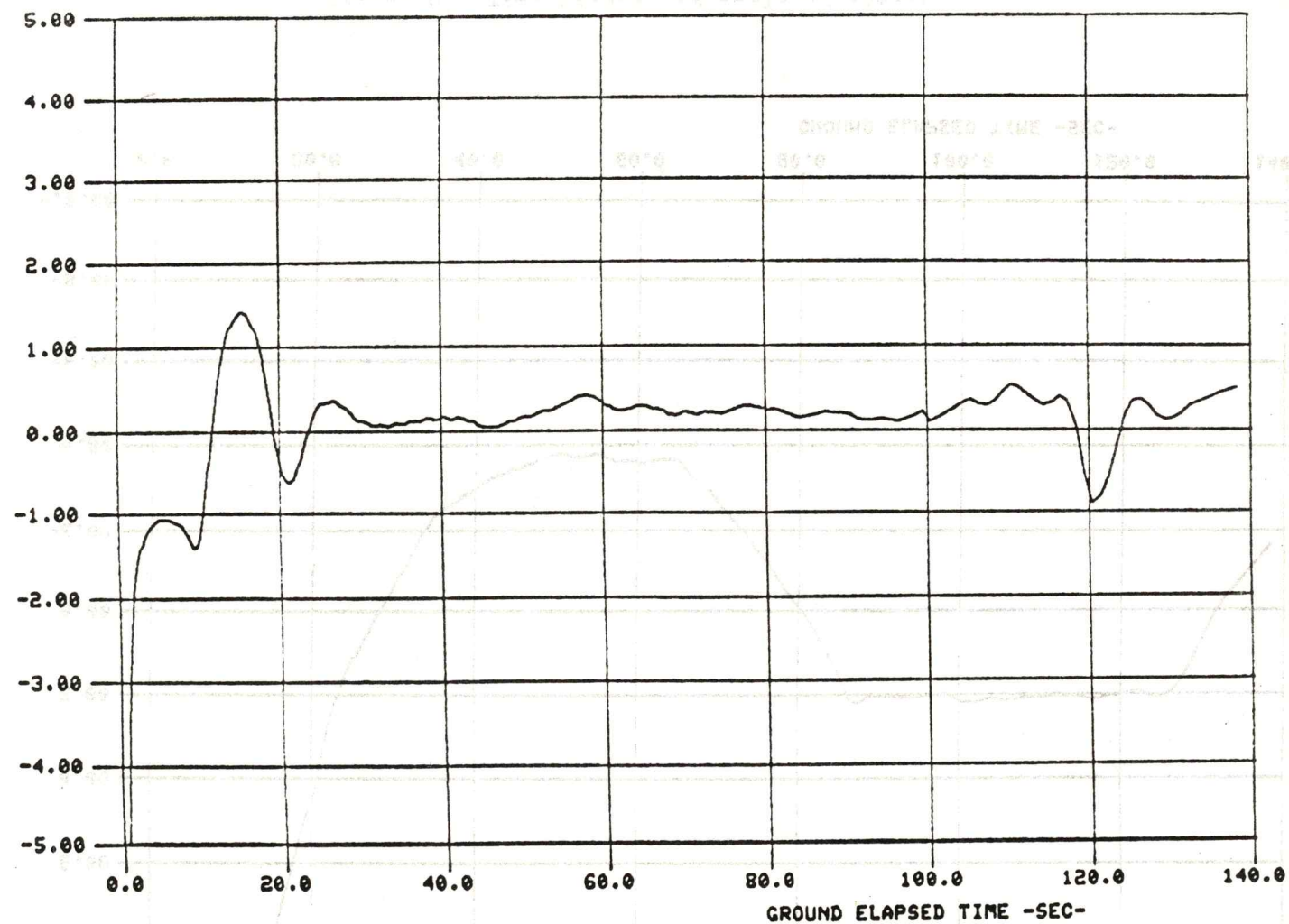


Figure 9.- Time history of angle of sideslip.

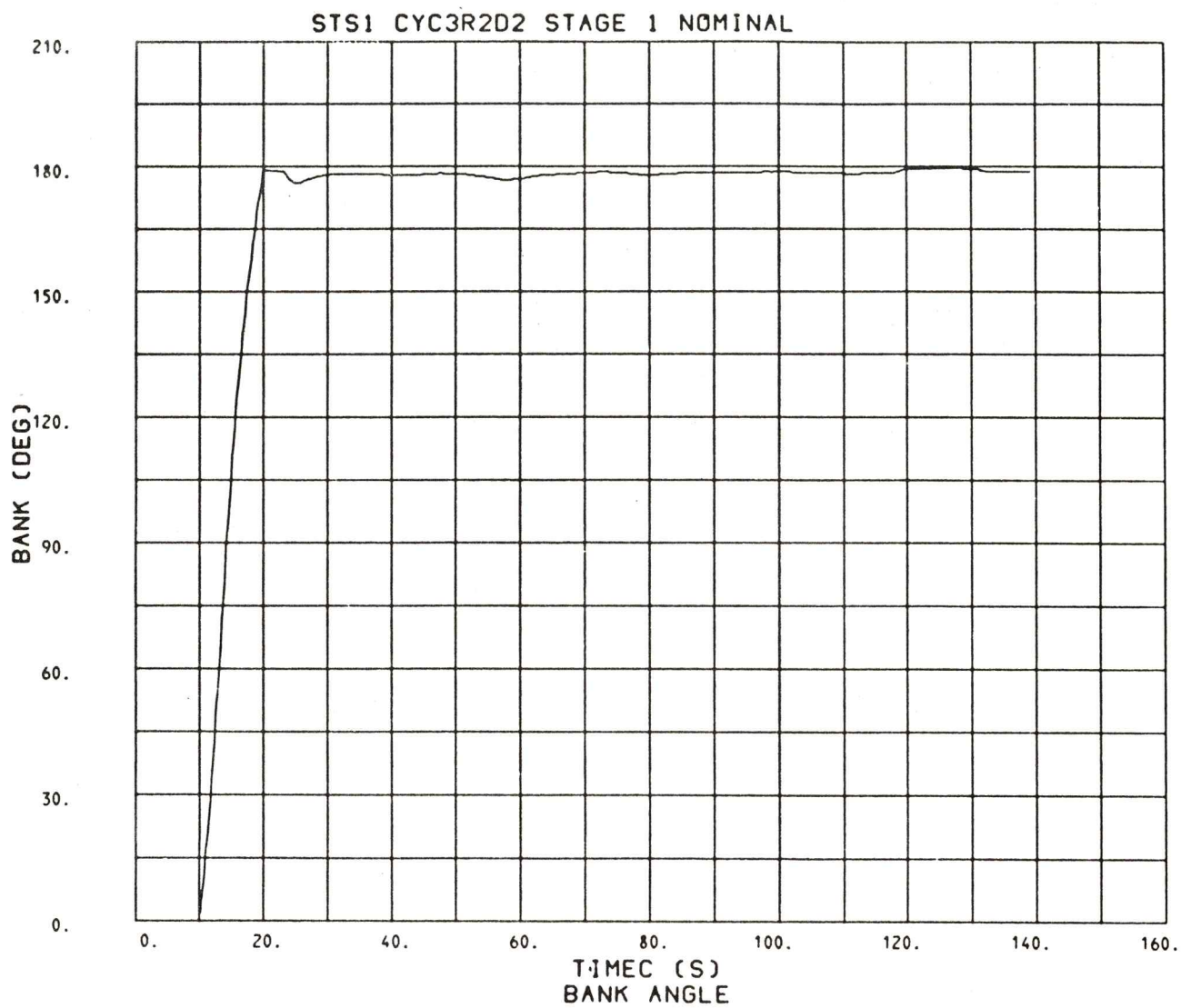


Figure 10.- Time history of bank angle.

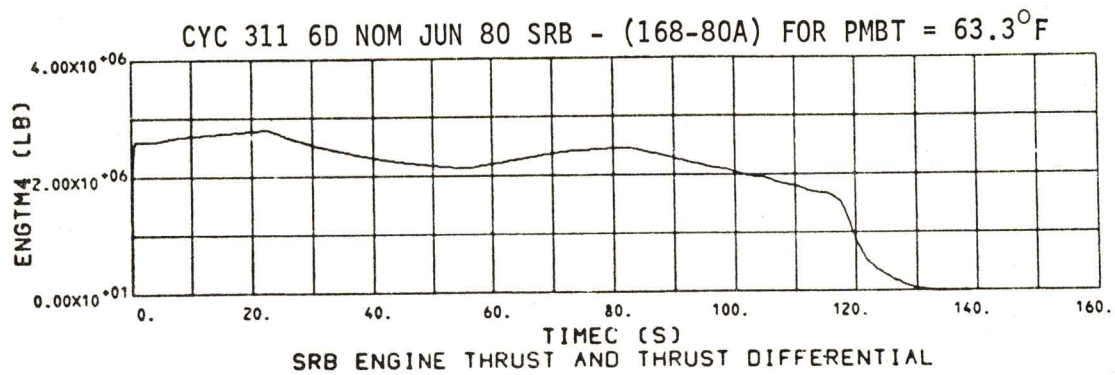
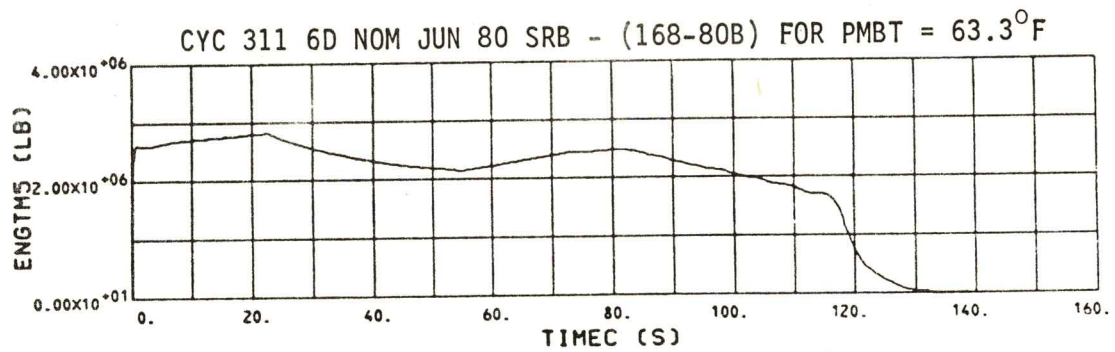


Figure 11.- Time history of SRB thrust.

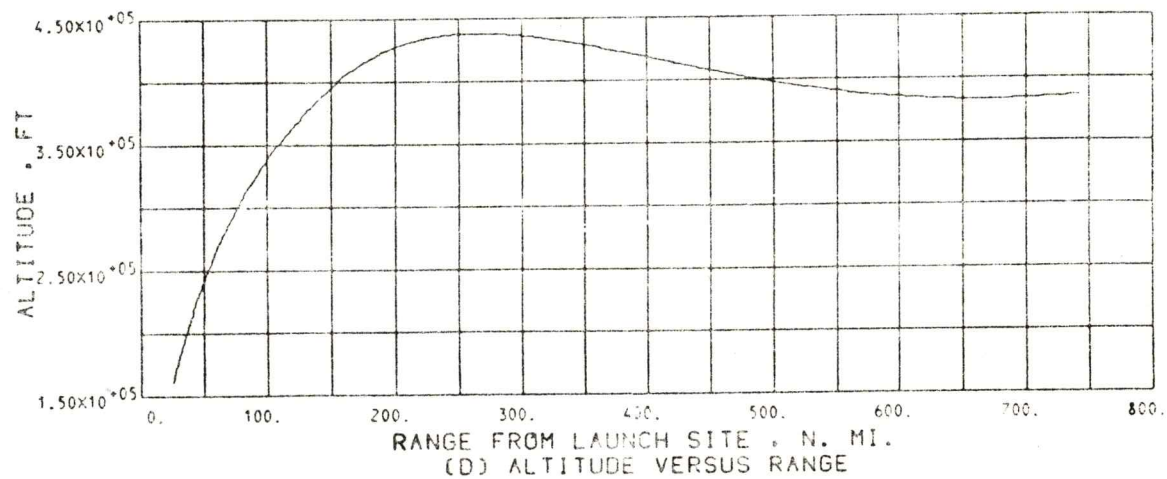
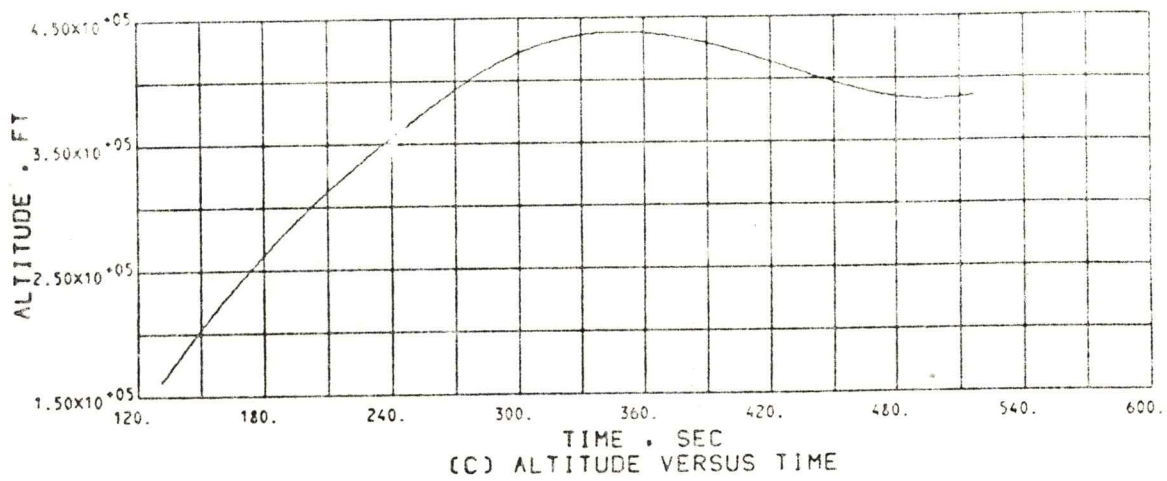


Figure 12.- Altitude time histories.

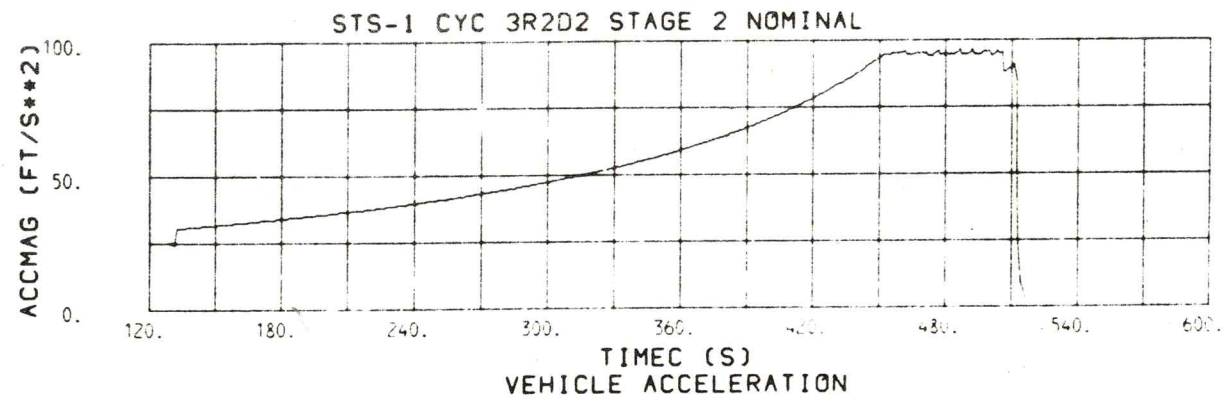
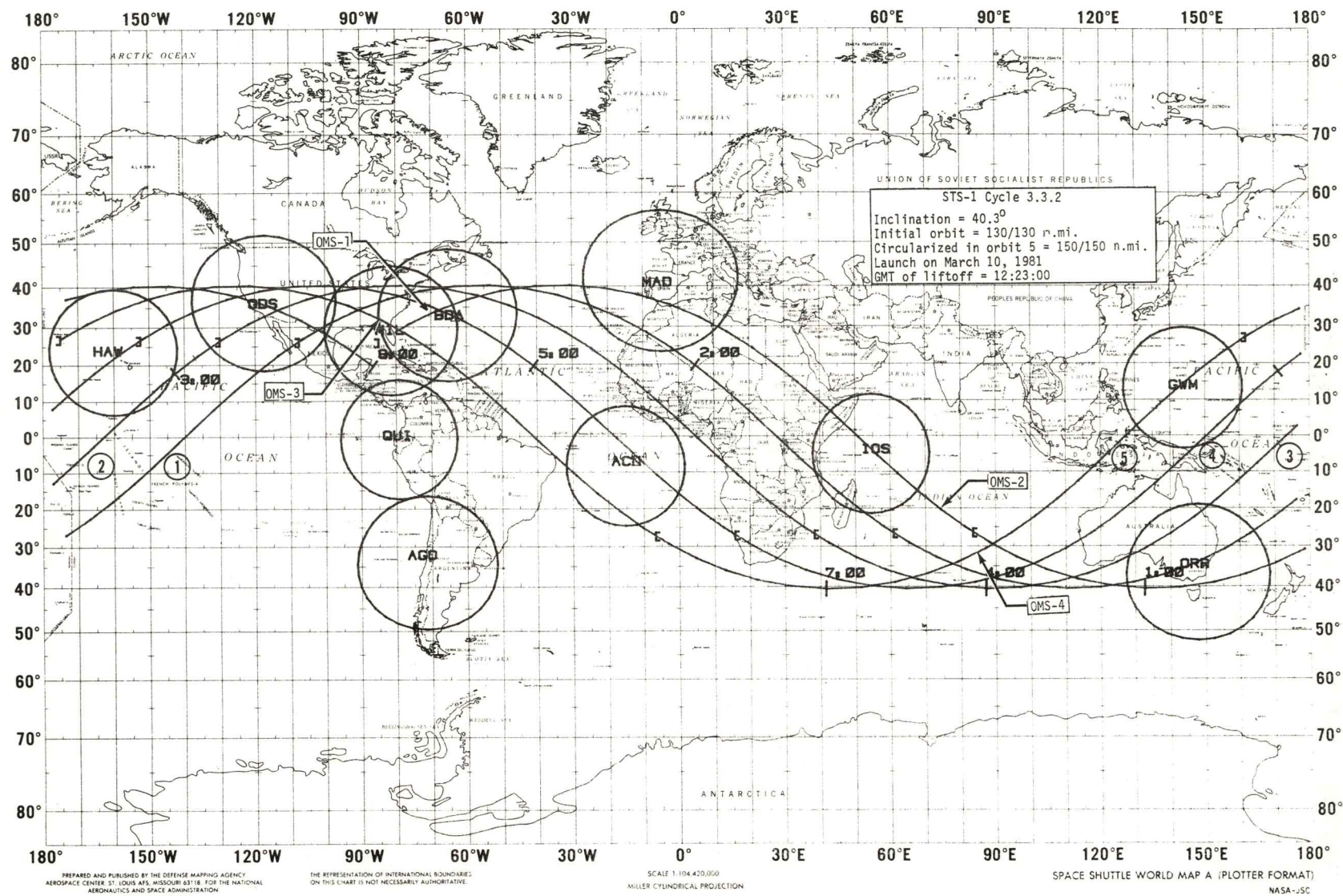
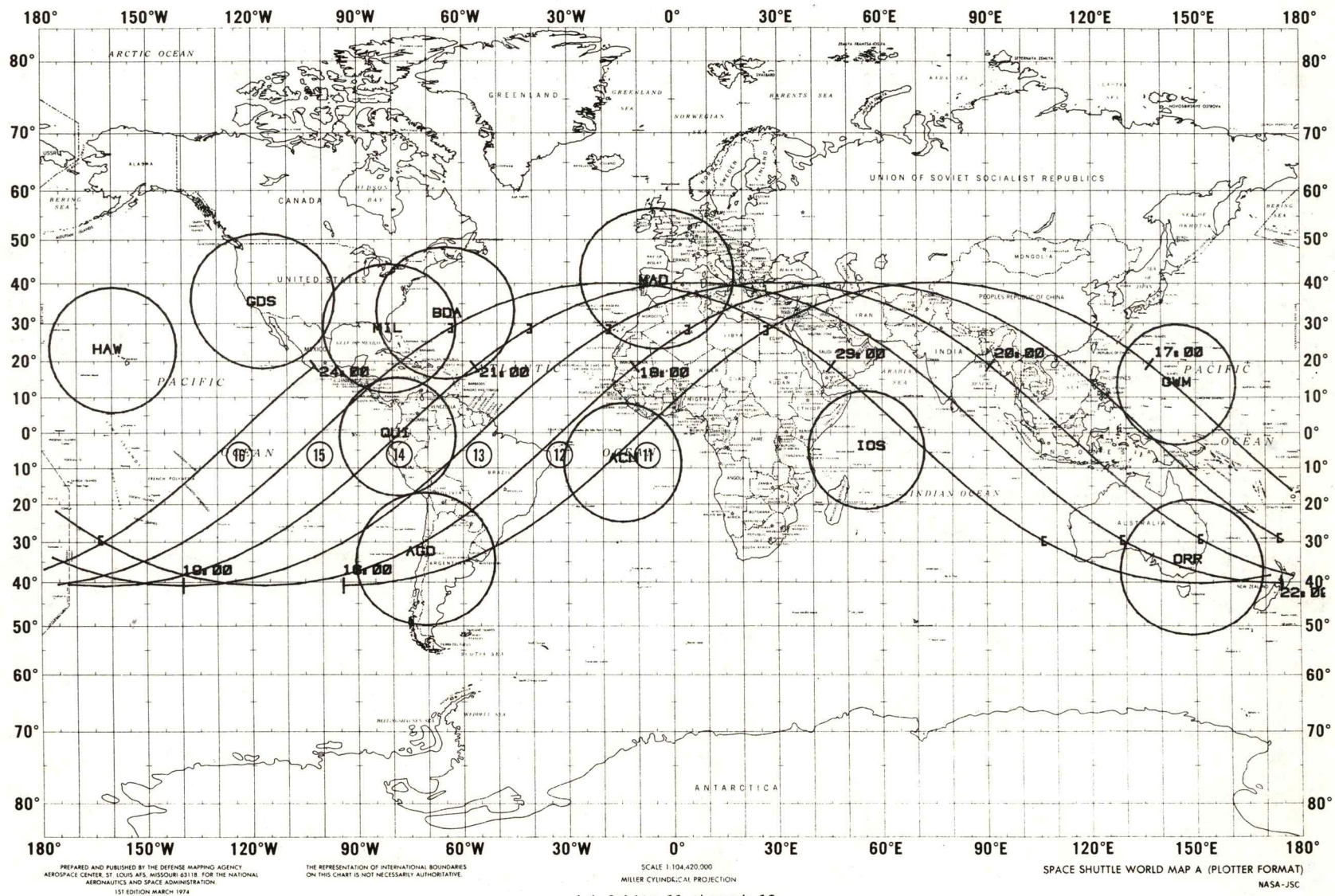


Figure 13.- Acceleration time history.



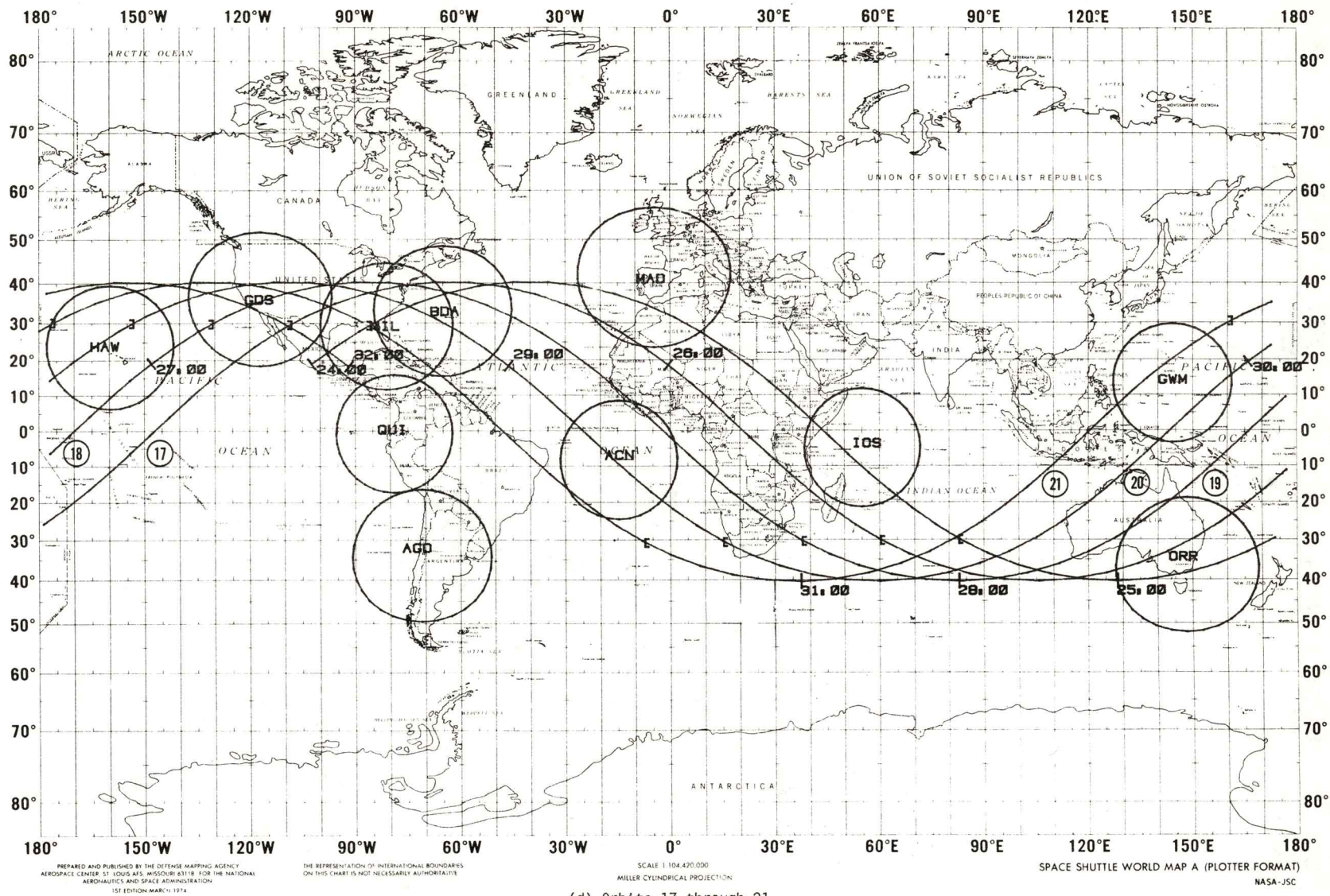
(a) Orbits 1 through 5.

Figure 14.- STS-1 nominal orbital groundtrack.



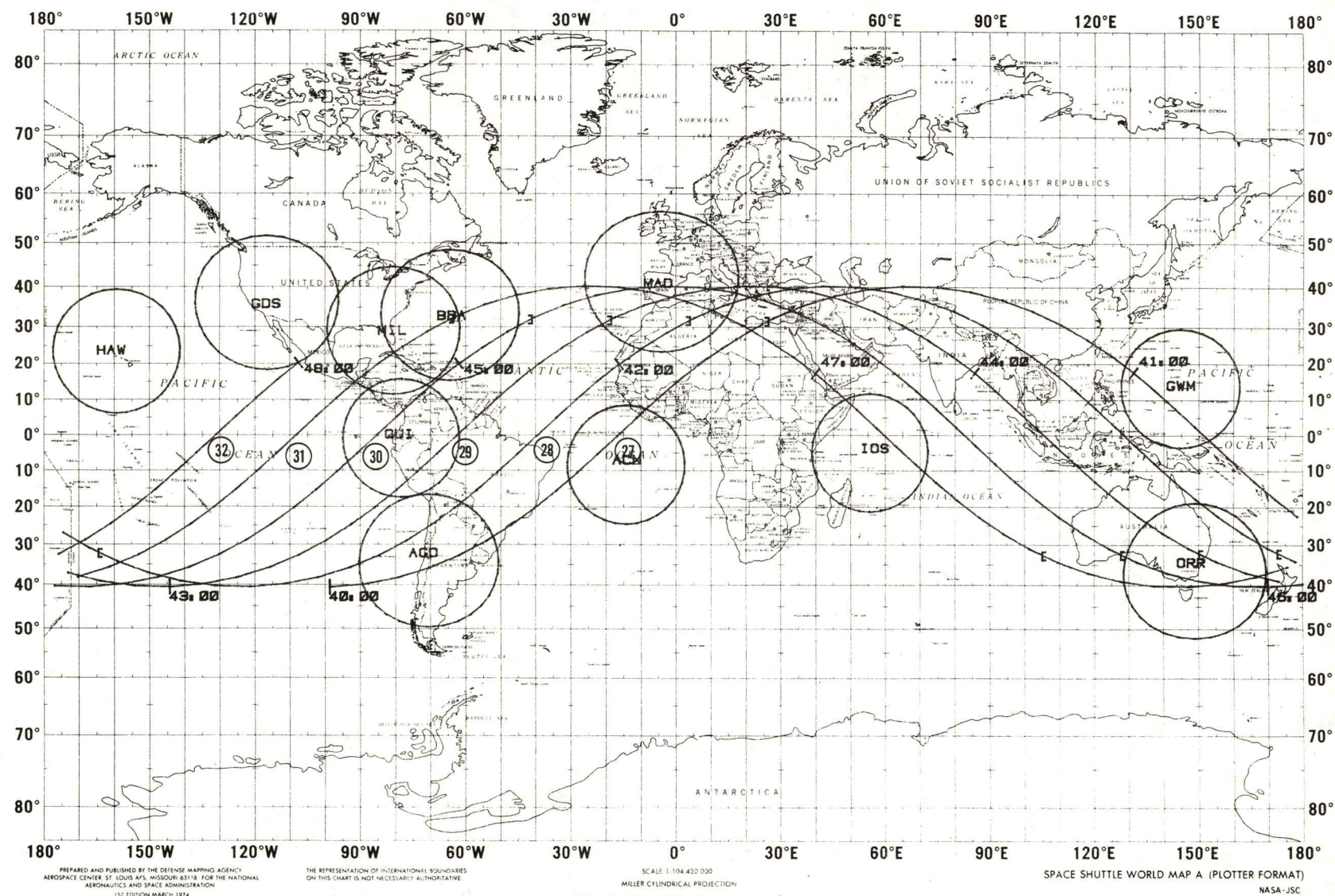
(c) Orbits 11 through 16.

Figure 14.- Continued.



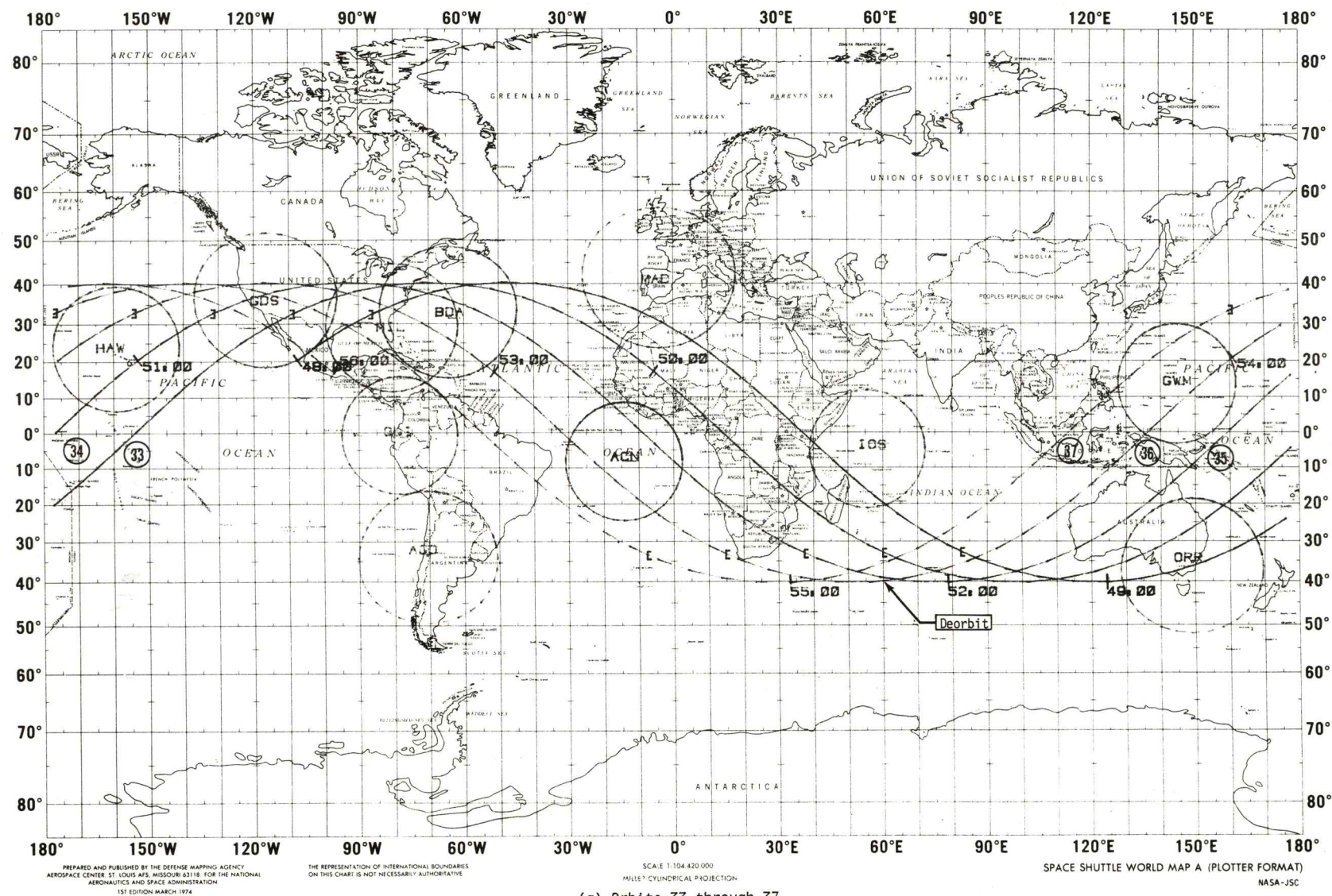
(d) Orbits 17 through 21.

Figure 14.- Continued.



(f) Orbits 27 through 32.

Figure 14.- Continued.



(g) Orbits 33 through 37.

Figure 14.- Concluded.

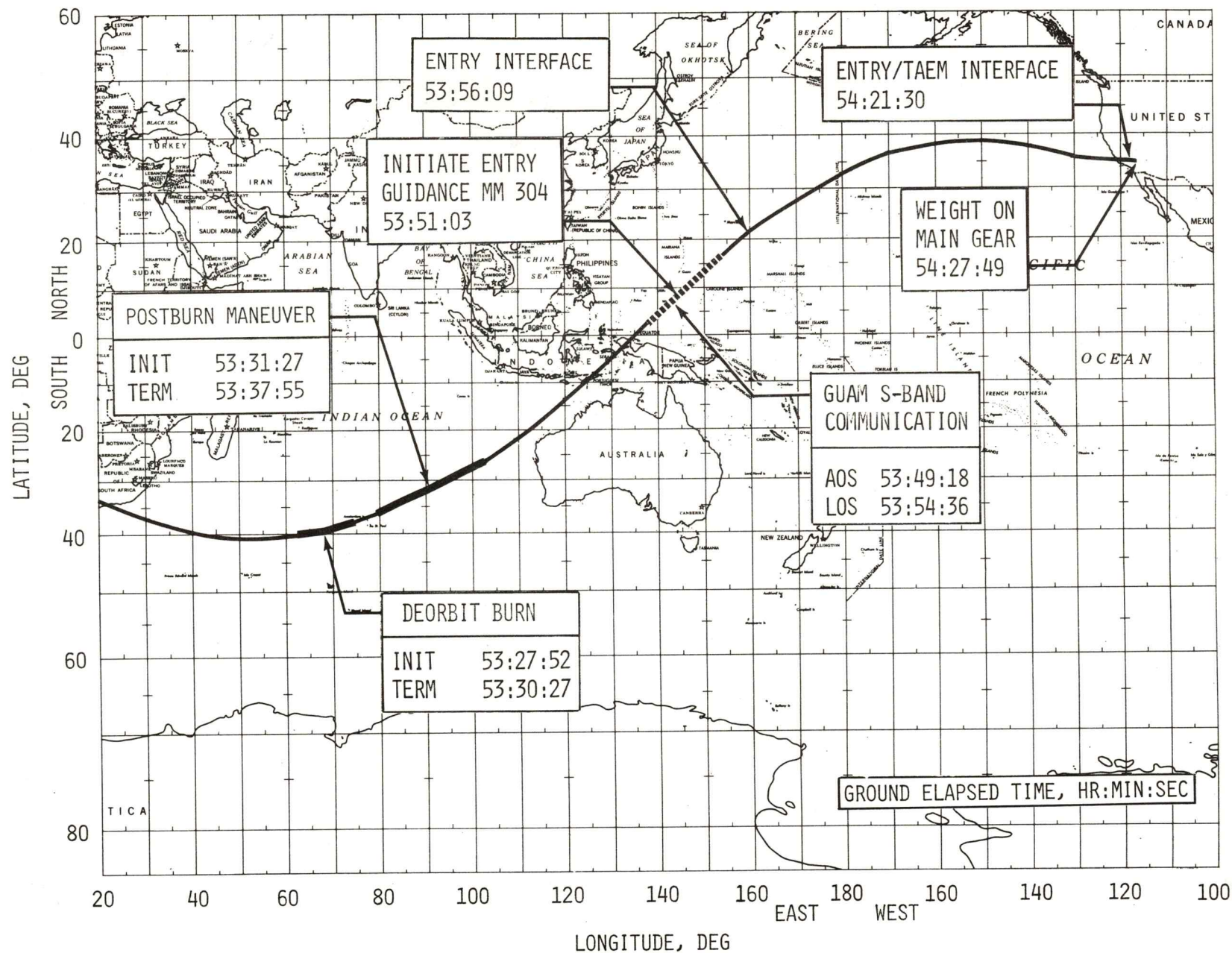
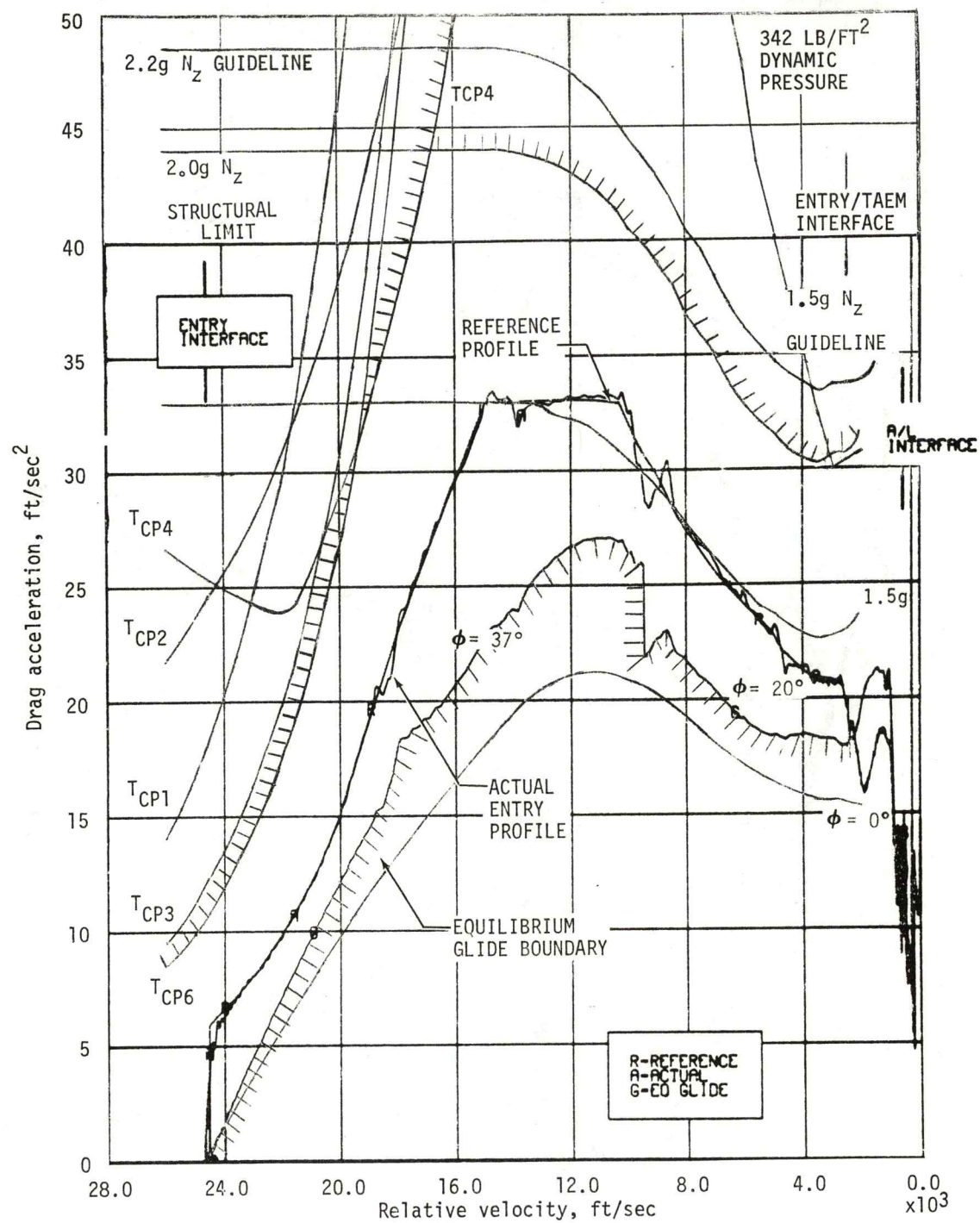


Figure 15.- STS-1 deorbit-through-landing groundtrack.



[Nominal thermal constraints boundaries]

Figure 16.- Entry drag acceleration corridor and flight profile during atmospheric descent.

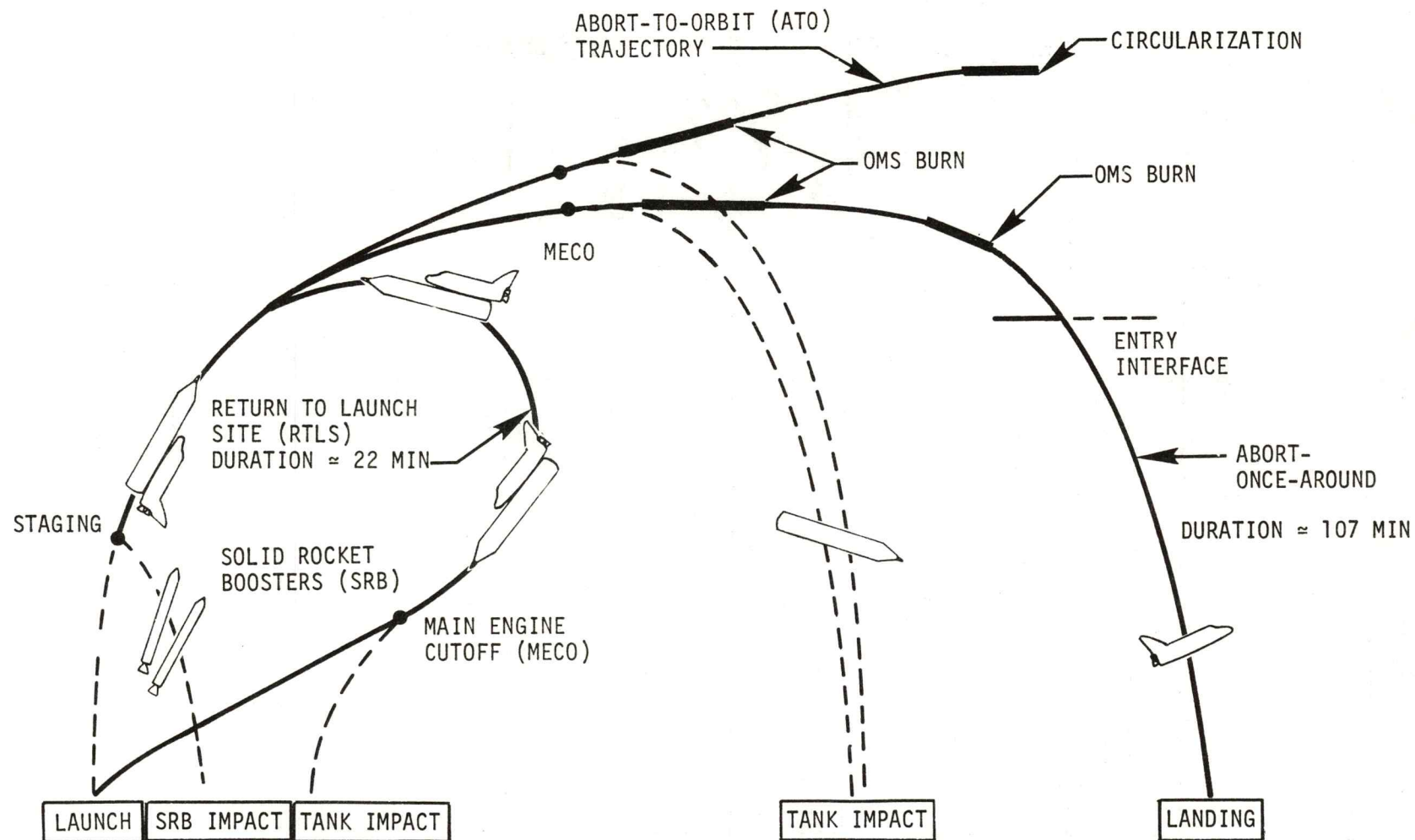


Figure 17.- STS-1 types of intact aborts.

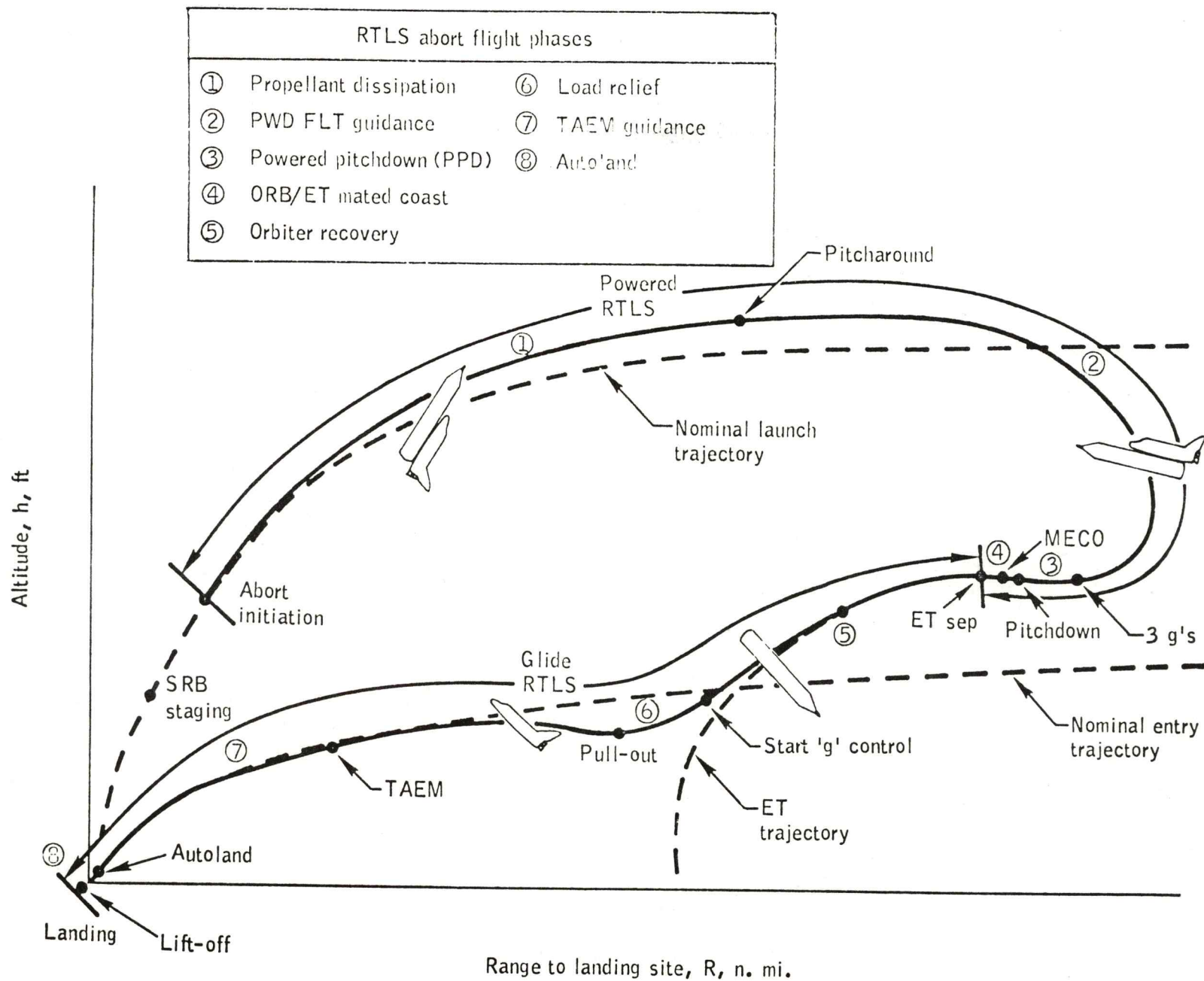


Figure 18.- STS-1 typical RTLS profile.

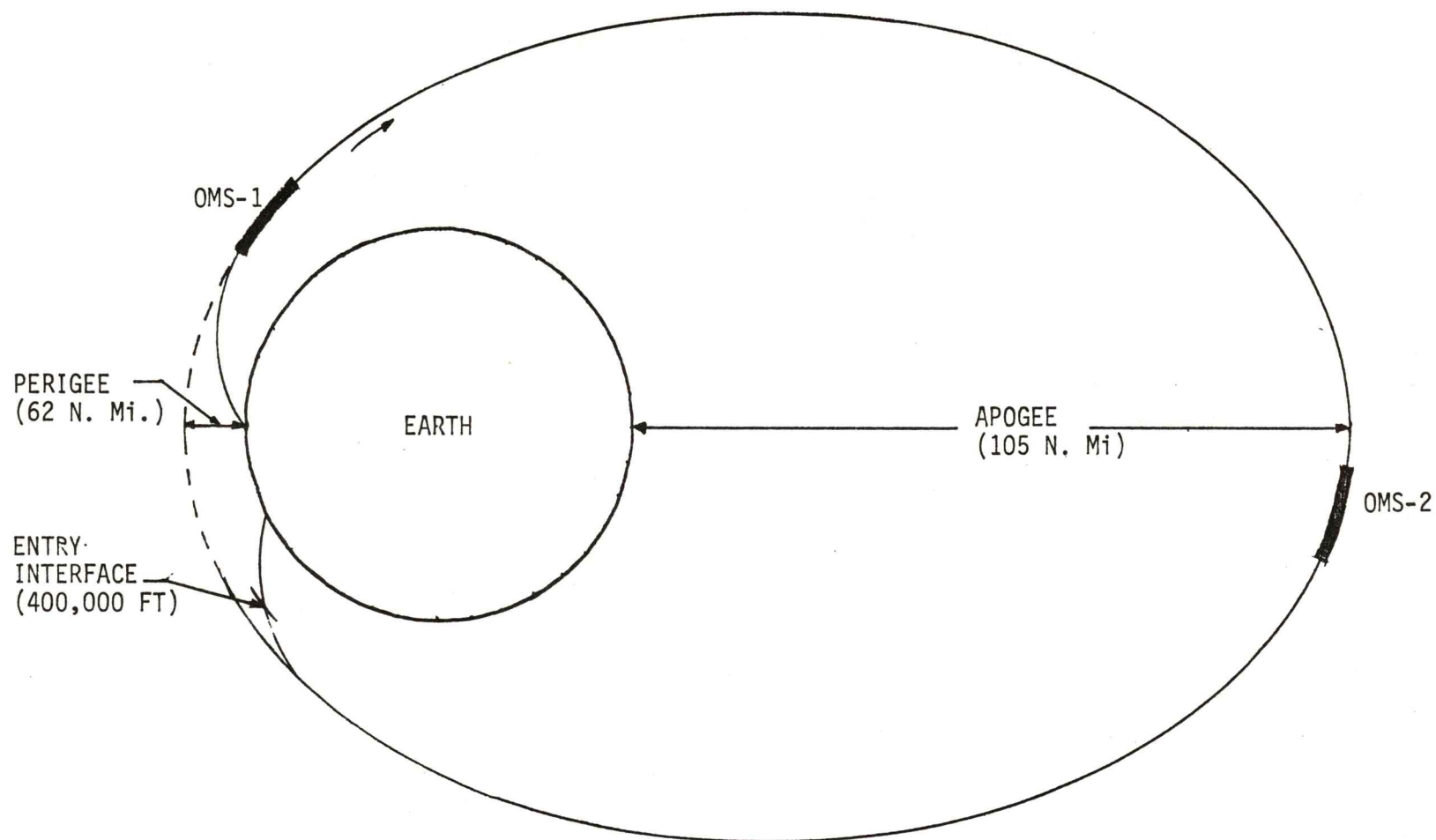


Figure 19.- STS-1 AOA post-MECO geometry.

CIRCULAR ORBIT
(105 N. MI.)

PERIGEE
(64 N. MI.)

MECO
OMS-1

EARTH

APOGEE
(105 N. MI.)

OMS-2

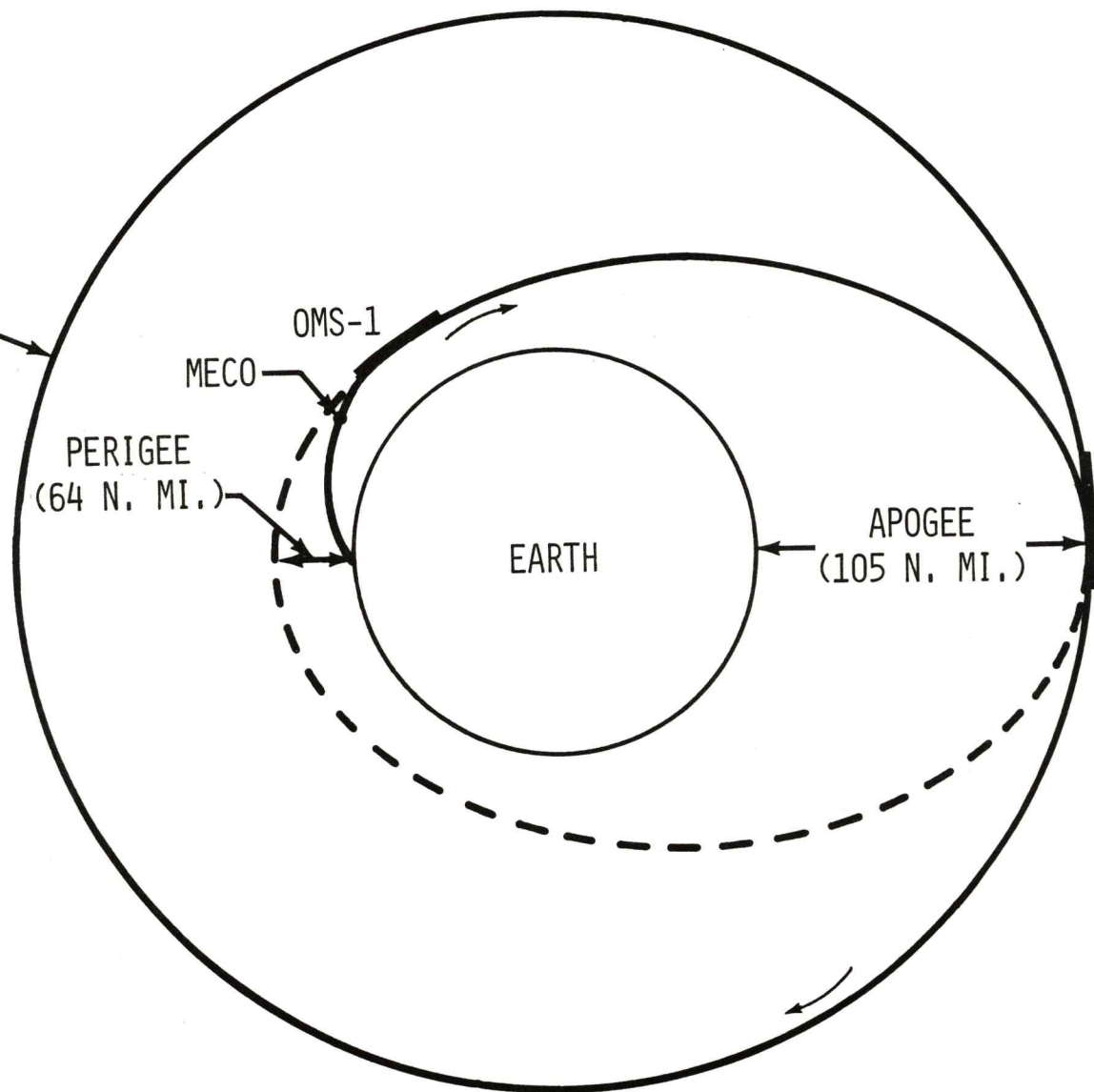


Figure 20.- STS-1 ATO post-MECO geometry.

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 CF7/T. R. Loe
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 CG5/E. L. Pavelka (5)
 CG6/R. K. Holkan
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 W. M. Merritt
 L. Frost
 F. Hughes
 A. Accola
 J. Mill
 M. Hernandez
 R. Williams
 R. Ranier
 D. Zwingman
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 CH3/J. D. Shannon
 A. M. Larsen
 CH6/W. Boone
 EA/Director
 EC2/E. Nitsch
 J. Jaax
 EC3/H. Rotter
 A. Behrend
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 EE/Chief
 EE4/R. A. Tremant
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 J. Lamoreux
 EF2/P. Kurten
 T. V. Chambers
 B. Marcantel
 C. Watkins
 EF3/J. Vanartsdalen

EG8/R. E. Wilson
 EH/J. F. Hanaway
 K. J. Cox
 EH1/T. P. Lins
 EH2/J. A. Porter
 P. C. Kramer
 D. A. Dyer
 EH7/H. R. Rosenberg
 D. W. Gilbert
 B. H. Hood
 A. Brandi
 EP2/W. Hammoch
 EP4/H. Brasseaux
 L. Jenkins
 ES2/R. Nieder
 ES12/W. G. McMullen (2)
 EW/W. W. Petynia
 EX/B. Redd
 B. G. Jackson
 J. E. DeFife
 EX4/P. G. Thomas
 EX31/M. Hayman
 EX43/M. Craig
 EX32/R. Barton
 FA/L. C. Dunseith
 R. P. Parten
 R. G. Rose
 C. H. Woodling
 FC95/R. Friday
 FD/C. R. Huss
 FE2/C. C. Olasky
 B. Force
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 R. H. Brown
 E. C. Lineberry
 FM2/K. A. Young
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 G. L. Hunt
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 LA/R. F. Thompson
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 L. W. Keyser
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 LO/C. R. Haines
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 S. A. Kamen
 LV/J. B. Jackson, Jr.
 R. W. Mitchell
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 R. B. Ramsell (2)
 ME4-EK4/W. H. Taylor
 MG/J. R. Craven
 G. A. Coultas
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 NS3/J. R. Hoffman
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