80-FM-40
(Supersedes 78-FM-51, Rev. 1)
Vol. IV

JSC-16683
(Supersedes JSC-14483)

STS-1
Operational Flight Profile

Volume IV
Onorbit Profile - Cycle 3.1.1

(NASA-TM-82183) STS-1 OPERATIONAL FLIGHT PROFILE. VOLUME 4: ONORBIT PROFILE-CYCLE 3.1.1 (NASA) 41 p HC A03/MF A01 CSCL 22A

N80-31445

Unclas
G3/16 30956

Mission Planning and Analysis Division

July 1980

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

80FM40:IV

80-FM-40
(Supersedes 78-FM-51, Rev. 1)
Vol. IV

JSC-16683
(Supersedes JSC-14483)

SHUTTLE PROGRAM

STS-1
OPERATIONAL FLIGHT PROFILE

VOLUME IV
ONORBIT PROFILE - CYCLE 3.1.1

By Flight Planning Branch

Approved: Ken Young
Kenneth Young, Chief
Flight Planning Branch

Approved:
Ronald L. Berry, Chief
Mission Planning and Analysis Division

Mission Planning and Analysis Division

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

Houston, Texas

July 1980

ACRONYMS

AOA	abort once around
AOS	acquisition of signal
CTPD	Crew Training and Procedures Division
DTO	detailed test objective
EAFB	Edwards Air Force Base
EI	entry interface
EST	eastern standard time
ET	external tank
FSSR	functional subsystem software requirements
g	gravity
GET	ground elapsed time
GMT	Greenwich mean time
GRTLS	glide RTLS
GSTDN	Ground Spaceflight Tracking and Data Network
IOS	Indian Ocean Site (Air Force tracking site)
KSC	Kennedy Space Center
LOS	line of sight, loss of signal
MECO	main engine cutoff
OFP	operational flight profile
OMS	orbital maneuvering system
PST	Pacific standard time
PEG	powered explicit guidance
RCS	reaction control system
RTLS	return-to-launch site
SRB	solid rocket booster

STS-1 Space Transportation System-1

TAEM terminal area energy management

Z-LV Z-axis local vertical

CONTENTS

TABLES

FIGURES

1.0 INTRODUCTION

The orbital flight test (OFT) phase of the Shuttle Program consists of four orbital flights beginning in November 1980 and continuing through 1981. 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 the onorbit portion 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 onorbit document (volume IV) is one in a series that, taken together, will define the STS-1 OFP. This OFP onorbit document represents a combination of the STS-1 groundrules and constraints and the initialization data presented in reference 3. The STS-1 flight requirements are presented in reference 4. This document supersedes the Operational Flight Profile, 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 May 1, 1980.

Detailed analyses of the ascent, descent, and abort phases will be provided as separate volumes of the OFP (refs. 5, 6, and 7).

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

All the STS-1 OFP documents and their scheduled distribution dates are listed in table I.

2.0 FLIGHT DESCRIPTION

The STS-1 will be a 54.5-hour flight launched from Kennedy Space Center (KSC) on November 30, 1980 at 11:50 Greenwich mean time (GMT). The flight test will be achieved in a 150-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 = 00:45:52). 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 be placed in a X-POP, Z-LV (wing into the 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. Two orbital OMS maneuvers will be performed during the flight to satisfy flight test objectives. The OMS-3 maneuver (delta-V = 20 fps) will be performed following the deorbit rehearsal on day 2 at GET = 30:59:50. The OMS-4 maneuver (delta-V = 20 fps) will be performed approximately 30 minutes after the OMS-3 maneuver at GET = 31:29:50. Both of these OMS maneuvers will be performed out of plane with the Orbiter remaining in a 150-n. mi. circular orbit. Deorbit (GET = 53:30:44) will occur on December 2. Nominal landing will occur on runway 23 'uring a descending pass (orbit 37) to Edwards

Air Force Base (EAFB). The GET for the nominal landing will be 54:31:00 (10:21 a.m. Pacific standard time (PST)).

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

2.1 ASCENT

The Shuttle will be launched from KSC (pad 39A) at 11:50:00 GMT (6:50 a.m. eastern standard time (EST)) on November 30, 1980. This launch time corresponds to the opening of the window based on lighting constraints for an abort-once-around landing at Northrup Strip. 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 $\pm10^\circ$ of the runway heading and 0° to 20° elevation.

c. The end-of-mission beta must be less than 60°.

Table III summaries the beta angles as a function of the launch date. For the nominal November 30 date, launch can occur as late as 9:25 EST (14:25 GMT) without violating the 60° end-of-mission beta angle constraint. For the nominal November 30 launch, this beta angle constraint determines the window closing time and launch window of 2 hours and 35 minutes. The resultant launch windows for each month of the year, considering the above constraints, are summarized in table IV.

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/ft^2.

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/ft^2 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, structural separation from the ET occurs, and a reaction control system (RCS) -Z translation separation maneuver is initiated. This maneuver takes 6 seconds and results in a -Z delta-V component of approximately 4 fps.

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 912 500 feet, which is biased from 150 n. mi. to compensate for J-2 effects.

Upon completion of the 204 fps OMS-1 burn, the resultant orbit has an apogee altitude of 151 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 00:45:52 GET. The 167 fps delta-V burn places the Orbiter into a near-circular orbit of approximately 150 n. mi. above the spherical Earth radius.

2.2 ONORBIT

The STS-1 orbital operations phase is initiated at the completion of the OMS-2 maneuver (GET = 00:47:22) and terminates at deorbit ignition (GET = 53:30:44).

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). The primary activity schedule for day 2 is deorbit rehearsal. Two orbital OMS maneuvers will be performed during the flight to satisfy flight test objectives. The OMS-3 maneuver (delta-V = 20 fps) will be performed following the deorbit rehearsal on day 2 at GET = 30:59:50. The OMS-4 maneuver (delta-V = 20 fps) will be performed approximately 30 minutes after the OMS-3 maneuver at GET = 31:29:50. Both of these OMS maneuvers will be performed out of plane with the Orbiter remaining in a 150-n. mi. circular orbit.

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 October 1980 is the official source for these types of data.

Deorbit opportunities to EAFB and five contingency landing sites (crossrange less than or equal to 690 n. mi.) are shown in table V. Detailed maneuver tables for OMS-3 and OMS-4 are provided in table VI. The flight groundtracks with major events noted are shown in figure 1. Ground Spaceflight Tracking and

Data Network (GSTDN) coverage, daylight/darkness, Orbiter groundtrack, and beta angle data are shown in figure 2. Flight activities are not shown in this figure since the crew activity plan (to be published by the CTPD in October 1980) is the official source for these types of data.

Detailed tabular trajectory and GSTDN data with masking (super tape printout) are provided in appendix A (to be published separately in July 1980). Detailed trajectory and attitude data are provided in appendix B (to be published in October 1980).

2.3 DESCENT

The deorbit maneuver is initiated at 53 hours 30 minutes 44 seconds GET during the 36th orbit, with subsequent landing on runway 23 at EAFB at 10:21 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 (delta-V) of 299.1 fps, with a thrust duration of 2 minutes 35 seconds and a 25-minute 35-second free-fall time between thrust termination and EI. Nominal conditions at EI of 400 000 feet altitude are 4352 n. mi. range-to-go, 25 750 fps inertial velocity, and -1.2° inertial flightpath angle, with an Orbiter weight of 196 288 pounds.

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 Btu/ft^2 and 61.2 Btu/ft^2/sec, respectively.

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.

3.0 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 c plete 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.

4.0 REFERENCES

1. Shuttle Master Verification Plan. JSC-07700-10-MVP-11.

2. Mission Planning and Analysis Division: STS-1 Operational Flight Profile, Volume IV - Onorbit Profile, Cycle 3. JSC IN 78-FM-51, Vol. IV, Rev. 1, Nov. 1979.

3. Mission Planning and Analysis Division: STS-1 Operational Flight Profile - Groundrules and Constraints, Cycle 3.1.1. JSC-14483 (to be published).

4. Space Transportation System Flight Requirement Document: Space Shuttle Orbital Flight Test (STS-1). JSC-10780, Basic, Rev. D, May 1980.

5. Mission Planning and Analysis Division: STS-1 Operational Flight Profile - Ascent, Cycle 3.1.1 (to be published).

6. Mission Planning and Analysis Division: STS-1 Operational Flight Profile - Descent, Cycle 3.1.1 (to be published).

7. Mission Planning and Analysis Division: STS-1 Operational Flight Profile - Abort Analysis, Cycle 3.1.1 (to be published).

TABLE I.- STS-1 OFP DOCUMENT PUBLICATION SCHEDULE

Document	Scheduled distribution date
Volume I - Groundrules and Constraints	July 1980
Volume II - Profile Summary	August 1980
Volume III - Detailed Ascent Profile	TBD
Volume IV - Onorbit Profile	July 1980
Volume V - Detailed Deorbit-Through-Landing Profile	TBD
Volume VI - Abort Analysis	TBD
Volume VII - OMS and RCS Analysis	July 1980
Volume VIII - Nonpropulsive Consumables Analyses	TBD

TABLE II.- SEQUENCE OF EVENTS

GMT of STS-1 Launch: November 30, 1980 11:50:00 (GMT)
Inclination = 40.3 Node Shift = 0
Orbital Altitude = 150/150 Nautical Miles

Event	Mission elasped 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	
OMS-1 ignition	0:10:32	
OMS-1 cutoff	0:12:22	[1]Orbit = 57/151
OMS-2 ignition	0:45:52	
OMS-2 cutoff	0:47:22	Orbit = 150/150
OMS-3 ignition	30:59:50	(Out of plane)
OMS-3 cutoff	31:00:11	Orbit = 149/150
OMS-4 ignition	31:29:50	(Out of plane)
OMS-4 cutoff	31:30:10	Orbit = 149/150
Deorbit ignition	53:30:44	
Deorbit cutoff	53:33:19	
Entry interface	53:58:54	
TAEM	54:24:00	
Landing	54:31:00	

[1] Reference to spherical Earth-assuming equatorial radius.

TABLE III.- STS-1 BETA ANGLE AS A FUNCTION OF LAUNCH DATE

Launch date	AOA to Northrup			AOA to EAFB		
	Lift-off time EST, hr:min (a.m.)	Launch beta, deg	End-of-mission beta, deg	Lift-off time EST, hr:min	Launch beta, deg	End-of-mission beta, deg
Jan. 31	7:03	-47	-38	7:53	-53	-45
Feb. 28	6:35	-36	-26	7:22	-41	-33
Mar. 31	5:56	-22	-12	6:41	-27	-18
Apr. 30	5:21	-10	0	6:03	-14	-6
May 31	5:00	1	10	5:40	-6	3
Jun. 30	5:01	3	12	5:41	-4	4
Jul. 31	5:19	-5	3	6:00	-10	-3
Aug. 31	5:39	-16	-8	6:23	-22	-15
Sep. 30	5:59	-31	-23	6:45	-35	-28
Oct. 31	6:22	-44	-35	7:11	-49	-42
Nov. 30	6:50	-52	-44	7:41	-58	-51
Dec. 31	7:08	-54	-45	8:08	-61	-54

TABLE IV.- STS-1 LAUNCH WINDOW SUMMARY

Launch date	Earliest lift-off EST, hr:min, a.m. (assuming AOA to Northrup with landing at sunrise -15 min)	AOA to Northrup launch window duration, hr:min				AOA to EAFB
		Landing at sunset +15 min (EOM, rev. 4)	Sun azimuth elevation avoidance azi: $\pm 10^{\circ}$ elev: $0-20^{\circ}$	Avoid EOM Beta > 60°	Resultant window	Launch delay or window loss if AOA to EAFB, min
Jan. 31	7:03	7:02	5:22	3:12	3:12	50
Feb. 28	6:35	7:59	6:54	4:55	4:55	47
Mar. 31	5:56	9:03	No constraint	No constraint	9:03	45
Apr. 30	5:21	10:02	No constraint	No constraint	10:02	42
May 31	5:00	10:46	No constraint	No constraint	10:46	40
Jun. 30	5:01	10:56	No constraint	No constraint	10:56	40
Jul. 31	5:19	10:26	No constraint	No constraint	10:26	41
Aug. 31	5:39	9:26	No constraint	No constraint	9:26	44
Sep. 30	5:59	8:23	7:38	5:45	5:45	46
Oct. 31	6:22	7:23	5:[illegible]	4:15	4:15	49
Nov. 30	6:50	6:38	5:43	2:35	2:35	51
Dec. 31	7:08	6:47	6:02	2:22	2:22	60

TABLE V.- DEORBIT OPPORTUNITIES

[Crossrange ≤ 690 n. mi.]

(a) EAFB

Deorbit orbit	Crossrange, n. mi.*	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit → EI)
2	129 N	2:17	2:47	3:17	ORR
3	248 S	3:52	4:22	4:52	ORR
4	317 S	5:27	5:57	6:27	--
5	66 S	7:02	7:32	8:02	GWM
6	459 N	8:37	9:07	9:37	--
17	515 N	24:46	25:16	25:46	ORR
18	30 S	26:26	26:50	27:20	ORR
19	308 S	27:55	28:25	28:55	--
20	266 S	29:30	30:00	30:30	--
21	86 N	31:05	31:35	32:05	GWM
22	687 N	32:40	33:10	33:40	--
33	305 N	48:48	49:18	49:48	ORR
34	158 S	50:23	50:53	51:23	ORR
35	330 S	51:58	52:28	52:58	--
36	179 S	53:31	54:01	54:31	GWM
37	266 N	55:07	55:37	56:07	GWM
49	119 N	72:51	73:21	73:51	ORR
50	252 S	74:25	74:55	75:25	ORR
51	315 S	76:00	76:30	77:00	--
52	58 S	77:35	78:05	78:35	GWM
53	472 N	79:10	79:40	80:10	--

*NOTE: "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.

TABLE V.- Continued

(Crossrange ≤ 690 n. mi.)

(b) KSC

Deorbit orbit	Crossrange, n. mi.*	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit → EI)
1	503 S	0:50	1:20	1:50	ORR
3	569 S	4:01	4:31	5:01	HAW
4	104 S	5:36	6:06	6:36	--
5	596 N	7:10	7:40	8:10	GWM
15	480 N	21:43	22:13	22:43	ORR
16	191 S	23:17	23:47	24:17	ORR
17	613 S	24:53	25:23	25:53	ORR
19	443 S	28:03	28:33	29:03	HAW
20	112 N	29:38	30:08	30:38	--
31	230 N	45:45	46:15	46:45	ORR
32	367 S	47:20	47:50	48:20	ORR
33	684 S	48:55	49:25	49:55	ORR
34	654 S	50:31	51:01	51:31	HAW
35	283 S	52:06	52:36	53:06	HAW
36	352 N	53:41	54:11	54:41	GWM
47	1 N	69:48	70:18	70:48	ORR
48	511 S	71:23	71:53	72:23	ORR
50	563 S	74:34	75:04	75:34	ORR
51	92 S	76:09	76:39	77:09	--
52	612 N	77:43	78:13	78:43	GWM

*NOTE: "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.

TABLE V.- Continued

(Crossrange ≤ 690 n. mi.)

(c) Northrup Strip

Deorbit orbit	Crossrange, n. mi.*	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit → EI)
1	312 N	0:45	1:15	1:45	ORR
2	208 S	2:19	2:49	3:19	ORR
3	443 S	3:55	4:25	4:55	ORR
4	347 S	5:30	6:00	6:30	--
5	61 N	7:05	7:35	8:05	GWM
17	108 N	24:47	25:17	25:47	ORR
18	323 S	26:22	26:52	27:22	ORR
19	448 S	27:57	28:27	28:57	--
20	240 S	29:33	30:03	30:33	--
21	258 N	31:07	31:37	32:07	GWM
32	526 N	47:16	47:46	48:16	ORR
33	69 S	48:50	49:20	49:50	ORR
34	403 S	50:25	50:55	51:25	ORR
35	414 S	52:00	52:30	53:00	HAW
36	100 S	53:35	54:05	54:35	GWM
37	480 N	55:10	55:40	56:10	GWM
48	300 N	71:18	71:48	72:18	ORR
49	215 S	72:53	73:23	73:53	ORR
50	444 S	74:28	74:58	75:28	ORR
51	342 S	76:03	76:33	77:03	--
52	72 N	77:38	78:08	78:38	GWM

*NOTE: "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.

TABLE V.- Continued

(Crossrange ≤ 690 n. mi.)

(d) Hickam

Deorbit orbit	Crossrange, n. mi.*	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit → EI)
3	94 S	3:42	4:12	4:42	ORR
8	22 S	11:40	12:10	12:40	IOS
18	440 N	26:10	26:40	27:10	ORR
19	341 S	27:45	28:15	28:45	--
23	492 S	34:08	34:38	35:08	IOS
24	250 N	35:43	36:13	36:43	IOS
34	150 N	50:13	50:43	51:13	ORR
35	563 S	51:48	52:18	52:48	--
39	261 S	58:11	58:41	59:11	IOS
40	538 N	59:45	60:15	60:45	IOS
50	109 S	74:16	74:46	75:16	ORR
51	756 S	75:51	76:21	76:51	--
54	684 S	80:38	81:08	81:38	IOS
55	7 S	82:13	82:43	83:13	IOS

*NOTE: "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.

TABLE V.- Continued

[Crossrange ≤ 690 n. mi.]

(e) Kadena

Deorbit orbit	Crossrange, n. mi.*	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit → EI)
6	323 N	8:12	8:42	9:12	--
7	348 S	9:47	10:17	10:47	--
10	536 S	14:33	15:03	15:33	ACN
11	51 N	16:08	16:38	17:08	ACN
22	72 N	32:15	32:45	33:15	--
23	522 S	33:50	34:20	34:50	IOS
26	365 S	38:36	39:06	39:36	ACN
27	299 N	40:11	40:41	41:11	ACN
37	576 N	54:43	55:13	55:43	--
38	156 S	56:17	56:47	57:17	--
39	663 S	57:53	58:23	58:53	IOS
41	667 S	61:04	61:34	62:04	--
42	163 S	62:39	63:09	63:39	ACN
43	567 N	64:13	64:43	65:13	ACN
53	308 N	78:45	79:15	79:45	--
54	359 S	80:20	80:50	81:20	--

*NOTE: "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.

TABLE V.- Concluded

(Crossrange ≤ 690 n. mi.)

(f) Rota

Deorbit orbit	Crossrange, n. mi.*	GET deorbit, hr:min	GET entry interface, hr:min	GET landing, hr:min	GSTDN coverage (deorbit → EI)
1	454 N	1:05	1:35	2:05	--
13	129 N	18:49	19:19	19:49	--
14	185 S	20:24	20:54	21:24	QUI
15	192 S	21:58	22:28	22:58	MIL/BDA
16	110 N	23:34	24:04	24:34	MIL
17	668 N	25:08	25:38	26:08	GDS
28	479 N	41:17	41:47	42:17	AGO
29	10 S	42:52	43:22	43:52	QUI
30	223 S	44:27	44:57	45:27	QUI
31	122 S	46:02	46:32	47:02	MIL/BDA
32	274 N	47:36	48:06	48:36	MIL/BDA
44	286 N	65:20	65:50	66:20	AGO
45	116 S	66:54	67:24	67:54	QUI
46	224 S	68:29	68:59	69:29	QUI
47	18 S	70:04	70:34	71:04	MIL/BDA
48	466 N	71:39	72:09	72:39	MIL/BDA

*NOTE: "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.

TABLE VI.- DETAILED MANEUVER DESCRIPTION

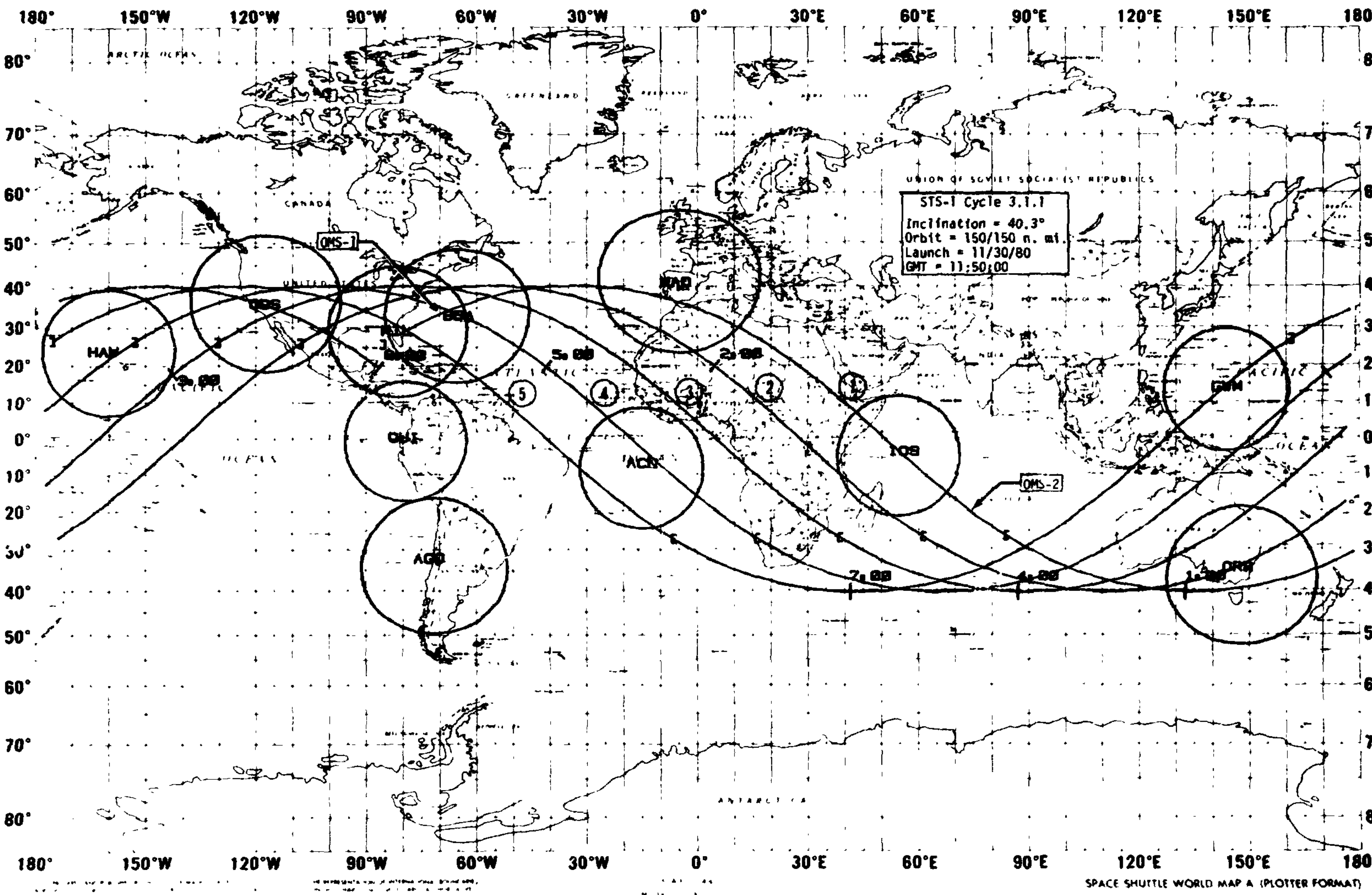
(a) OMS-3

```
                              DETAILED MANEUVER TABLE NO. 1
                               GMT   1980 12  1 18 49 49.5
 CODE     ORS01FCT                            PAD
 GMTI   1 18 49 49.5                    G HRS        42                GMTR     0 11 50     .0
 PETI   1  6 59 49.5                    M MIN        49                OUTOUT MAT            1
 DVM      20.0   CT B      0 21.1       T SEC      4947                OSTAID            VEH1ORB
             DT RCS        0    .0      P HRS        30                GMTV     1 18 20     .0
 VX     -11.30   R          78.57       E MIN        59                PETV     1  6 30     .0
 VY      -6.38   P         195.91       T SEC      4947                OEPH     1
 VZ     -15.22   Y         327.67          VX         0                TSTAID            VEH2VH2
 VXB     18.80   YH         77.90          VY       199                GMTV     0  0  0     .0
 VYB     -4.19   PH        344.00          VZ         0                PETV     0-11-50     .0
 VZP      5.39   RH        180.00          R         79                TEPH     1
                                           P        196                FSTAID            VEH1ORB
 DVTO      .09   TVR       180.00          Y        328                GMTV     1 18 20     .0
 DTTO      .10   ULL          .00          C1         0                PETV     1  6 30     .0
                                           C2         0
 HA     149.45   HBI       149.4           HT         0                WINIT        204687.00
 HP     148.65   PEI      40 18 S       THETAT        0                WOMS               .00
 L AN 121  5 E   LPI      37 30 E        PRPLT        0                WRCS               .00
 WP      48.56   FPI      223.80           RT         0                WFNL         204281.18
 I       40.44
 E     .000087                                                          DVREMPRI        -20.00
 A      3593.1                                   ADI                    DVREMSEC           .00
                                      INRTL      +X   LVLH      +X        ORB  TRIMS
  31   1.4      DH          .00           R    78.6   R      232.1         L         R
 UNTIL           THETA      .00           P   195.9   P      306.2     P  -16.00    -16.00
  DAY      THETA DOT        .00           Y   327.7   Y       70.0     Y   12.10    -12.10

                                      RELMAT-- M50 TO ADI
                           1.00000000   .00000000   .00000000
                            .00000000   .00000000  1.00000000
                            .00000000 -1.00000000   .00000000

    GIMBAL ANGLES               REFSMAT- M50 TO IMU PLATFORM
 YIMU     77.901           -.50009261   .86593346   .00816180
 PIMU    344.001           -.56485072  -.31903876  -.76102427
 RIMU    180.000           -.65639245  -.38519281   .64867207
```

TABLE VI.- Concluded

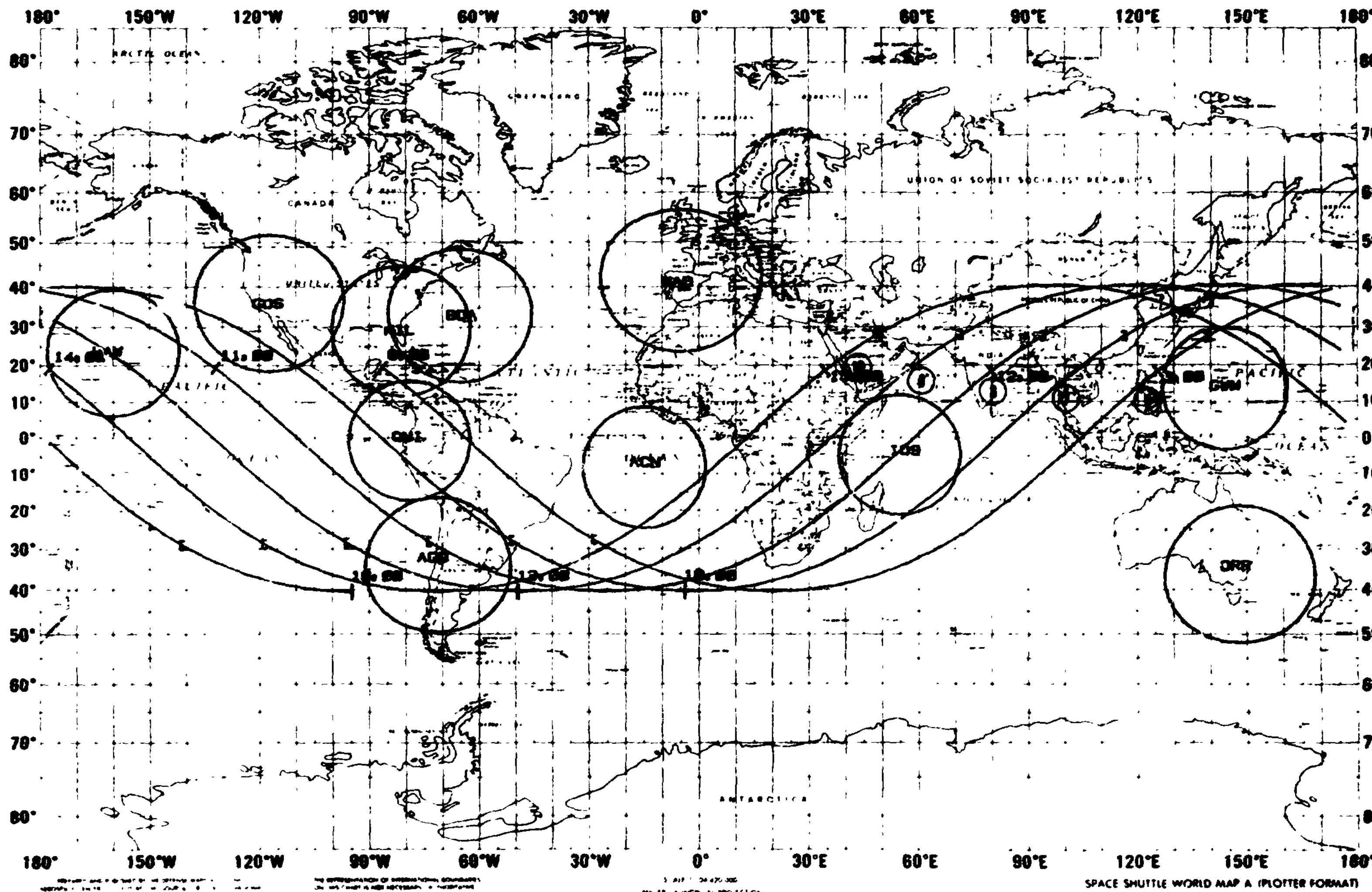
(b) OMS-4

```
                              DETAILED MANEUVER TABLE NO.  2
                                GMT   1980 12  1 19 19 49.5
CODE      OLSO2FCT                          PAD
GMTI      1 19 19 49.5               G HRS        43          GMTR     0 11 50    .0
PETI      1  7 29 49.5               M MIN        19          OUTOUT MAT          2
DVM       20.0  DT B   0 21.0        T SEC      4949          OSTAID          VEH1ORB
               DT RCS  0    .0       P HRS        31          GMTV     1 18 20    .0
VX       -11.31  R       95.49       E MIN        29          PETV     1  6 30    .0
VY        -6.38  P      225.79       T SEC      4949          OEPH     2
VZ       -15.21  Y      326.36            VX       0          TSTAID          VEH2VH2
VXB       18.80  YH      70.48            VY     200          CMTV     0  0  0    .0
VYB        4.19  PH     355.71            VZ       0          PETV     0-11-50    .0
VZB        5.39  RH     295.95            R       95          TEPH     2
                                          P      226          FSTAID          VEH1ORB
DVTO        .09  TVR    293.50            Y      326          GMTV     1 18 20    .0
DTTO        .10  ULL       .00           C1        0          PFTV     1  6 30    .0
                                         C2        0
HA       149.51  HBI     149.1           HT        0          WINIT       204281.18
HP       148.59  PRI    19 14 N      THETAT        0          WOMS              .00
L AN    98  ( E  LBI   143 26 E       PRPLT        0          WRCS              .00
WP        46.29  FBI    345.35           BT        0          WFNL        203876.15
I         40.44
E      .000953                                                DVREMPRI       -40.00
A        3596.4                             ADI               DVREMSEC          .00
                                   INRTL      +X  LVLH    +X      ORB   TRIMS
  1  1.0        DH          .00      R      95.5   R    307.9        L        R
UNTIL        THETA          .00      P     225.8   P    347.3     P -16.00   -16.00
DAY      THETA DOT          .00      Y     326.4   Y     70.0     Y  12.10   -12.10

                              RELMAT-- M50 TO ADI
                         1.00000000    .00000000    .00000000
                          .00000000    .00000000   1.00000000
                          .00000000  -1.00000000    .00000000

  GIMBAL ANGLES             REFSMAT- M50 TO IMU PLATFORM
YIMU     70.485        -.31858349   -.76625243    .55799801
PIMU    355.705        -.56540304   -.31886760   -.76068577
RIMU    295.946         .76080481   -.55783571   -.33165550
```



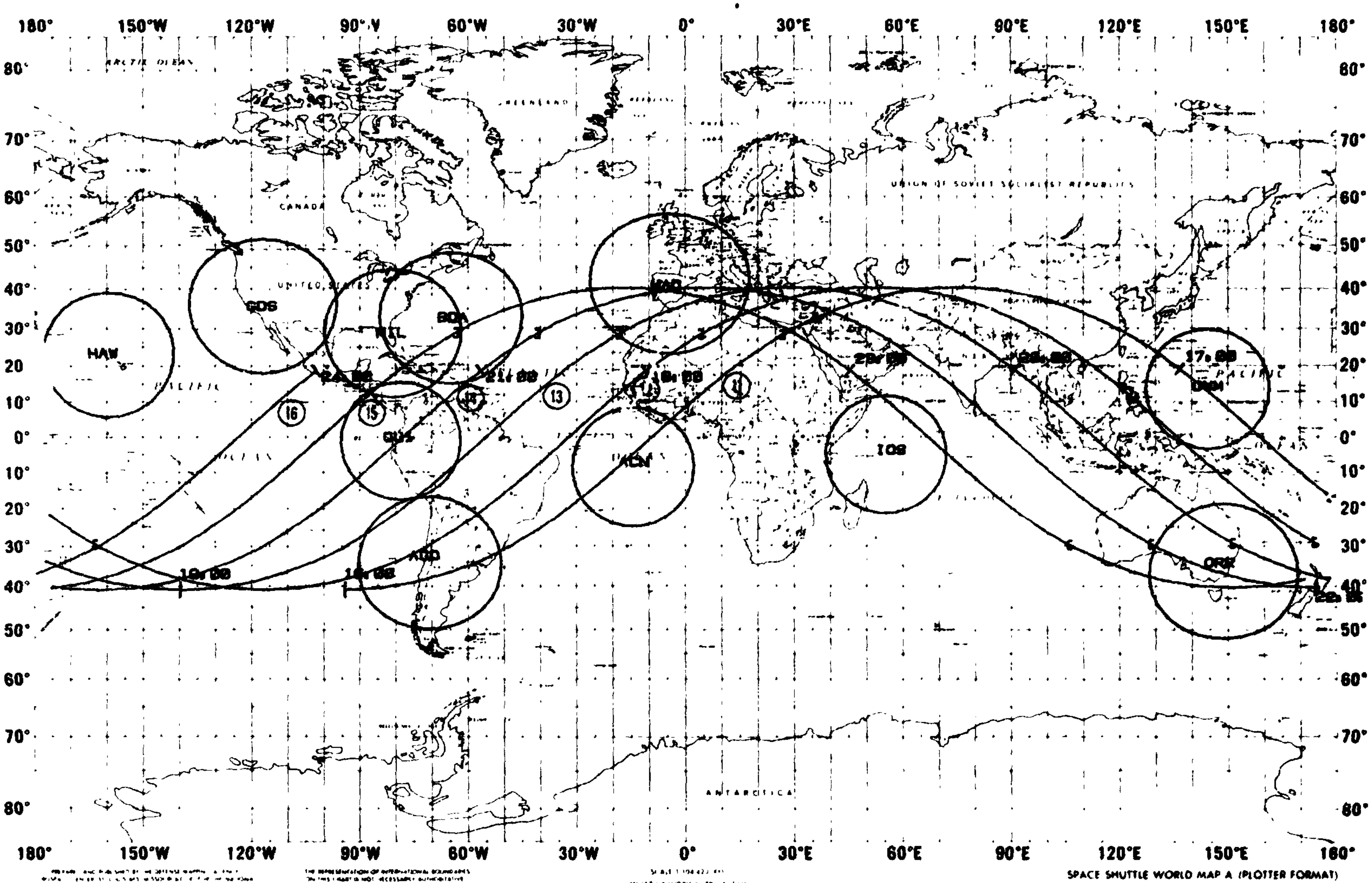
(a) Orbits 1 through 5.

Figure 1.- Nominal groundtrack.



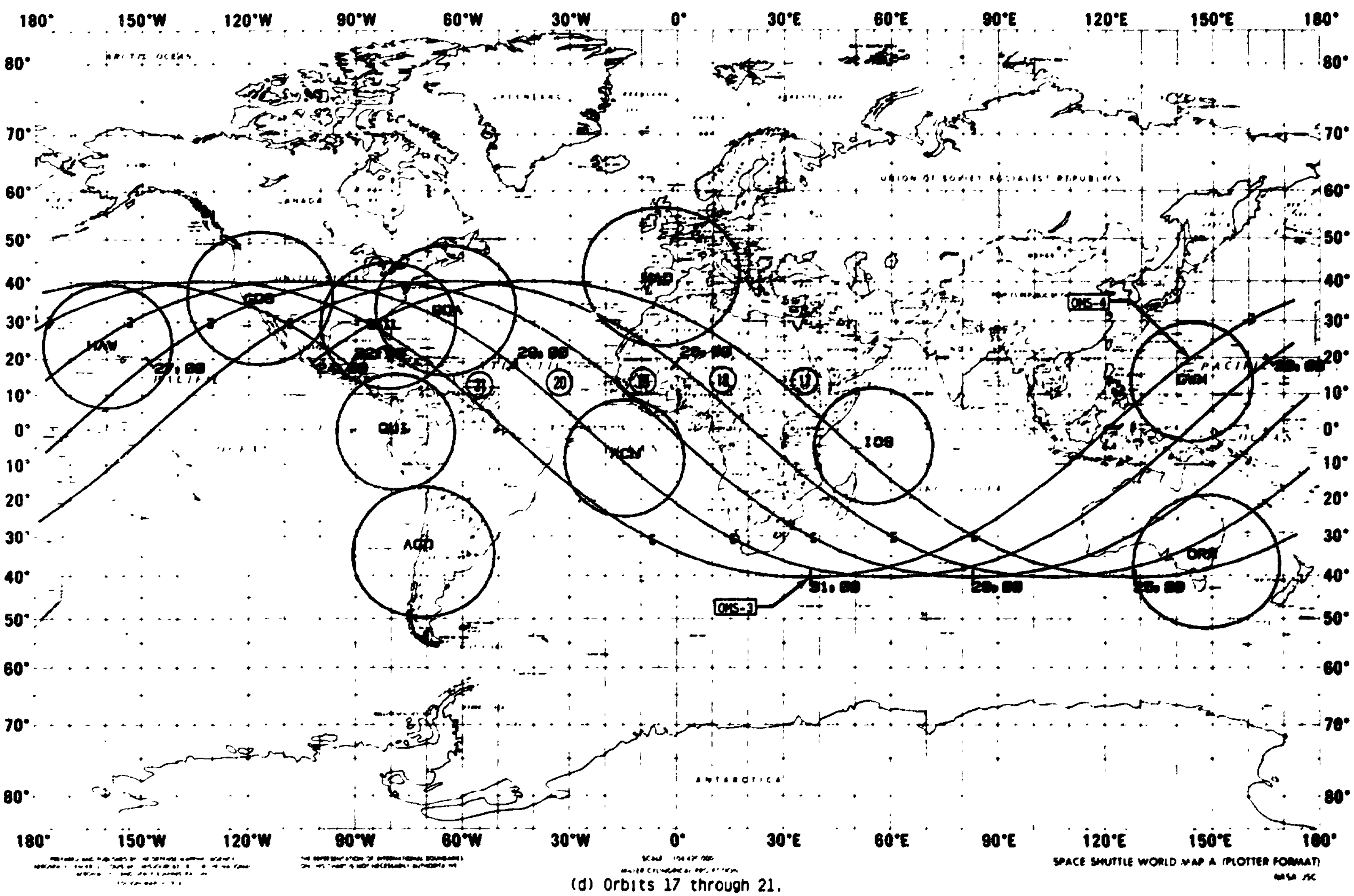
(b) Orbits 6 through 10.

Figure 1.- Continued.



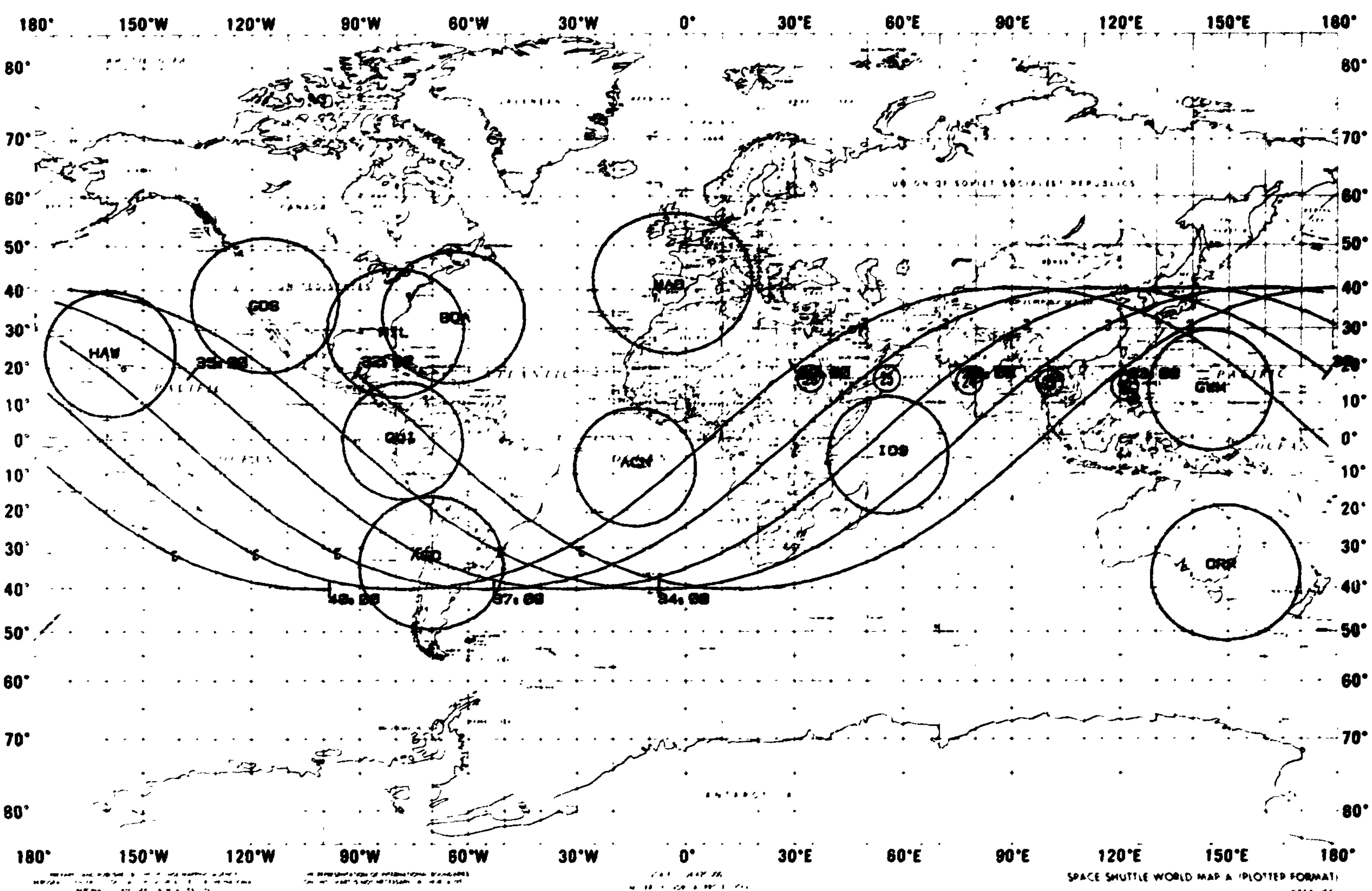
(c) Orbits 11 through 16.

Figure 1.- Continued.



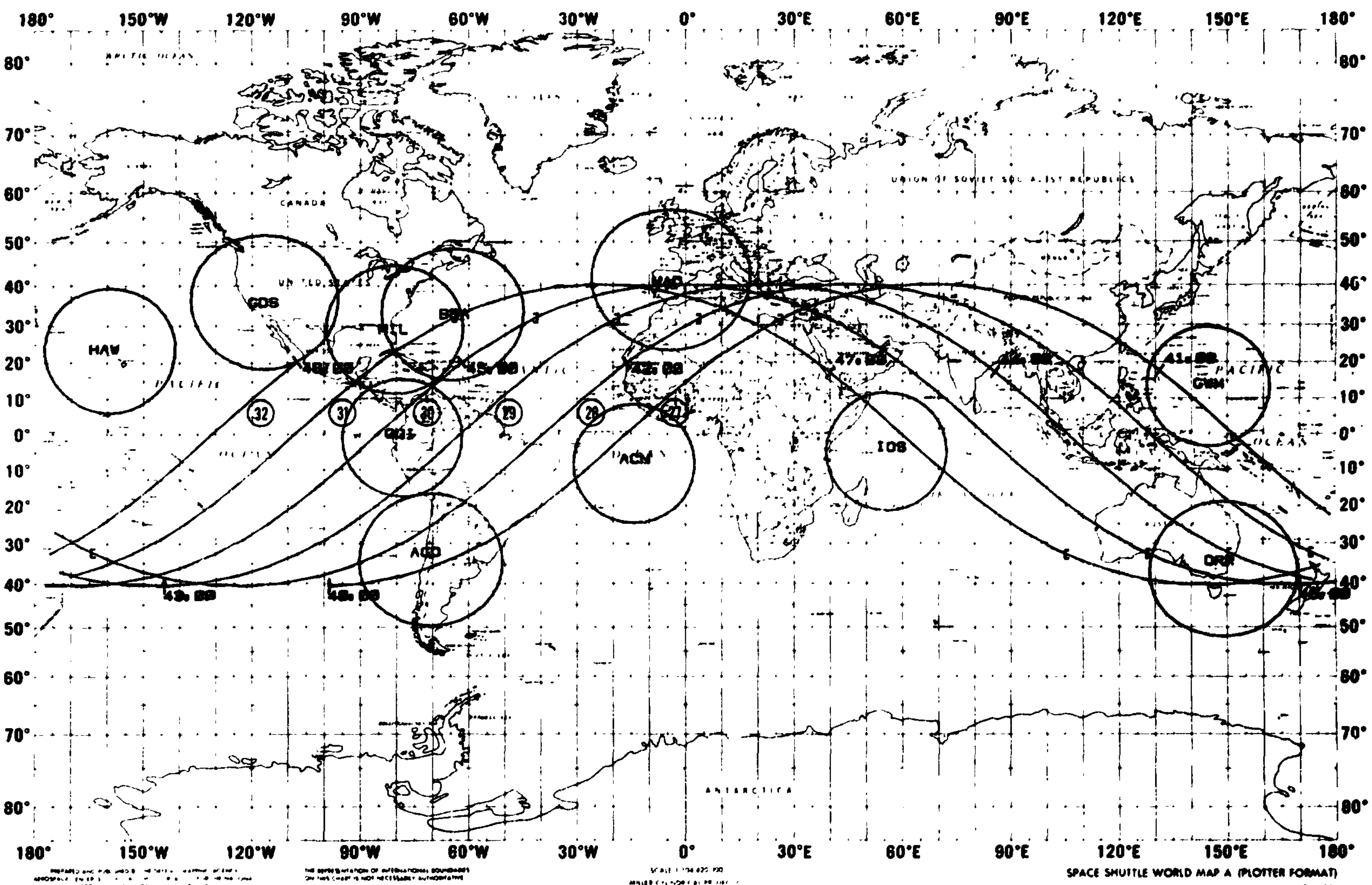
(d) Orbits 17 through 21.

Figure 1.- Continued.



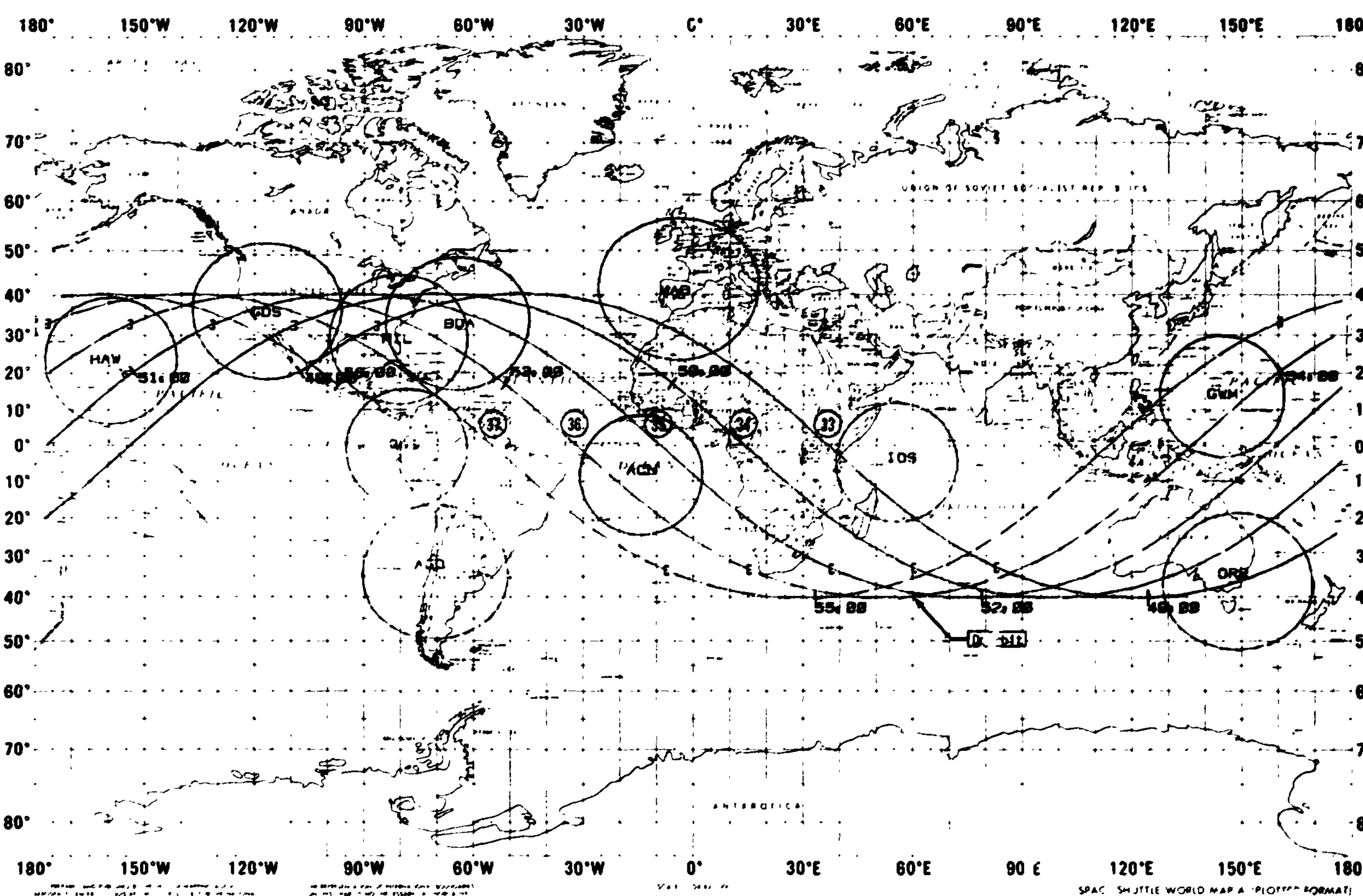
(e) Orbits 22 through 26.

Figure 1.- Continued.



(f) Orbits 27 through 32.

Figure 1.- Continued.



(g) Orbits 33 through 37.

Figure 1.- Concluded.

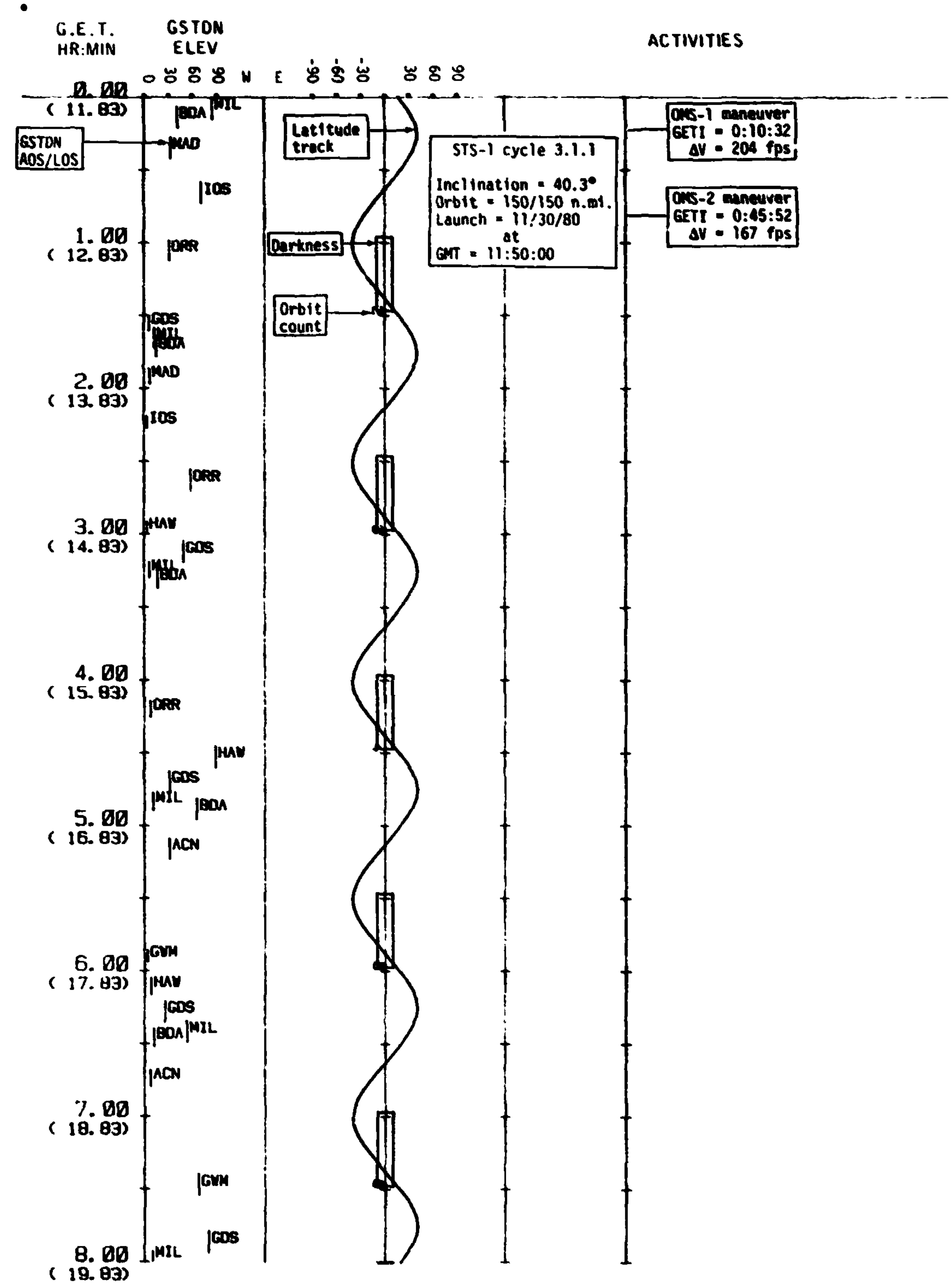


Figure 2.- Nominal event timeline.

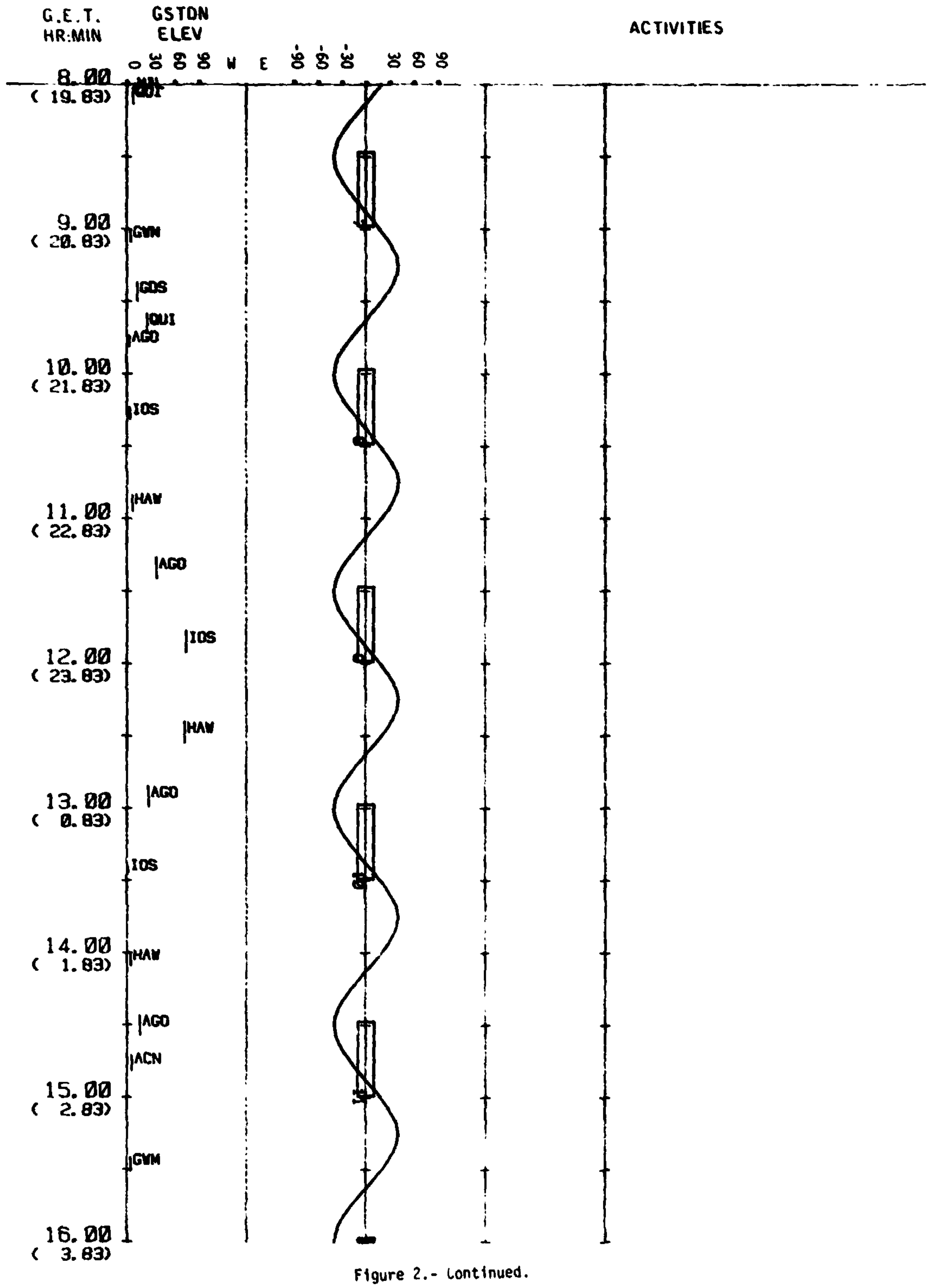


Figure 2.- Continued.

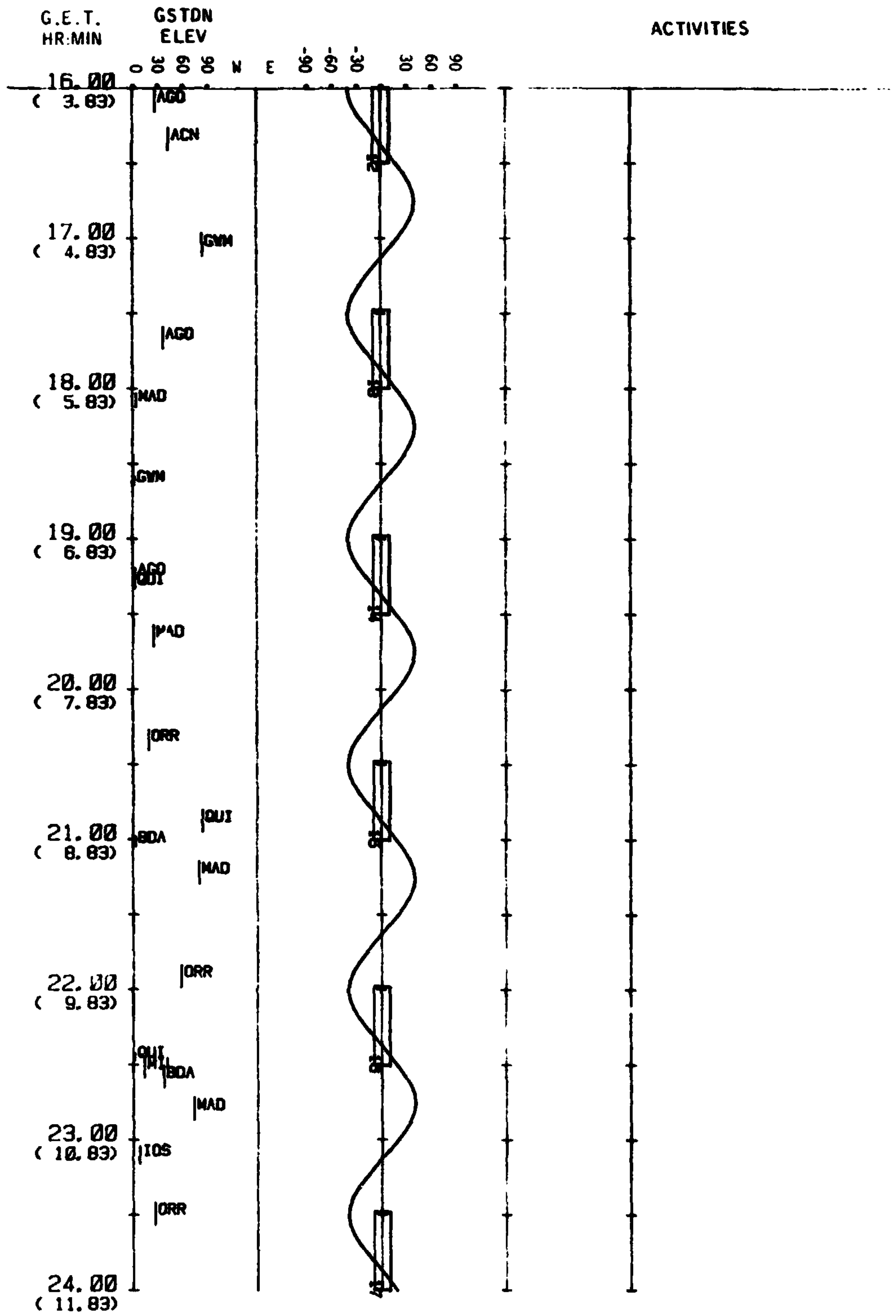
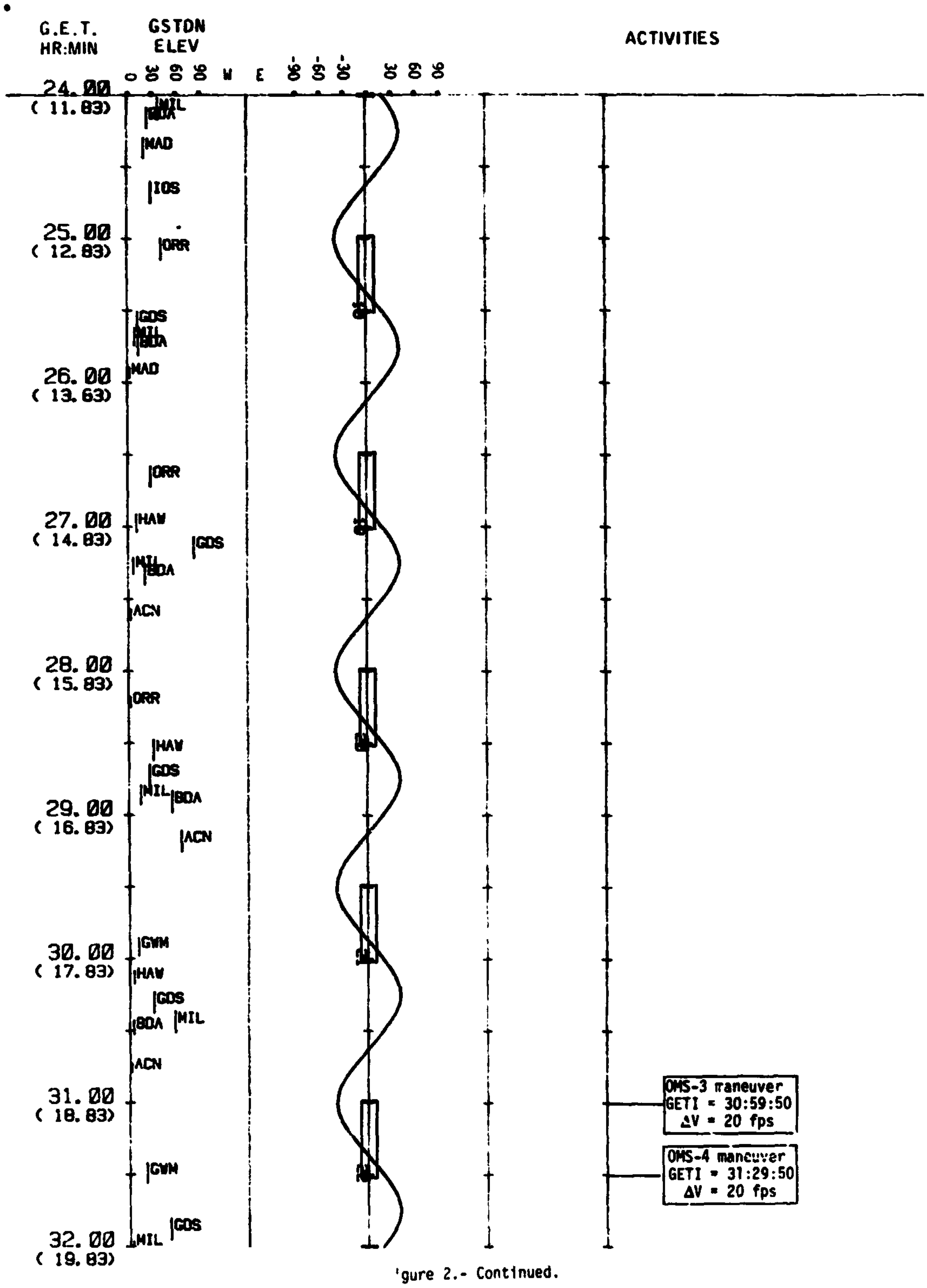


Figure 2.- Continued.



'gure 2.- Continued.

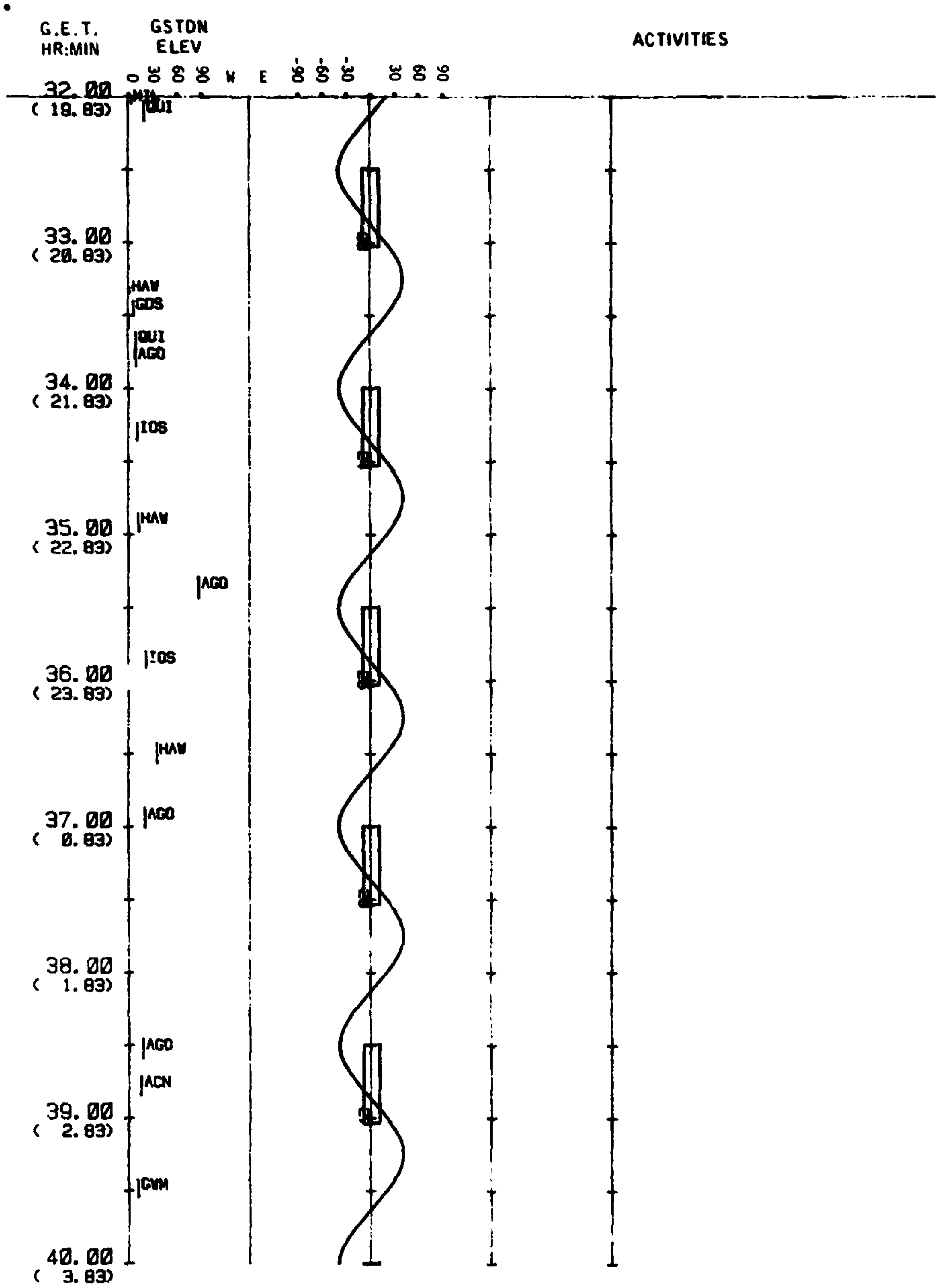


Figure 2.- Continued.

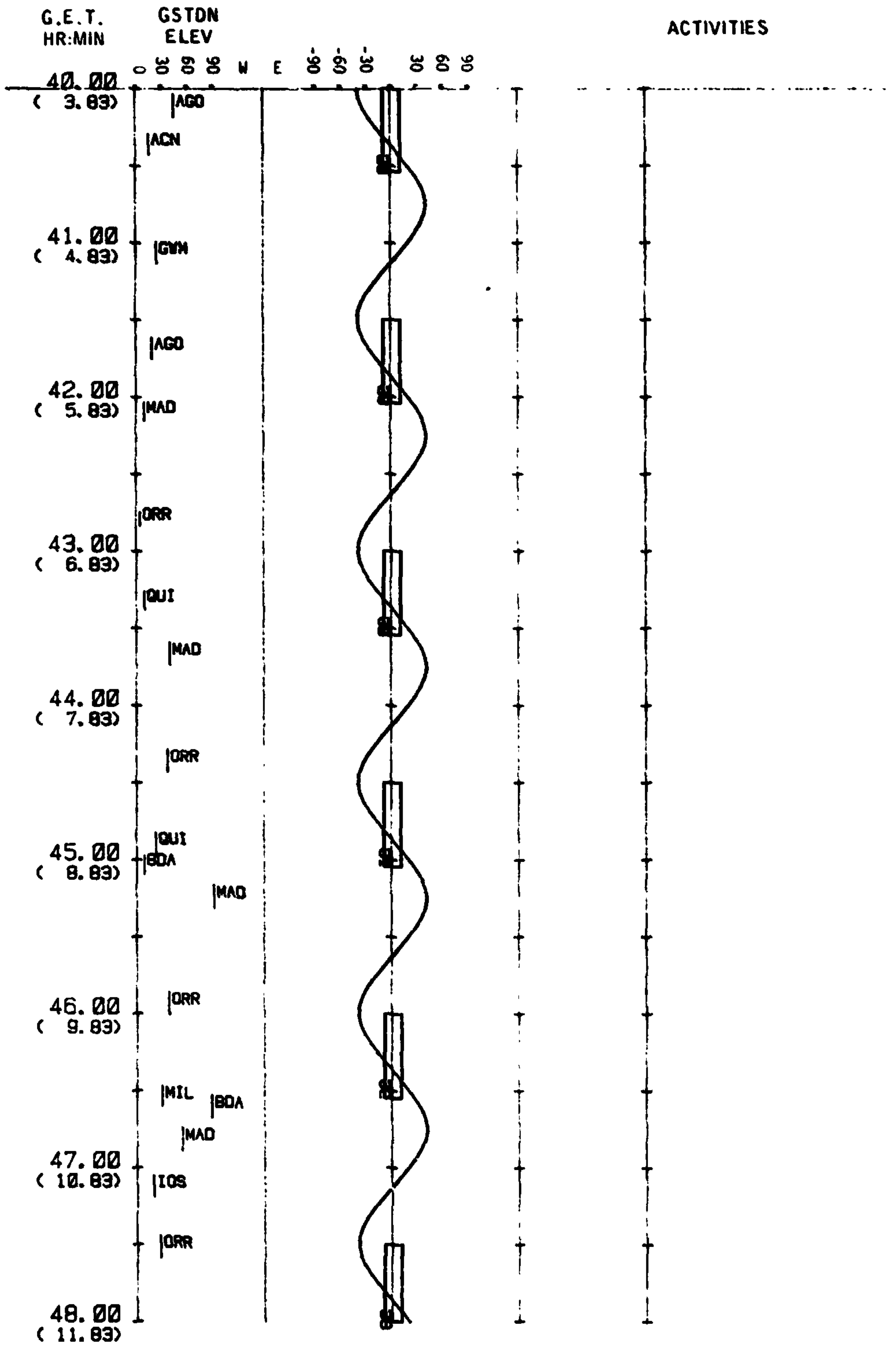


Figure 2.- Continued.

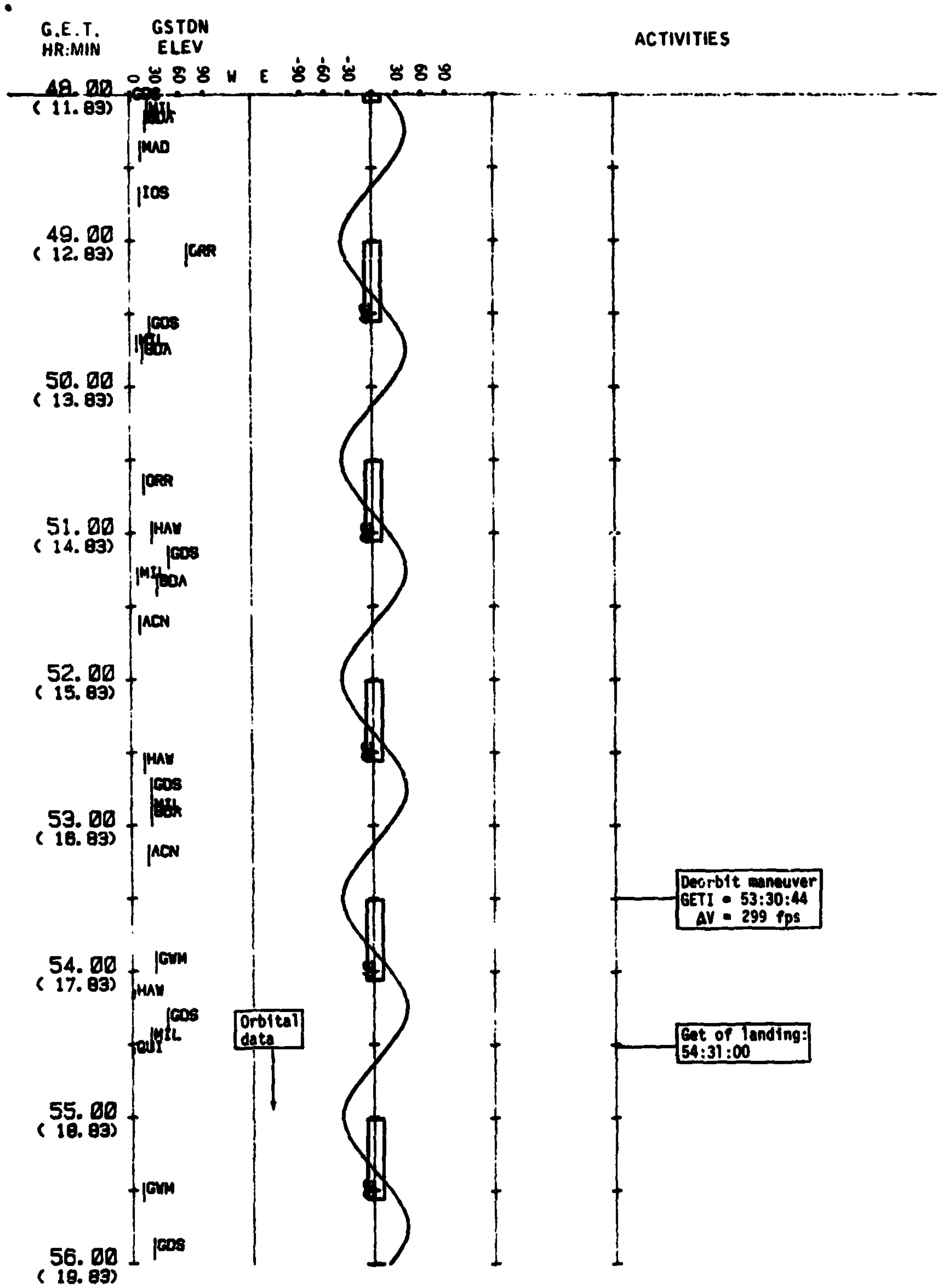


Figure 2.- Concluded.

APPENDIX A

ONORBIT TRAJECTORY DATA (SUPER TAPE)

(To be published in July 1980)

APPENDIX B

ONORBIT TRAJECTORY AND ATTITUDE DATA

(To be published in October 1980)

☆ U.S GOVERNMENT PRINTING OFFICE: 1980—671-099/20 85