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Flight Feasibility Assessment of Shuttle/Landsat-D/Landsat-D′ Missions

Mission Planning and Analysis Division

August 1980

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
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SHUTTLE PROGRAM

FLIGHT FEASIBILITY ASSESSMENT OF SHUTTLE/LANDSAT-D/LANDSAT-D' MISSIONS

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FOREWORD

This document describes the orbital portion of a flight designed to deliver the Landsat-D' and then to retrieve the Landsat-D on the second flight from the western test range (WTR) as specified in the Space Transportation System (STS) flight manifest 13000-1-3D (updated February 14, 1980). This work was essentially completed upon receipt of the STS flight assignment working manifest (preliminary) 13000-2-33 (last update May 16, 1980, 1119), which shows the second flight from the WTR assigned to a Department of Defense (DOD) payload. This document remains applicable for any WTR flight (e.g., flight 4W) with the possible exception of the deorbit and landing data (this study is based on a Kennedy Space Center (KSC) landing).

ACKNOWLEDGMENT

The estimated maximum altitudes for the combined Landsat-D' delivery, Landsat-D retrieval missions, and the launch weight estimates and consumables summary were supplied by Gus Babb, Flight Planning Branch, Mission Planning and Analysis Division (MPAD). Any questions pertaining to these areas may be referred directly to him (phone 483-4401).

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1.0 INTRODUCTION

The STS flight assignment working manifest (preliminary) has scheduled the second Shuttle flight from WTR for June 29, 1984. The objective of this flight is to deploy the Landsat-D' and to retrieve the Landsat-D, previously placed in orbit by an expendable launch vehicle.[1] In addition to the payloads manifested for this flight, a Flight Support System (FSS) to house the Landsat-D' and Landsat-D when they are in the cargo bay is included.

Because of performance limitations, the Shuttle cannot rendezvous with the Landsat-D in its primary orbit; the actual rendezvous altitude is a function of the performance of the two Landsat vehicles and of the Shuttle. Presently, the weight quoted for the airborne support equipment (ASE) is 9000 pounds and that of the satellite itself is 4500 pounds. At the inception of this assessment, it appeared that the Orbiter would be able to retrieve the Landsat-D from a 210-n. mi. orbit for this heavy weignt ASE case using the OV-103. Further analyses indicated that the OV-103 could not achieve the 210-n. mi. retrieval altitude. Although the OV-103 could not retrieve the Landsat-D from this orbit, the orbital information already generated was valid and is published for information purposes.

Thus, this document presents a flight feasibility assessment from an orbital analysis point of view for retrieval of the Landsat-D from a 210-n. mi. orbit, following delivery of the Landsat-D' to a 200-n. mi. orbit. The profile associated with this assessment is not detailed in nature, and no in-depth analyses for trajectory, attitude, consumables (propulsive or nonpropulsive) or timeline data have been generated. The document does identify those parameters such as orbital altitude, phasing, and length of rendezvous, which affect flight design for this flight.

In addition to the analysis of delivery to a 200-n. mi. orbit and retrieval from a 210-n. mi. orbit, the results of a study made for delivery to a 235-n. mi. orbit followed by retrieval from 245 n. mi. are included in the appendix.

2.0 ACRONYMS AND SYMBOLS

AOA	abort once around
ASE	airborne support equipment
ATO	abort to orbit

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[1] The interface requirements definition document shows a requirement for deployment of the Landsat-D' by the STS, but at present does not impose a servicing, retrieval, or redelivery requirement on the STS. There is a requirement to retrieve the Landsat-D on the same orbital flight (retrieval does not impose a delivery, servicing, or redelivery requirement on the STS).

c.g.	center of gravity
delta-V	change in velocity (due to thrusting)
EST	eastern standard time
ET	external tank
fps	feet per second
FSS	flight support system
GET	ground elapsed time
GMT	Greenwich mean time
KSC	Kennedy Space Center
LSD	Landsat-D
LSD'	Landsat-D'
MCC	Mission Control Center
MECO	main engine cutoff
NAV	navigation
NC1	phasing maneuver
NCC	corrective combination maneuver
NH	height maneuver
NSR	coelliptic maneuver
OMS	orbital maneuvering system
OV	Orbiter vehicle
POCC	Payload Operations Control Center
PST	Pacific standard time
PSA	presleep (or postsleep) activities
RCS	reaction control system
RTLS	return-to-launch site
SRB	solid rocket booster

SSME	Space Shuttle main engine
STS	Space Transportation System
TDRSS	tracking and data relay satellite system
TPF	terminal phase finalization (braking)
TPI	terminal phase initiation
WTR	western test range

3.0 ASSUMPTIONS AND GROUNDRULES

The following assumptions and groundrules were used in generation of this flight feasibility assessment for delivery of Landsat-D' on the same flight as retrieval of the Landsat-D.

a. The Landsat-D' delivery weight is 4500 pounds; the Landsat-D retrieval weight is 3600 pounds.

b. The FSS, which must be carried in the payload bay for these two payloads, weighs 9000 pounds.

c. The Landsat-D and Landsat-D' operational orbits are 383 n. mi. circular altitude and 98.2° inclined with a constant descending node crossing at 9:30 a.m. local time.

d. The Landsat-D is a passive target for rendezvous purposes.

e. The Landsat-D attitude for retrieval will be fixed and the STS must be oriented with respect to the Landsat-D.

f. The Orbiter plume impingement shall not cause destabilization of the Landsat-D.

g. The Landsat-D will be confirmed ready for retrieval prior to launch and final approach from any stationkeeping point.

h. Landsat-D' is deployed in a 200-n. mi. orbit (10 n. mi. below Landsat-D) prior to retrieval of Landsat-D; retrieval is not attempted on the same crew workday.

i. NAV update/deploy time and attitude updates are required prior to deployment.

j. Following deployment of Landsat-D', control and monitor support from the Orbiter is required through onorbit checkout.

k. The Orbiter will provide power up to the time of deployment of Landsat-D' and from umbilical connection to powerdown before stowing for Landsat-D.

l. The Orbiter and the MCC provides real-time serial command and telemetry access between either the Landsat-D' and the Payload Operations Control Center (POCC) or between the Landsat-D and the POCC.

m. The OV-103 vehicle will be used.

n. The flight requires a three-man crew.

o. There will be no staggered crew work/rest periods.

p. A 109/109 percent SSME thrust capability is assumed.

q. Water and APU are fully loaded in the event an early return is required.

r. Two loaded cryo tank sets are included.

s. The reaction control system (RCS) tanks are fully loaded.

t. The integral orbital maneuvering system (OMS) tanks are loaded; one OMS kit is partially loaded.

u. Launch will be made from WTR with nominal landing occuring at KSC.

v. Abort once around (AOA) lands at WTR; abort to orbit (ATO) lands at Hawaii during the second revolution (rev).

w. There are no restrictions on north or south approaches to KSC.

x. A daylight landing is desirable but not mandatory.

y. The entry crossrange will be $\leq$ the operational crossrange capability.

z. Nominal deorbit opportunities will be planned so that an acceptable backup opportunity exists on the orbit to follow, if possible.

aa. The maximum dynamic pressure during ascent will be $\leq$ 650 psf.

bb. An in-plane, on-time launch is assumed; the duration of the window is dependent on excess performance, if any.

cc. A 2-day rendezvous is assumed in order to open phasing capability.

dd. The nominal phasing maneuver will be no less than 10 fps.

ee. First and second coelliptic altitudes are 10 and 5 n. mi., respectively.

ff. The flight duration is approximately 3 days.

gg. The OMS will not be budgeted for a payload separation maneuver.

hh. Payload installation into the Orbiter payload bay was not considered; the Orbiter launch/entry configuration is assumed to be compatible with the center of gravity (c.g.).

ii. Ballast requirements were not considered.

jj. The cargo entry weight is assumed to be 12 600 pounds.

4.0 MISSION DESCRIPTION

The Landsat-D will be transferred from its 383-n. mi., 98.2° inclined orbit (9:30 a.m. local time descending node crossing) to the 210-n. mi. retrieval orbit using its onboard propulsion system. The descent will be made with sufficient time (approximately 48 hours) for orbit verification prior to Shuttle lift-off.

The launch will be timed so that lift-off will occur in the plane of the Landsat-D (9:48 PST, June 29, 1984). Following insertion into a low-Earth parking orbit of 160 n. mi., the Orbiter performs a burn (NC1) to adjust the phasing between it and the Landsat-D. After a period of time in this phasing orbit, a maneuver (NH) is performed to raise apogee to an altitude approximately 10 n. mi. below the payload orbit; one-half rev later, the Orbiter achieves a coelliptic orbit with a 10-n. mi. differential altitude. During this coelliptic orbit (approximately 24 hours long), deployment of the Landsat-D' is completed, followed by an Orbiter separation burn and transfer of the Landsat-D to its operational orbit.

After the coast in the first coelliptic orbit, during which time onboard rendezvous navigation is performed, the Orbiter does a corrective combination maneuver (NCC) that makes phasing, height, and plane change adjustments if necessary. This maneuver is followed by a second coelliptic burn that places the Orbiter 5 n. mi. below the Landsat-D orbit. Further onboard navigation is accomplished during this coelliptic orbit. The Orbiter then performs the terminal phase initiation (TPI) maneuver to establish an intercept with the target. Finally, the Orbiter begins a series of braking maneuvers (TPF) to null the relative velocity between the two, prior to stationkeeping and rendezvous.

Upon completion of the retrieval of the Landsat-D and a crew rest period, a descending deorbit to and landing at KSC (9:48 a.m. EST) is accomplished 69 hours after lift-off.

5.0 ORBITAL ANALYSIS

5.1 NODAL TIME REQUIREMENT

To set the node at a certain local Sun time is a common requirement for Sun-synchronous satellites. For example, an early STS WTR launch will deploy a TIROS satellite requiring either a 0730 descending node or a 1430 ascending node. Landsat requires a descending node time of 0930 local. Once this nodal time is set (and the satellite remains at the proper altitude), it will remain constant for each rev. This Sun-synchronous condition is achieved by placing a satellite in a retrograde orbit where inclination and altitude are dependent variables chosen so that nodal precession will approximately equal the Earth's angular rate about the Sun (0.986 deg/day). Figure 1 illustrates these relationships for retrograde satellites. The dotted line in this figure indicates the desired nodal precession for Sun-synchronous orbits. A Landsat inclination of 98.2° at an altitude of 383 n. mi. will produce this precession. TIROS achieves the same rate with 98.7° inclination and an altitude of 450 n. mi.

The current mission profile for the Lands -D replacement flight requires that special consideration be made for maintaining the correct nodal time. As seen in figure 1, when Landsat-D leaves its operational altitude, descending to a lower altitude for retrieval, the node will no longer precess at 0.983 deg/day. Instead, if it descends to 210 n. mi., the node will precess at 1.155 deg/day. The replacement satellite will initially be deployed at a 200-n. mi. altitude, with a nodal precession of 1.166 deg/day. In all, while 3 days transpire from Landsat-D, leaving a 383-n. mi. altitude to the replacement (Landsat-D') arriving at that altitude, a nodal crossing error of about 0.6° will accumulate. To compensate for this error, it is recommended that Landsat-D accomplish a 0.6° node shift in conjunction with the maneuver to descend from 383 to 210 n. mi. This will relieve the burden from the Shuttle and/or from Landsat-D', both of which have a much more restrictive propellant budget.

5.2 LANDSAT-D/LANDSAT-D' ALTITUDE FOR PLACEMENT/RETRIEVAL

Assuming the OV-103 will be used for this delivery/retrieval mission with a cargo weight of 13 500 pounds, the Orbiter should be able to deliver the Landsat-D' to a 200-n. mi. circular orbit while retrieving the Landsat-D from a 210-n. mi. circular orbit (ref. 1). For a lighter cargo weight of 10 000 pounds (ASE weight reduced by 3500 pounds), the delivery can be made at an altitude of 235 n. mi. with retrieval at an altitude of 245 n. mi. To accomplish the combined delivery/retrieval mission, the Landsat-D will lower its orbit (using its internal propulsion system) to one achievable by the Shuttle.

5.3 LAUNCH WINDOW CONSIDERATIONS

The nodal time requirement discussed earlier is common for WTR payloads and, if present, is the driving launch window consideration. It establishes an orbital plane that must be targeted, allowing only one opportunity per day for a southerly launch (range safety precludes a northerly launch). In addition, the window at this opportunity is relatively small.

Figure 2 shows some results of ascent simulations for a 98.2° inclination launch. Launch azimuth is approximately 190°. The best weight to orbit is achieved by launching 5.5 minutes prior to the theoretical in-plane time. Launching at a time other than this requires yaw steering to intercept the plane, and performance degrades much more quickly than for an ETR launch. For instance, launching 3 minutes after the "optimum" time results in a performance loss of about 1500 pounds. A 5-minute delay would reduce capability by over 3500 pounds.

Launch phasing will be discussed in section 6.0. At this point, it should be noted that for missions such as the Landsat retrieval, the payload manuever to decrease altitude to that of the Shuttle can be timed prior to Shuttle launch to ensure proper phase angle.

5.4 RENDEZVOUS CONSIDERATIONS

5.4.1 Two-Day Timeline

A 2-day rendezvous plan will be employed to ensure that delivery and retrieval can be accomplished without drastically affecting normal crew work/rest cycles. The 2-day rendezvous plan allows for a major rest period after the parking and phasing maneuvers and before the maneuvers (height and first coelliptic) necessary to get to an orbit of 10 n. mi. below the Landsat-D. The Landsat-D' deployment and the Orbiter separation maneuver are accomplished prior to the second major crew rest period. Additionally, the two burns to place Landsat-D' in its desired orbit are performed prior to the second crew rest period (no major crew participation for these two burns was anticipated). Following the second rest period, the corrective combination burn, a second coelliptic maneuver, the TPI maneuver, and the braking burns are performed. The Orbiter retrieves the Landsat-D during the 5-hour period prior to the third major crew rest period. This rest period is followed by deorbit preparation and deorbit and landing. Figure 3 presents a graphic of this rendezvous timeline for the 210-n. mi. rendezvous case while table I gives times and delta-V's for the various burns simulated in the assessment. Table II contains the launch weight estimates for this flight. A summary of consumables loading and usage is provided in table III. Tables II and III were generated based on a 57-n. mi. main engine cutoff (MECO) altitude.

The 2-day rendezvous sequence is also beneficial in that it increases the range of the acceptable phase angles between the target and the Orbiter at the time of the phasing maneuver. The range of allowable phase angles can further be extended by having the capability for the height maneuver either early (one-half rev after the phasing maneuver) or late (one-half rev multiples after the phasing burn).

5.4.2 Reduction In Coelliptic Delta-H

The 2-day rendezvous plan is basically the same as the standard Space Shuttle rendezvous sequence. One change was to reduce the first coelliptic maneuver altitude from 20 to 10 n. mi. and to reduce the second coelliptic maneuver from 10 to 5 n. mi. This change was necessitated by the fact that the former delta-H orbits result in onboard optical tracking of the target vehicle at ranges of up to 300 n. mi. prior to the corrective combination maneuver. Although no specific numbers were available, it is believed that the reflectance of the Landsat-D is such that optical tracking will be impossible for ranges near 200 to 300 n. mi. Since the Landsat-D is a passive target in that it carries no transponder, the rendezvous radar is of no use until post-TPI when ranges get below 10 n. mi. Modification of the coelliptic maneuvers from 10 to 5 n. mi. reduces the target range so that optical tracking can be accomplished.

5.4.3 Nominal NC Phase Maneuver

For the closing of the insertion phase angle window, the phasing maneuver delta-V should be zero for the ideal case. However, for this rendezvous sequence, there is a payload separation maneuver between the first coelliptic and corrective combination maneuvers which, if not accounted for by the phasing maneuver, will adversely effect the remaining maneuvers. In addition to the delta-V required to account for phasing correction due to the separation burn, some delta-V at NC1 must be alloted for possible dispersion errors at insertion, since circularization of the orbit prior to the phasing maneuver is accomplished by a preflight-targeted circularization burn at a prespecified time. The maneuver will not be retargeted to compensate for these errors in the postinsertion orbit. Therefore, for this rendezvous sequence, an NC1 maneuver of 10 to 15 fps was performed to account for possible insertion dispersions that may occur.

6.0 SUMMARY

Delivery of the Landsat-D' and retrieval of the Landsat-D on the same Shuttle flight appear feasible if the cargo weight (ASE specifically) can be reduced such that the Orbiter can achieve the orbit of the Landsat-D after its orbit is lowered from the operational orbit. This assessment indicates that even with use of a 57-n. mi. MECO to gain performance, a negative margin exists (1818 pounds) when the 9000 cradle is placed in the OV-103 cargo bay and the Shuttle attempts to deliver the Landsat-D' to a 200-n. mi. orbit and retrieve the Landsat-D from a 210-n. mi. orbit. Thus, for this assessment the RCS/OMS loading is critical because of the MECO weight limit.

The Landsat-D should be brought down at such a time as to provide a compatible phasing situation between it and the Orbiter at insertion. This is approximately 48 hours prior to lift-off for the Landsat-D retrieval altitude of 210 n. mi. In addition to lowering the Landsat-D orbit to an orbit achievable by the Orbiter, it is necessary for the Landsat-D to also make the plane change required to account for the difference in orbit precession rate between the two altitudes (0.3° plane change during each of the Landsat-D burns is adequate). This assumes that Landsat-D' must attain the same 9:30 a.m. local time node for its operational orbit.

Star tracker acquisition necessary for navigation updates prior to the corrective combination maneuver is not probable at 250 n. mi., considering Landsat-D reflectance. Therefore, the differential altitudes at the first and second coelliptic maneuvers were reduced from 20 and 10 n. mi. to 10 and 5 n. mi., respectively, to reduce the tracking range.

A 3-day flight duration results in a descending orbit (rev 46) near the eastern coast of the United States for a return from a 210-n. mi. orbit to KSC. An ascending pass to KSC occurs 12 hours later but could cause crew work/rest scheduling problems. If the payload and Orbiter can be returned to Vandenberg Air Force Base (VAFB), there are two possible descending deorbits - revs 48 and 49.

The Landsat-D' checkout requirements through the Orbiter were unknown. For this assessment, 1 hour between the separation maneuver and the first Landsat-D' burn was assumed. If longer checkout is required in a stationkeeping mode, up to 6 hours could be accommodated before interfering with the crew rest period. However, the RCS budget for such a checkout could be critical depending on stationkeeping and attitude requirements. No stationkeeping analysis has been performed.

7.0 REFERENCE

1. Berry, R. L.: Estimated Maximum Altitudes For the Combined Landsat D Delivery, Landsat D Retrieval Mission. JSC Memorandum FM22(80-31), Feb. 19, 1980.

TABLE I.- STS-2W BASIC SEQUENCE OF EVENTS FOR THE 210-N. MI. RETRIEVAL ORBIT

Event	MET (DD:HH·MM:SS)	Comments
Landsat-D lower perigee (with 0.3° plane change)	-2:01:18:30	ΔV = 309 fps
Circular orbit at 210 n. mi. (with 0.3° plane change)	-1:22:55:10	ΔV = 313 fps
Lift-off	0:00:00:00	GMT lift-off = 1748, 6/29/84
OMS-1	0:00:09:58	ΔV = 520 fps
OMS-2	0:00:47:31	ΔV = 186 fps
Open PLBD's	0:01:00:00	
NC1 (phasing)	0:03:11:41	ΔV = 13 fps
Begin crew rest	0:09:00:00	
End crew rest	0:20:30:00	
NH (height)	0:21:53:20	ΔV = 69 fps
NSR1 (coelliptic)	0:22:49:17	ΔV = 62 fps
Deploy Landsat-D' and perform Orbiter separation maneuver	1:01:49:17	ΔV = 3 (RCS)
Landsat-D' first maneuver	1:02:48:28	Destination is 383 n. mi. circular altitude at 9:30 a.m. local descending node
Begin crew rest	1:08:00:00	
End crew rest	1:19:30:00	
NCC (corrective combination)	1:22:22:13	ΔV = 12
NSR2 (coelliptic)	1:22:59:13	ΔV = 21
TPI (intercept)	1:23:52:36	ΔV = 11
Braking/begin proximity ops	2:00:25:58	RCS maneuvers

TABLE I.- Concluded

Event	MET (DD:HH:MM:SS)	Comments
Retrieve Landsat	2:02:30:00	
Begin crew rest	2:06:00:00	
End crew rest	2:16:00:00	
Close PLBD's	2:18:30:00	
Deorbit from 210 n. mi.	2:19:58:44	$\Delta V = 377$
Landing (orbit 46)	2:21:00:00	Descending to KSC

TABLE II.- LAUNCH WEIGHT ESTIMATES

Item	Weight	Comments
Reference weight nominal MECO 109 percent, 3g/109 percent, 3σ performance enhancements	312 300	
SSME throttle settings 109/109 . . .	--	
Change in inclination to 98.2° . . .	--	
ET block II inert	-70 990	
EPS tank set #3	--	
Orbiter vehicle 103 inert (2 EPS) . .	-141 922	With RMS
Manifest changes	--	
SSME x 3	20 484	
Nonpropulsive comsumables (2 EPS) . .	4 857	Water for ATO to Hawaii included
STS weight charged to operator . . .	1 457	
Personnel (3M/3D)	2 195	
Unusuable fluids (MPS)	9 043	
MPS FPR (Nominal 3σ)	5 551	
OMS propellant	29 300	
RCS propellant (aft)	5 355	
RCS propellant (fwd)	2 464	
Nominal ET margin required	0	
Variable Iy (i > 30°)	0	
OMS kit inertial	-4 000	
Capability	14 682	
STS reserve	3 000	

TABLE II.- Concluded

Item	Weight	Comments
Payload requirement (composite payload)	13 500	High Landsat cradle weight of 9000 lb assumed
Margin	-1 818	

TABLE III.- STS-2W CONSUMABLES SUMMARY

Propulsive consumables	OMS	Forward RCS	Aft RCS
Total loaded	29 300	Full	Full
Total trapped	1 117	--	--
Total dispersions and contingencies	975	--	--
Nominal required	27 200	TBD	TBD
Margin	8	TBD	TBD

Nonpropulsive consumables (hydrogen budget)	LBM	Tank sets
Flight-independent requirements	--	--
Flight-dependent requirements	--	--
Total mission requirements	TBD	TBD
Total loaded	TBD	2
Margin	TBD	TBD

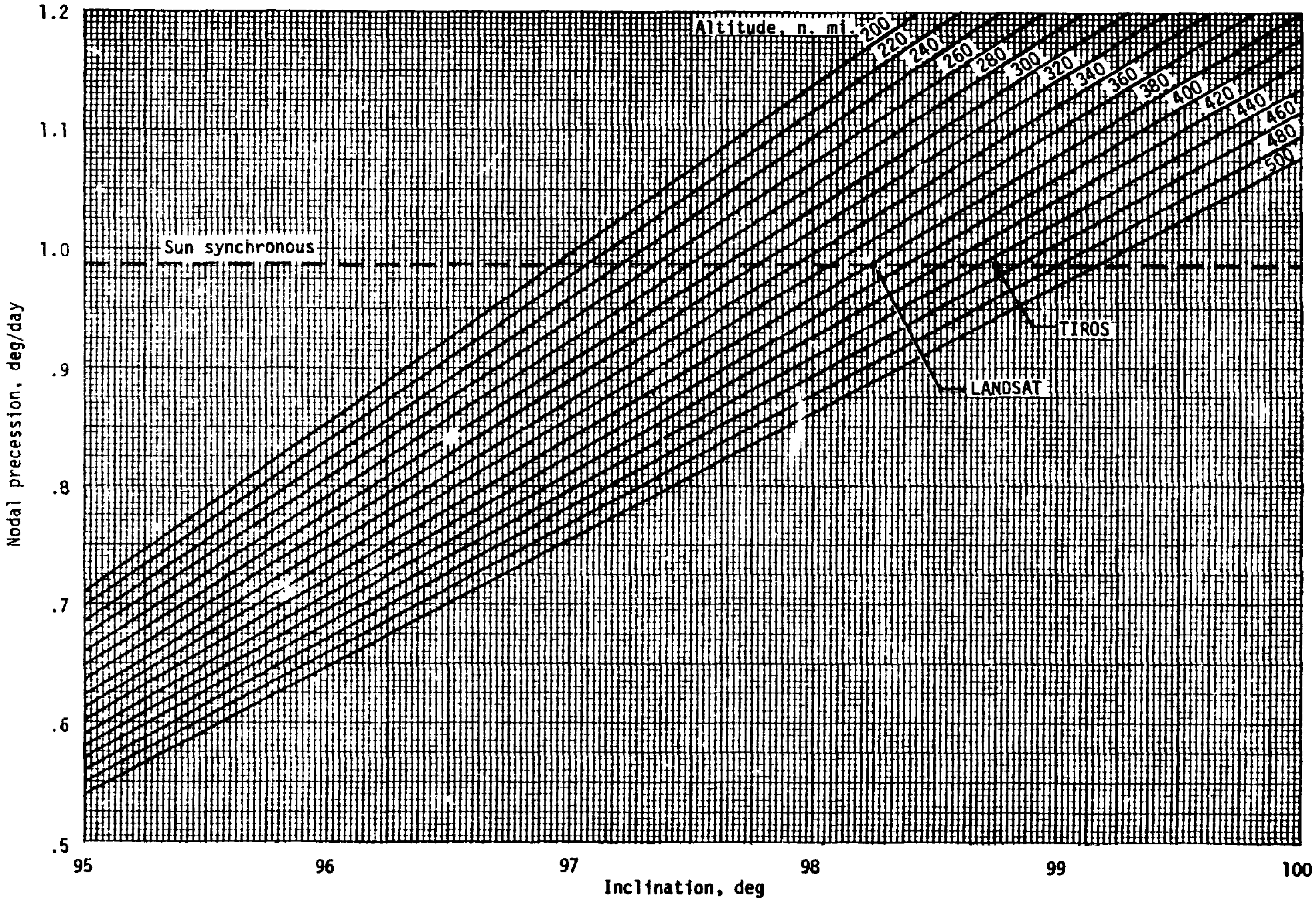


Figure 1.- Nodal precession for circular retrograde orbits.

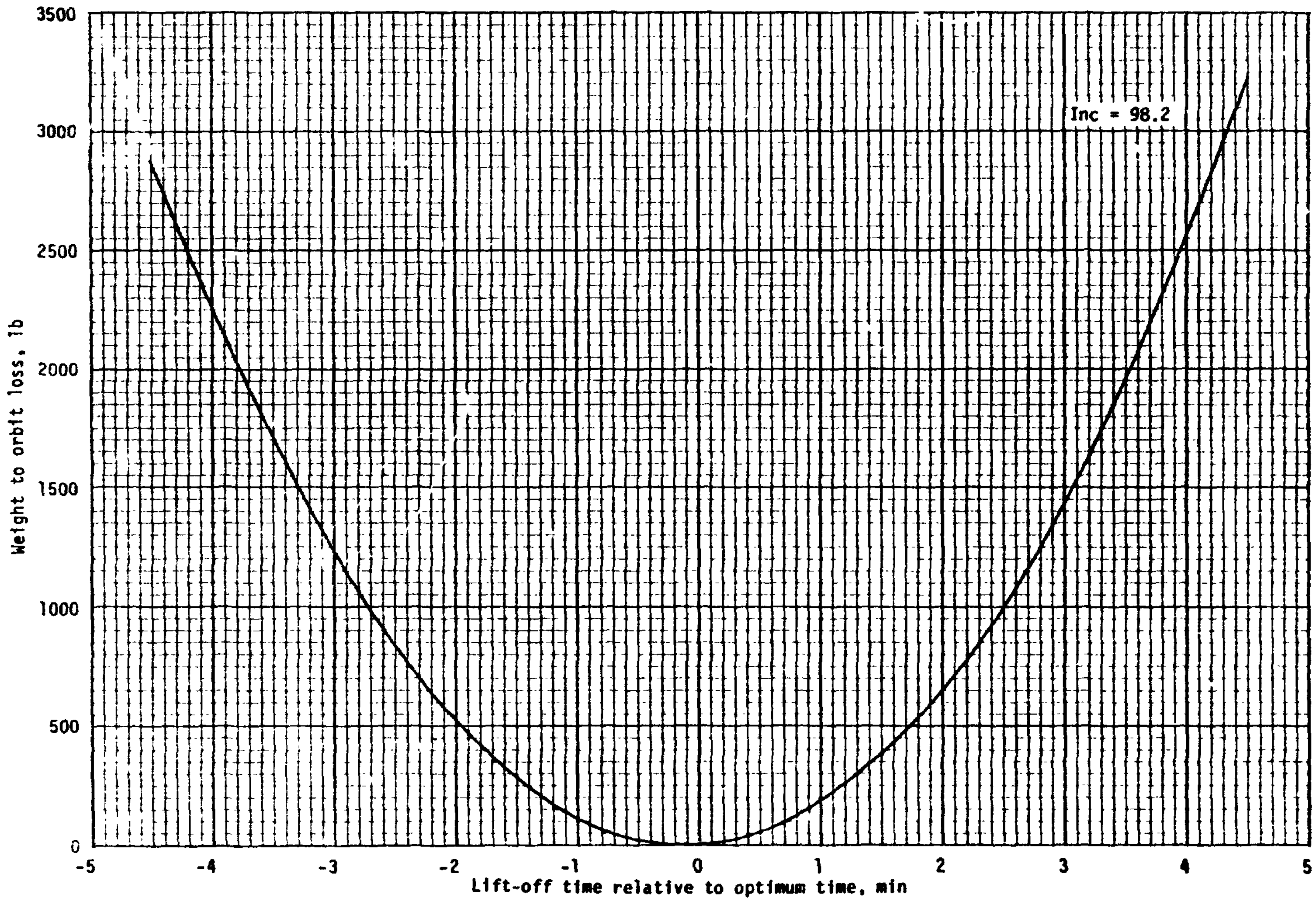


Figure 2.- Weight-to-orbit loss for 98.2° inclination.

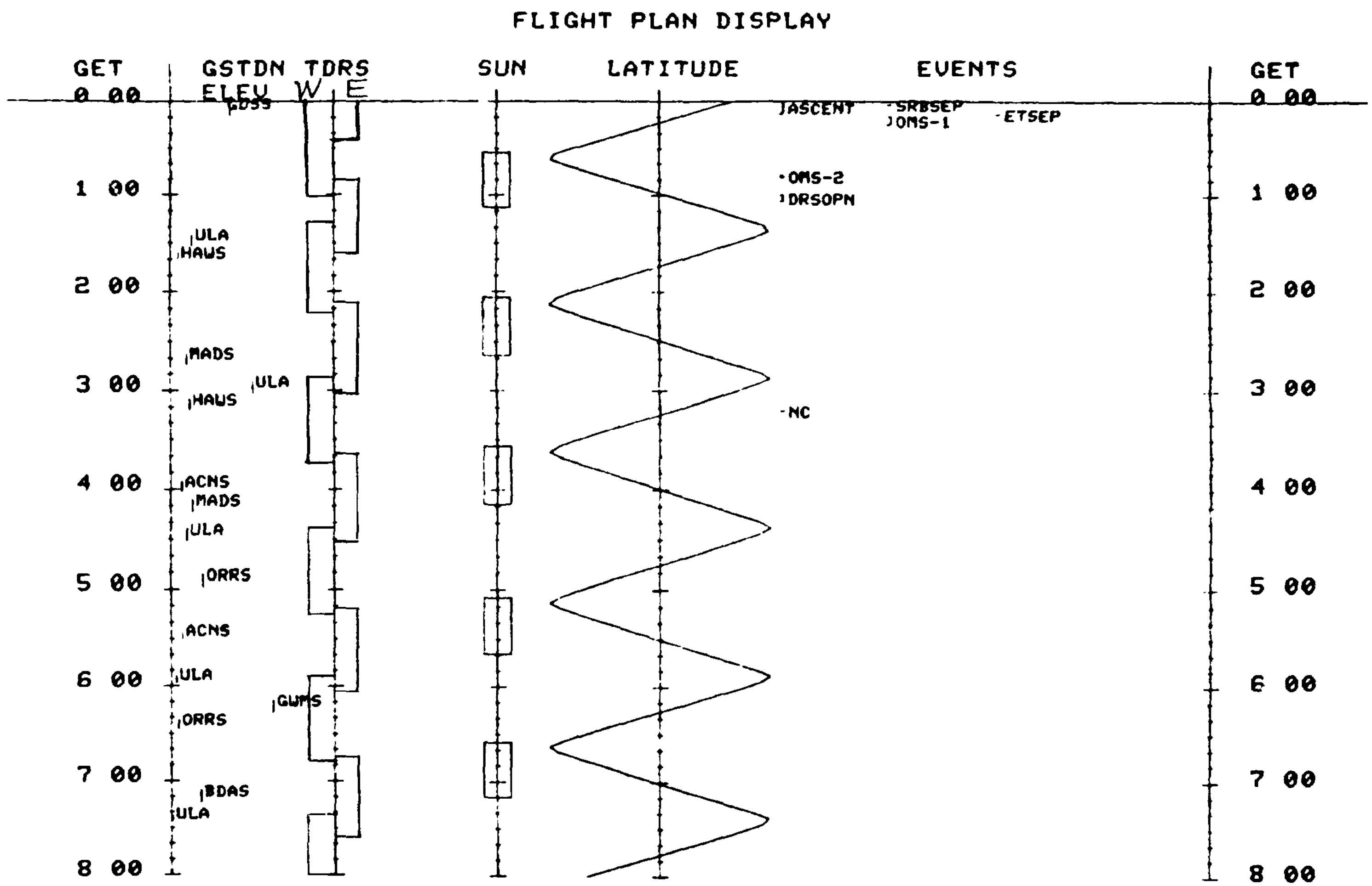
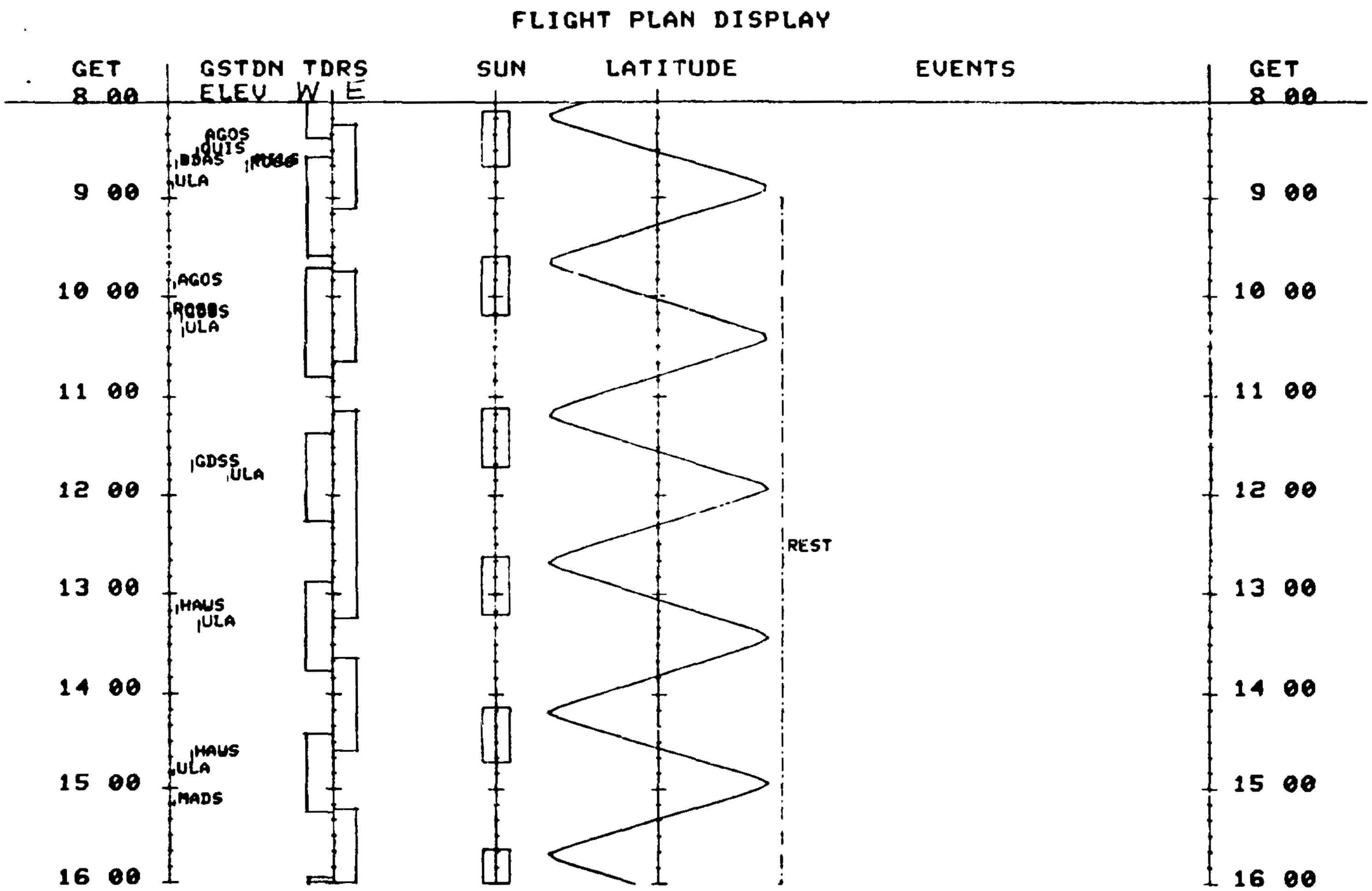


Figure 3.- Flight plan display for the Landsat-D 210-n. mi. retrieval case.



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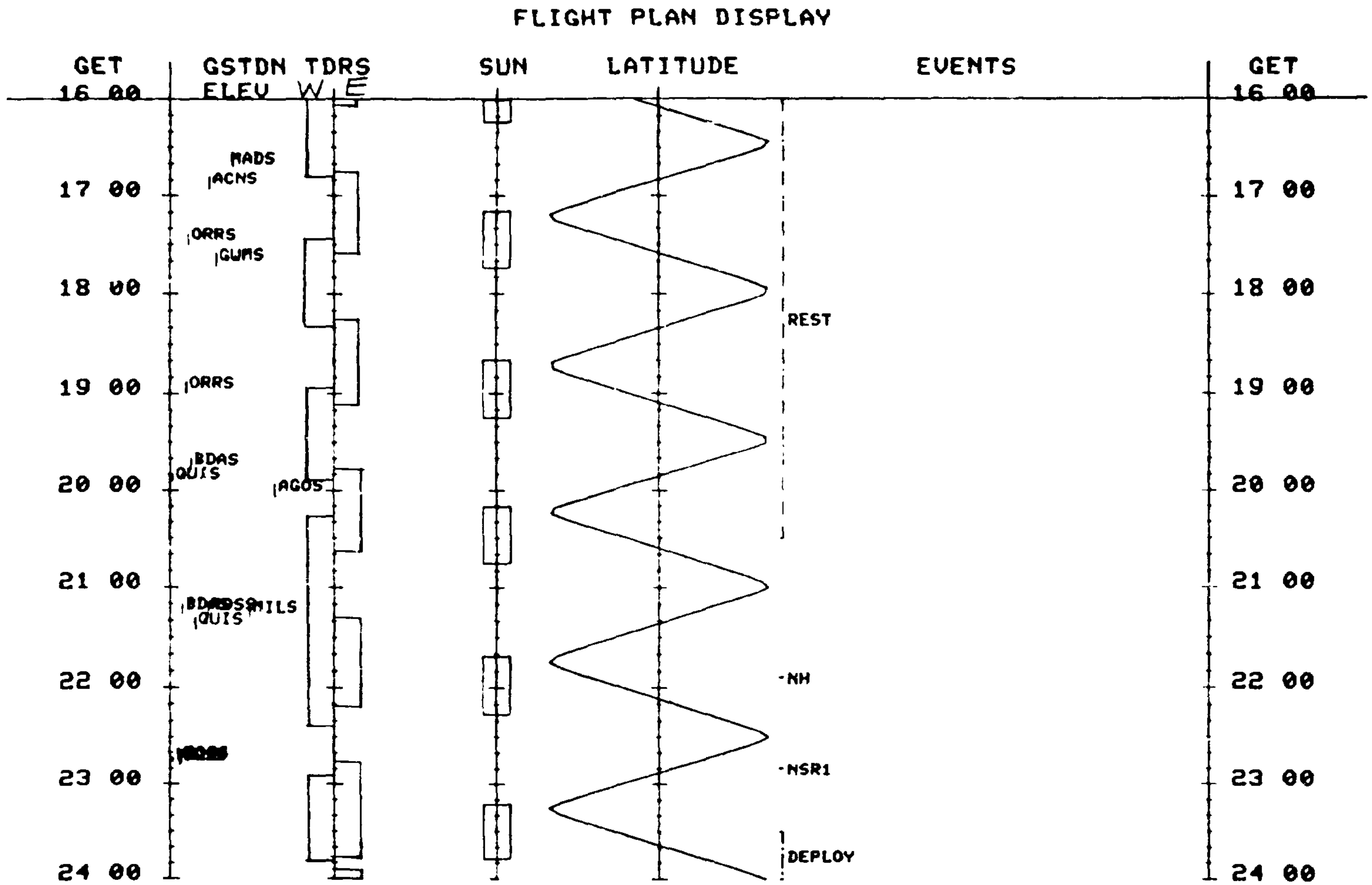

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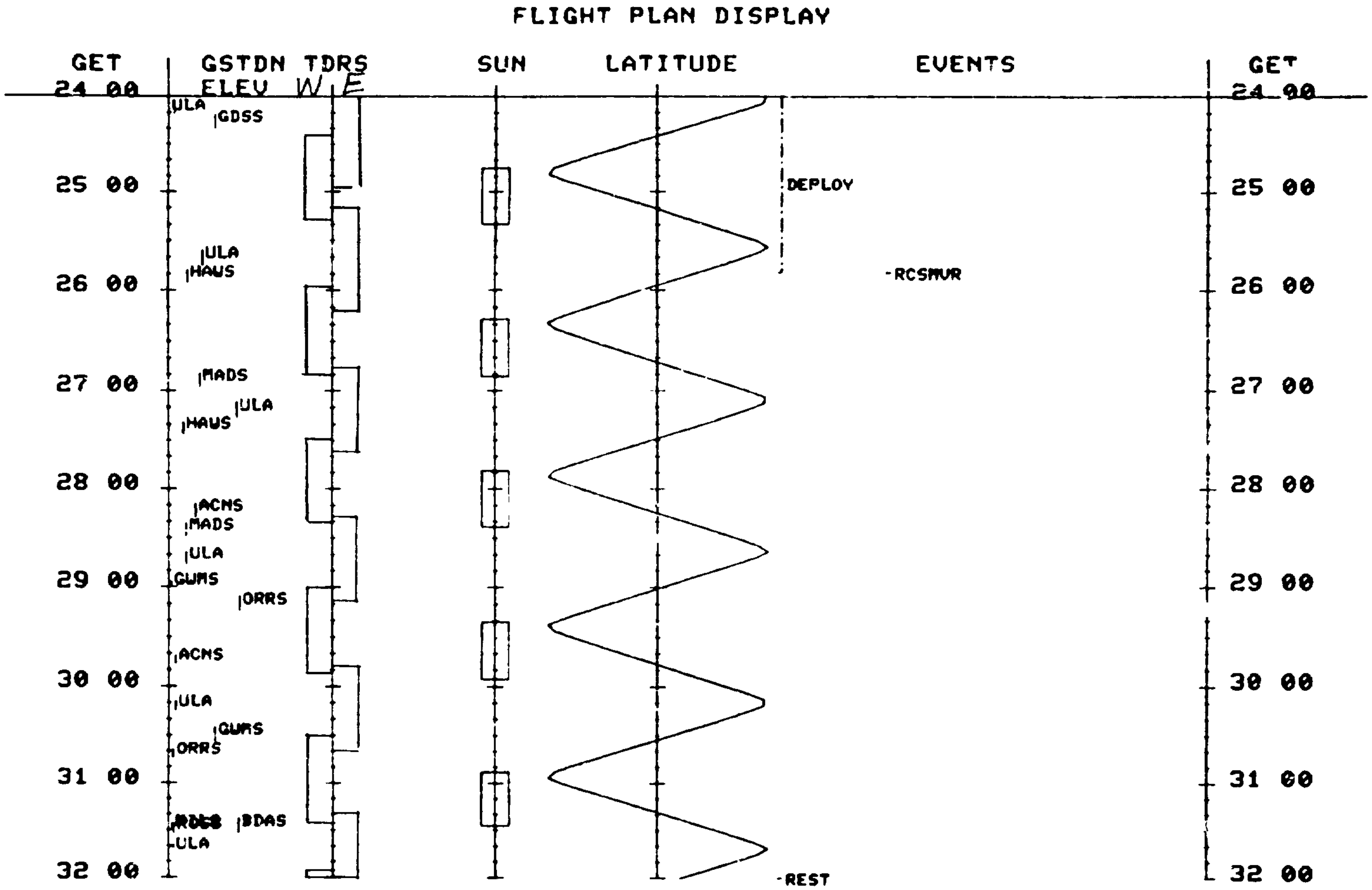

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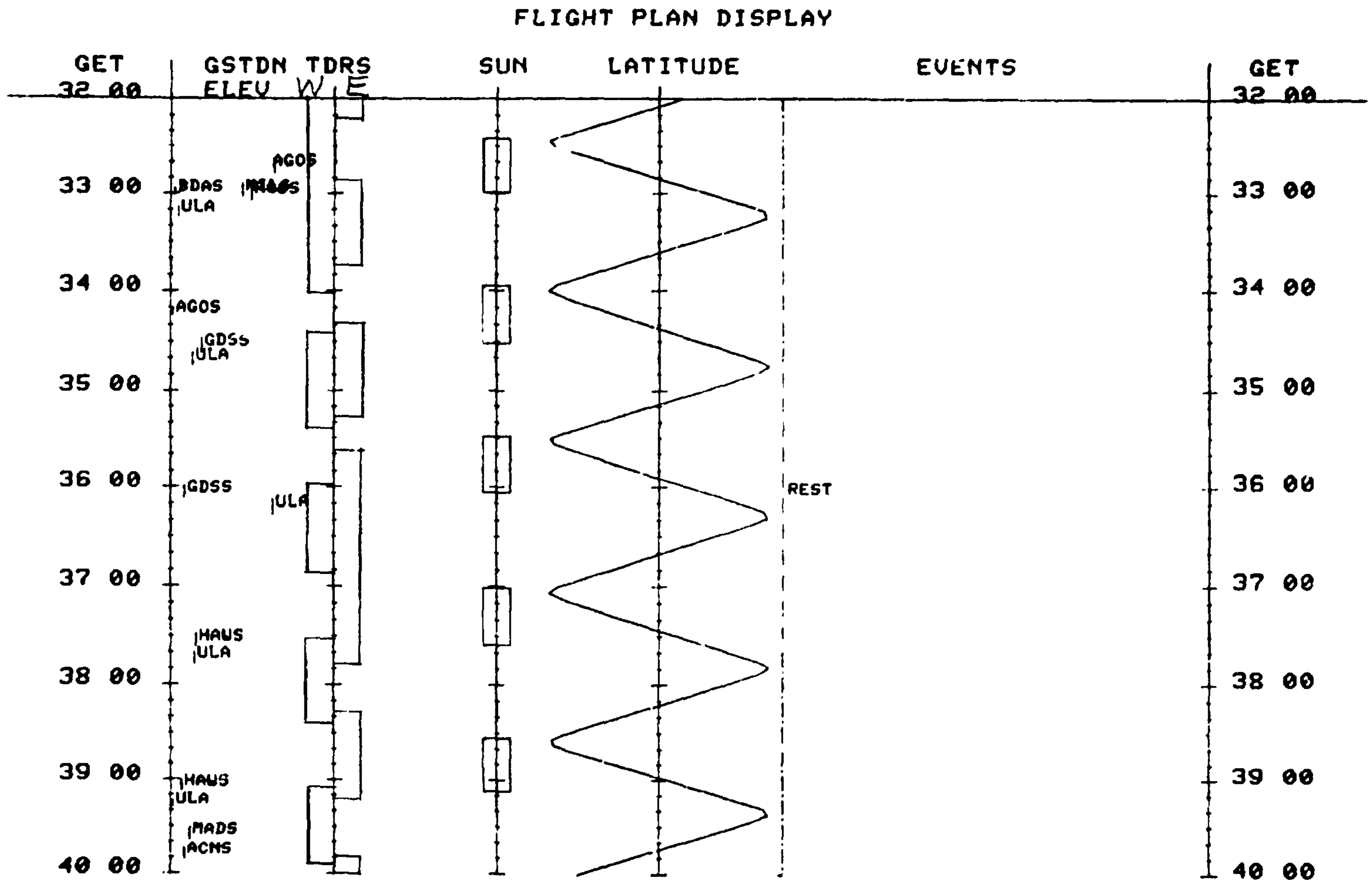

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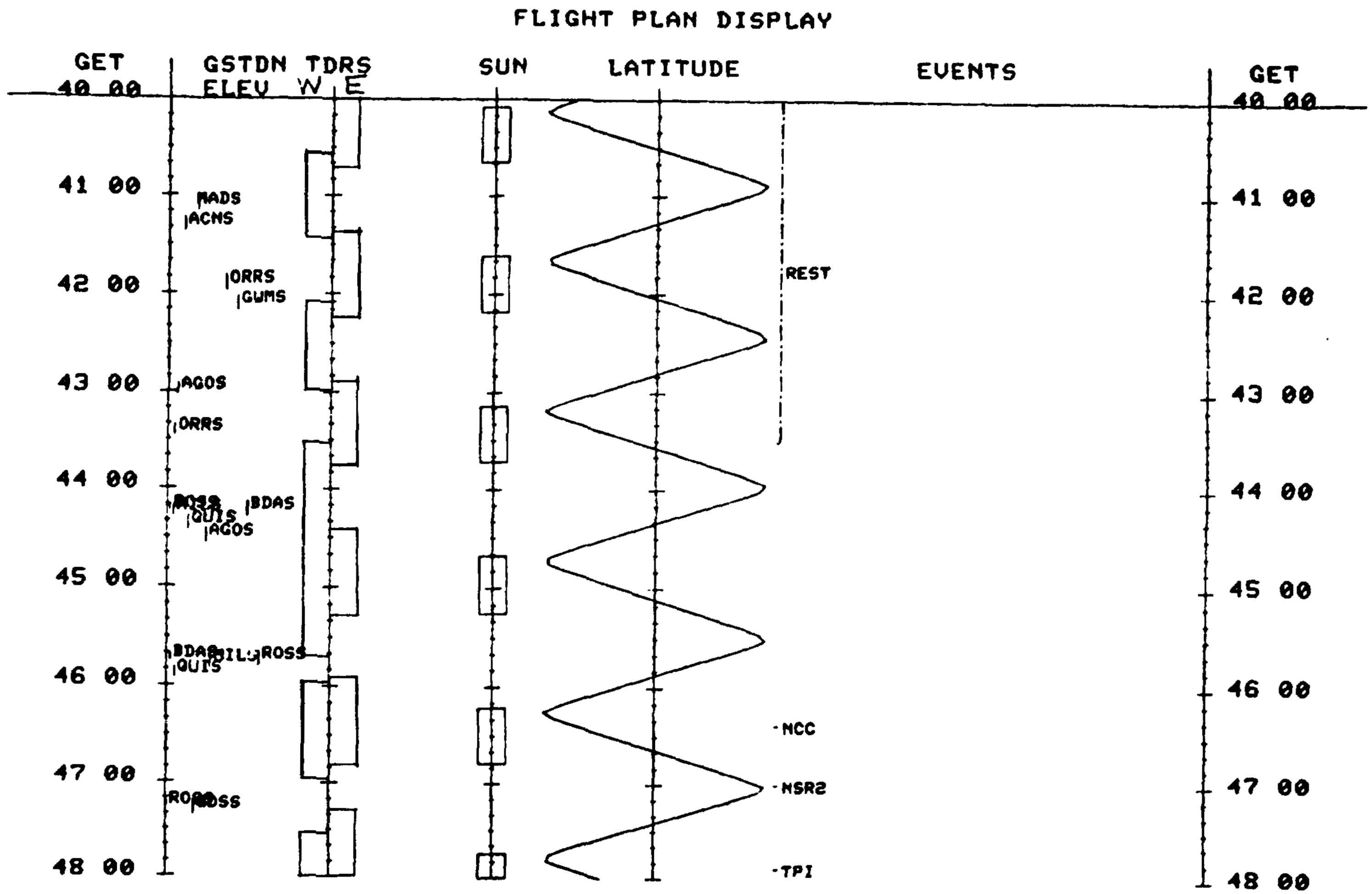

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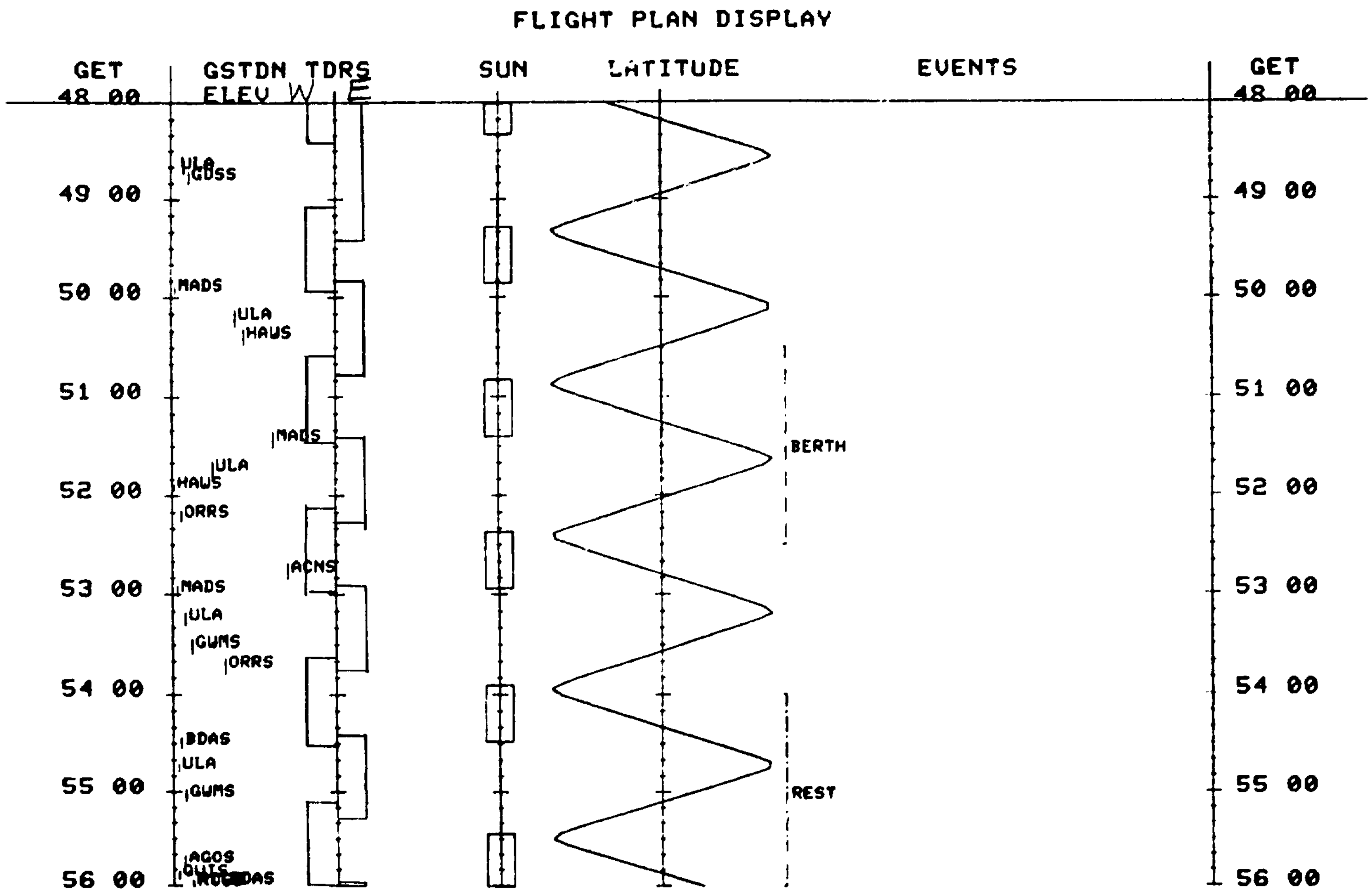

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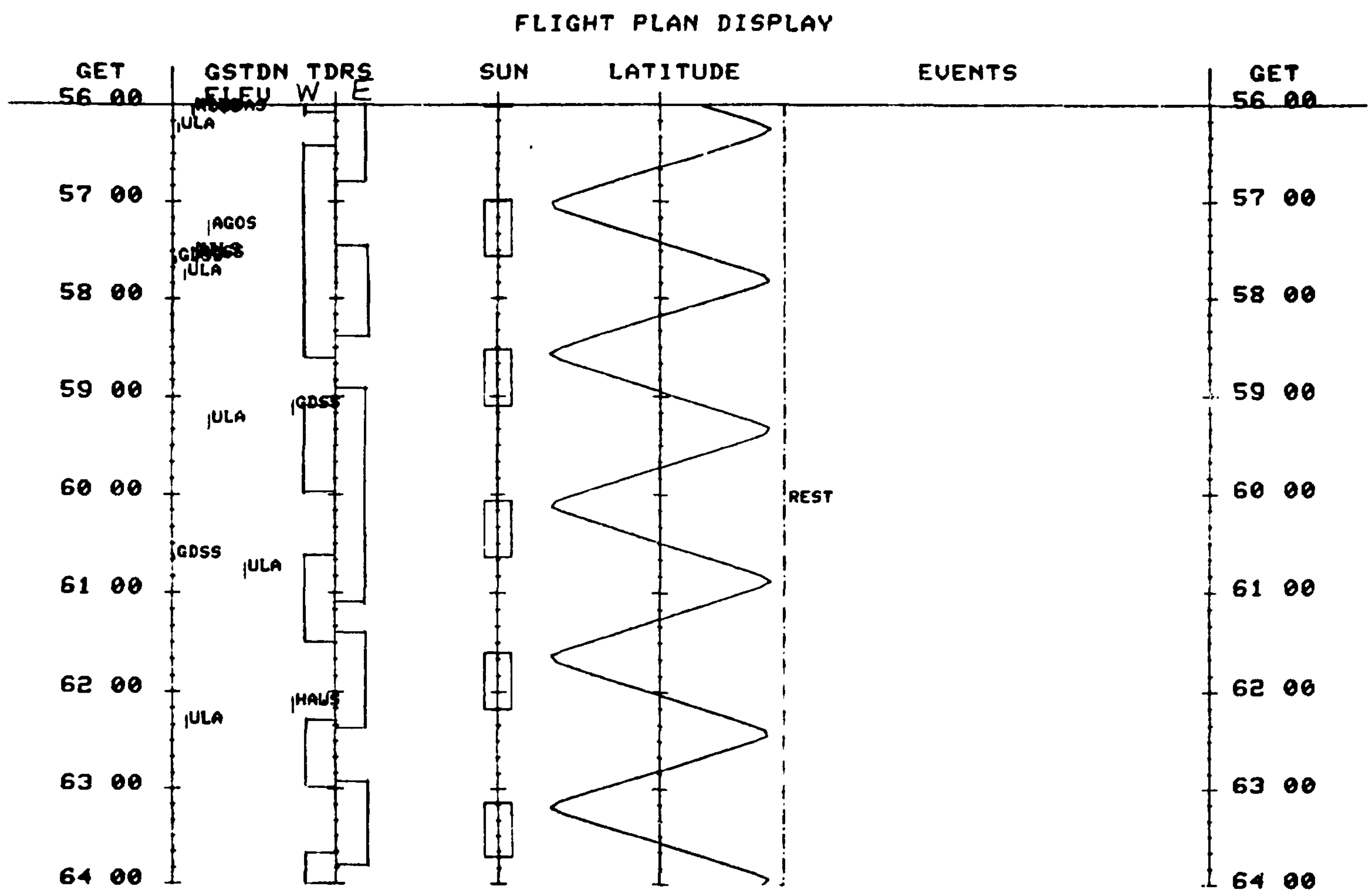

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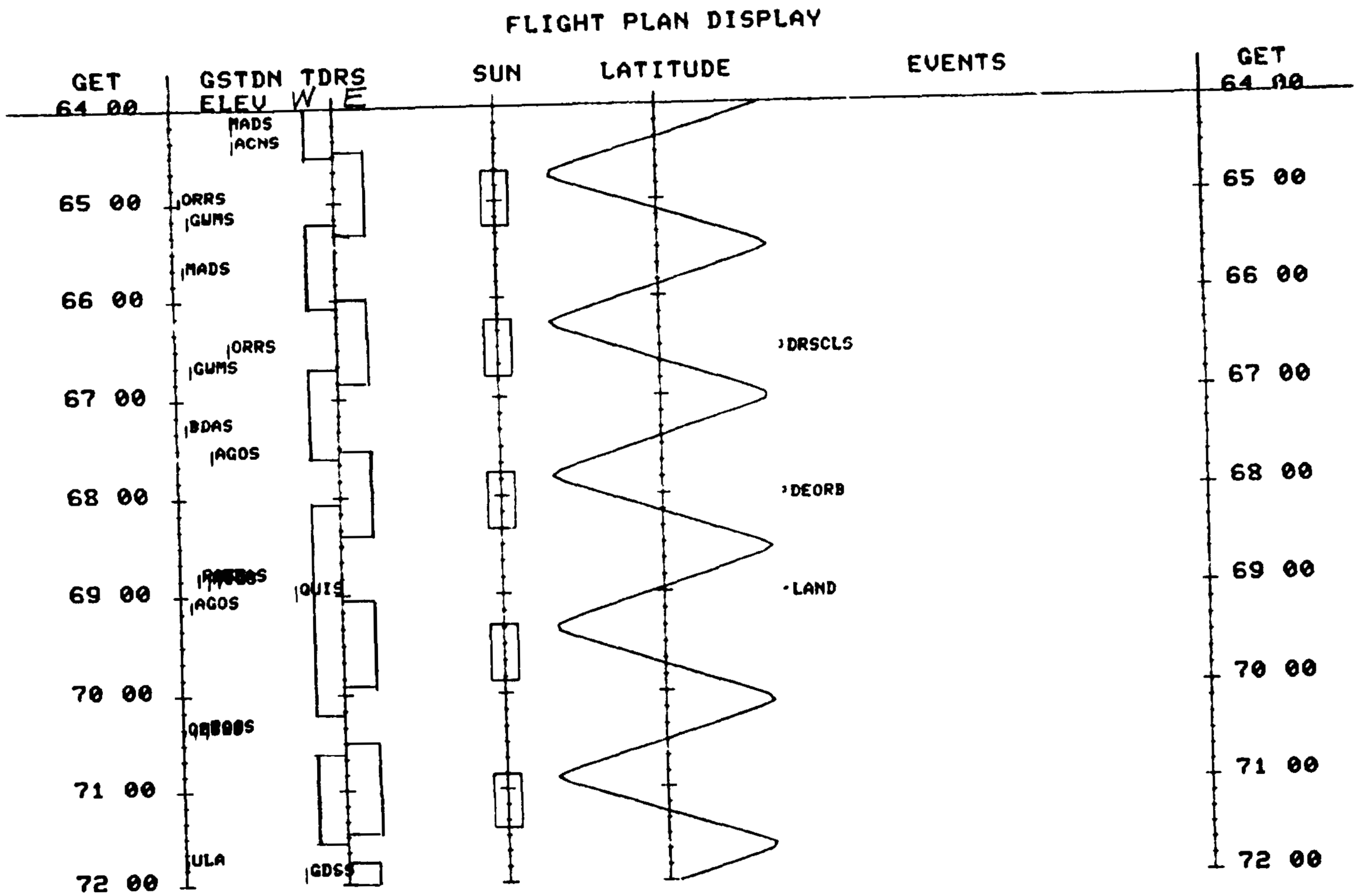

Figure 3.- Concluded.

APPENDIX

DELIVERY TO 235-N. MI. ORBIT/RETRIEVAL FROM A 245-N. MI. ORBIT

This appendix contains an assessment of the Landsat-D' delivery and Landsat-D retrieval for a reduced payload weight that would allow the Orbiter to attain a higher delivery/retrieval altitude. The assessment was based on the following groundrules and assumptions:

a. The FSS weighs 5500 pounds.

b. The Landsat-D' is deployed in a 235-n. mi. orbit; the Landsat is retrieved from a 245-n. mi. orbit.

c. There is a requirement for a deorbit backup opportunity.

d. The cargo entry weight is 9100 pounds.

e. All other groundrules and assumptions are the same as those defined for the 210-n. mi. retrieval assessment.

The profile for this assessment is similar to that for the 210-n. mi. retrieval case. At approximately 40 hours prior to lift-off, the Landsat-D performs maneuvers necessary to lower its orbit to a 245-n. mi. circular orbit and to make plane changes required to account for the difference in orbit precession rate between the two orbits (a 0.25° plane change during each burn as compared to the 0.3° needed for the 210-n. mi. case).

The timeline for this assessment is very similar to tnat for the 210-n. mi. retrieval assessment. Table A-1 and figure A-1 present data describing this timeline.

The only other major difference noted between the two assessments is that for the 245-n. mi. retrieval case, there is no backup deorbit opportunity following the nominal deorbit (rev 46 descending) to KSC. Revs 53 and 54 provide two consecutive ascending deorbit opportunities to KSC but would require a change in the crew work/rest scheduling. Two consecutive deorbit opportunities to VAFB (revs 47 and 48 descending) exist if there is no objection to returning the Orbiter and payload to VAFB.

TABLE A-1.- STS-2W BASIC SEQUENCE OF EVENTS FOR THE 245-N. MI. RETRIEVAL ORBIT

Event	MET (DD:HH:MM:SS)	Comments
Landsat-D lowers perigee (with 0.25° plane change)	-1:15:25:07	ΔV = 247 fps
Circular orbit at 245 (with 0.25° plane change)	-1:13:00:47	ΔV = 249 fps
Lift-off	0:00:00:00	GMT lift-off = 1748, 6/29/84
OMS-1	0:00:09:58	ΔV = 520 fps
OMS-2	0:00:47:31	ΔV = 186 fps
Open PLBD's	0:01:00:00	
NC1 (phasing)	0:03:02:02	ΔV = 15 fps
Begin crew rest	0:09:00:00	
End crew rest	0:20:30:00	
NH (height)	0:21:50:01	ΔV = 150 fps
NSR1 (coelliptic)	0:22:35:56	ΔV = 146 fps
Deploy Landsat-D' and perform Orbiter separation maneuver	01:01:35:56	ΔV = 3 fps (RCS)
Landsat-D' first maneuver	01:02:35:56	Destination is 383 n. mi. circular 9:30 a.m. local descending node
Begin crew rest	01:08:00:00	
End crew rest	01:19:30:00	
NCC (corrective combination)	01:22:42:08	ΔV = 11 fps
NSR2 (coelliptic)	01:23:19:08	ΔV = 19 fps
TPI (intercept)	02:00:14:01	ΔV = 11 fps
Braking/begin Proximity OPS	02:00:47:53	RCS maneuvers
Retrieve Landsat	02:02:45:00	

TABLE A-I.- Concluded

Event	MET (DD:HH:MM:SS)	Comments
Begin crew rest	2:06:00:00	
End crew rest	2:16:00:00	
Close PLBD's	2:18:30:00	
Deorbit from 245 n. mi.	2:20:34:14	ΔV = 428 fps
Landing (orbit 46)	2:21:39:00	Descending to KSC

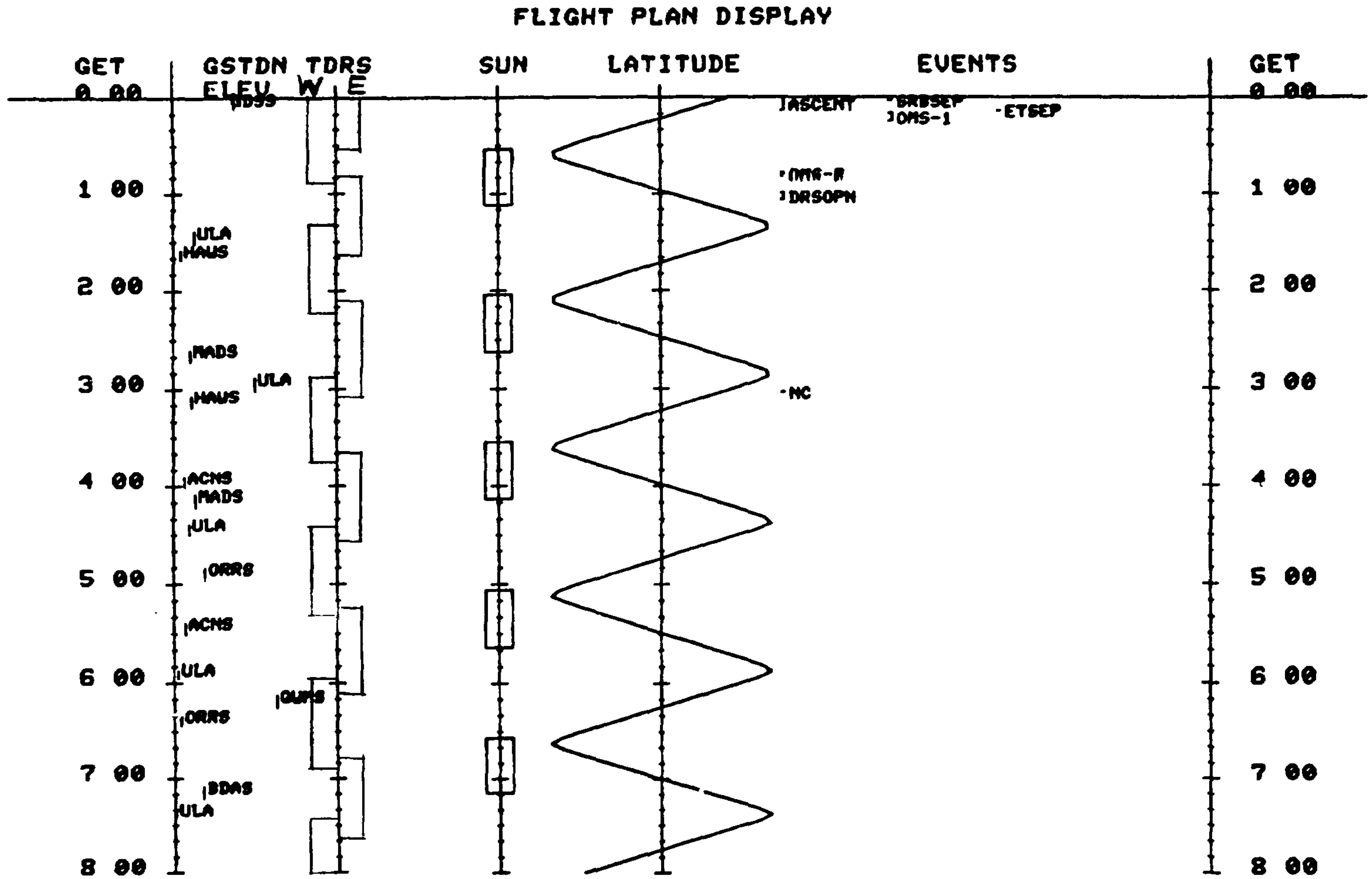

Figure A-1.- Flight plan display for the Landsat D 245-n. mi. retrieval case.

FLIGHT PLAN DISPLAY

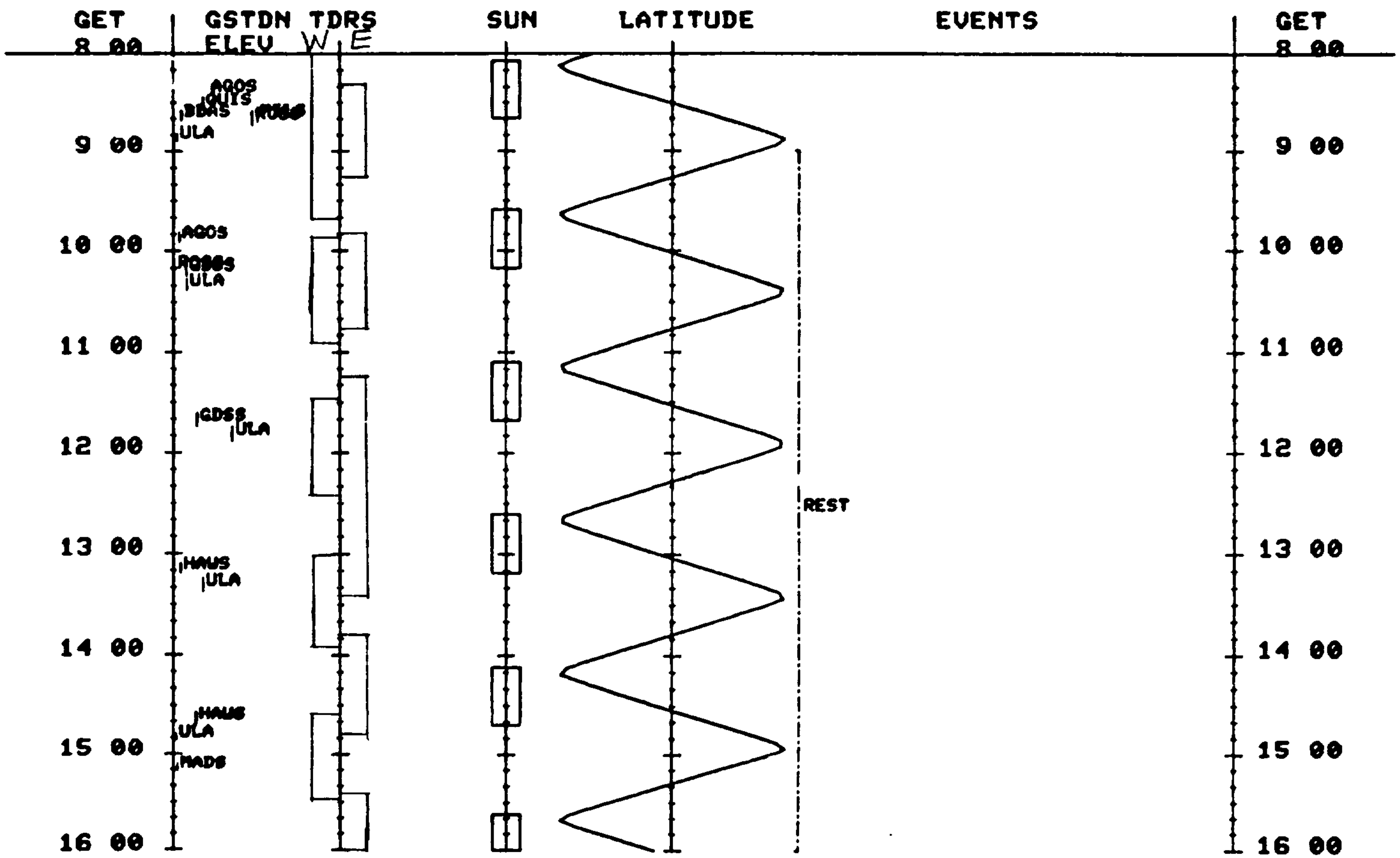

Figure A-1.- Continued.

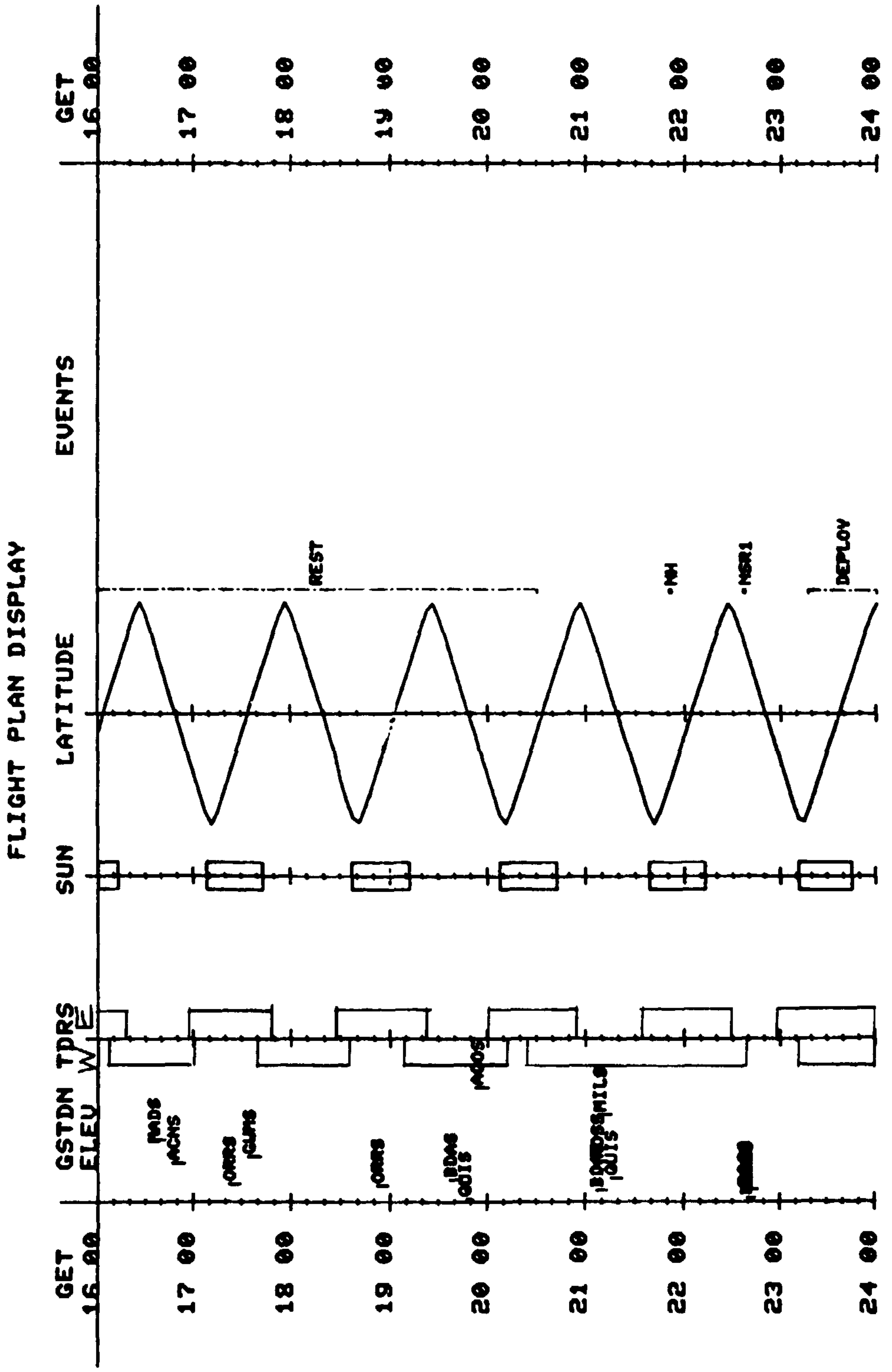

Figure A-1.- Continued.

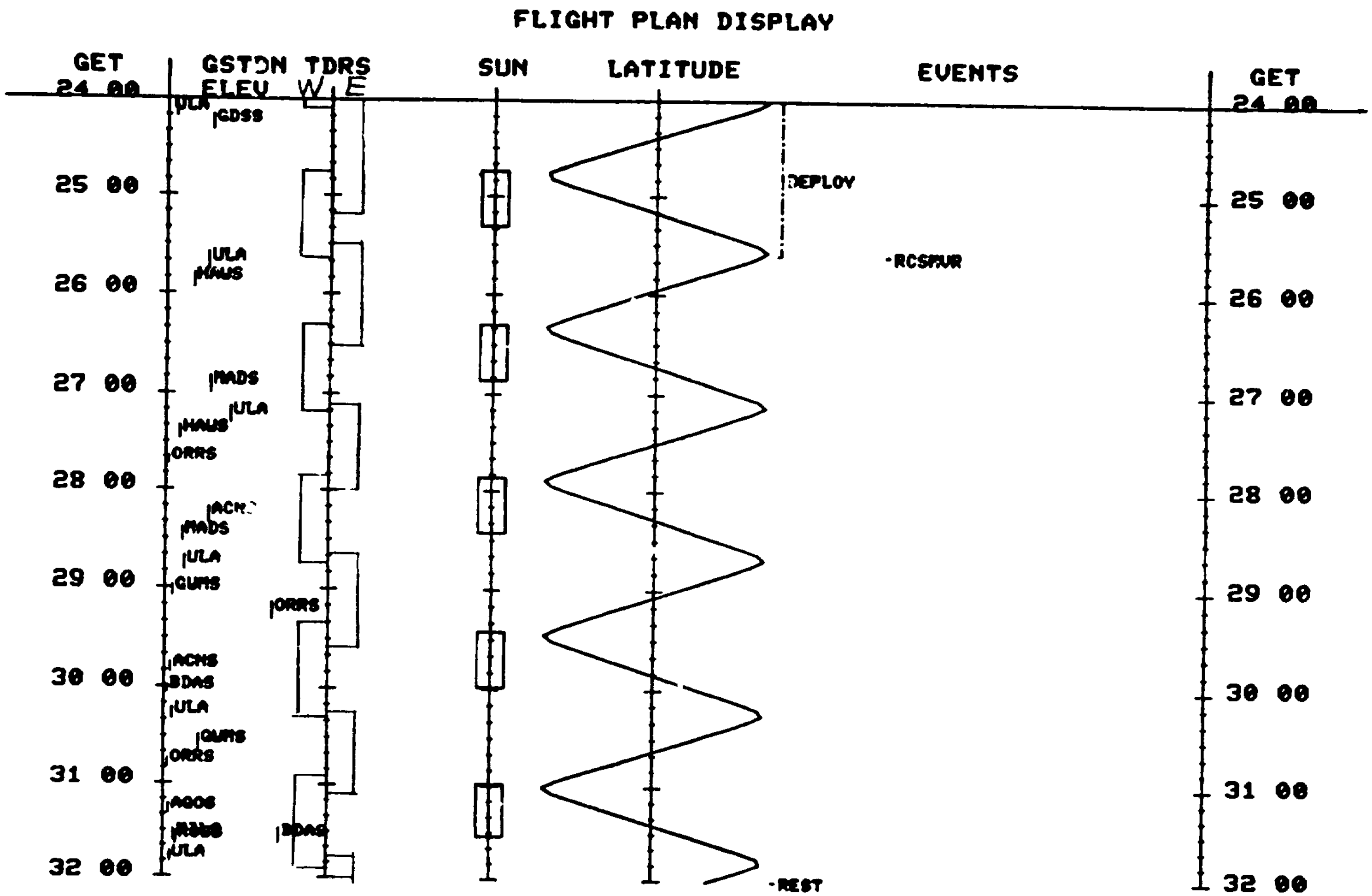

Figure A-1.- Continued.

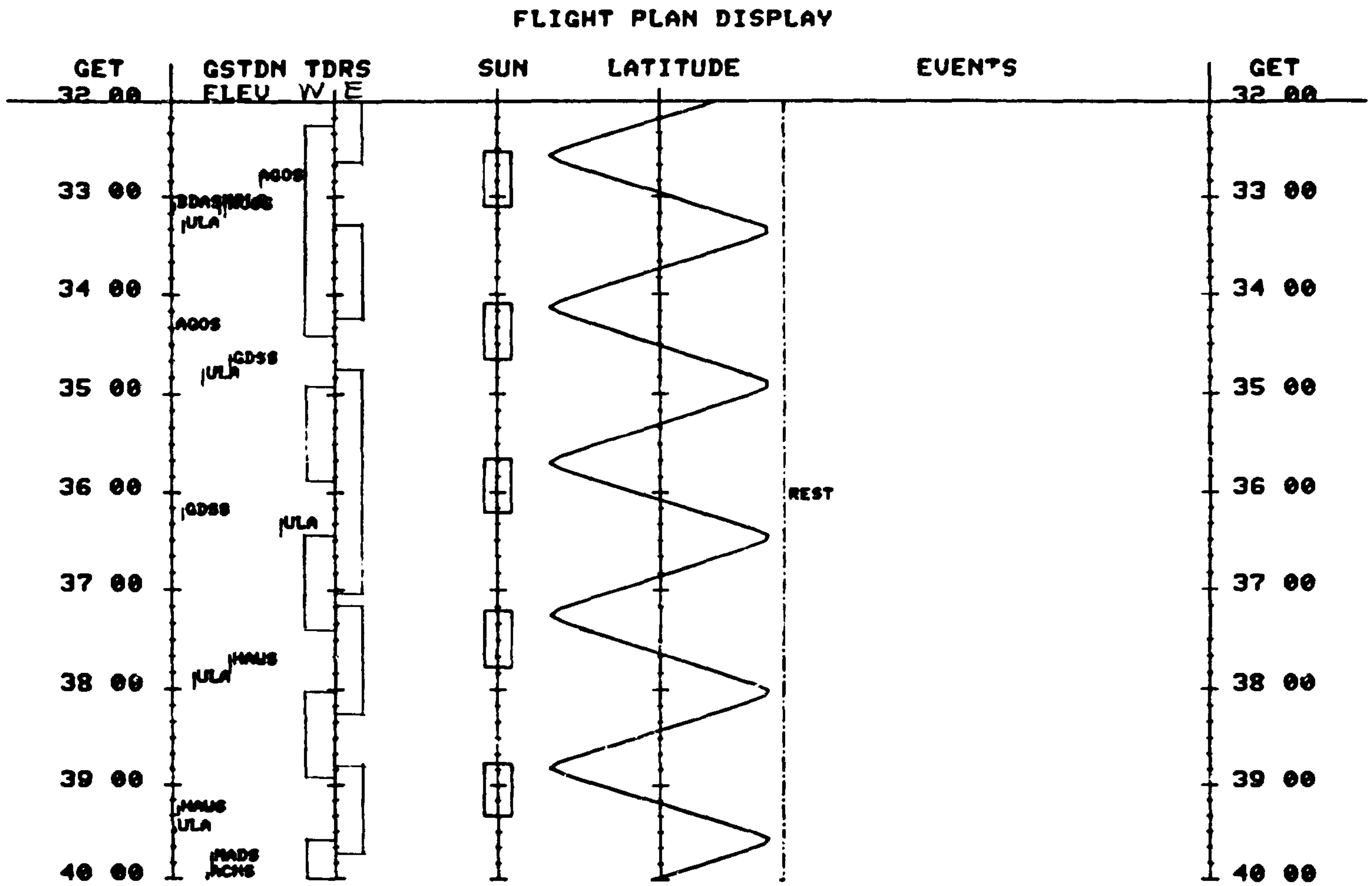

Figure A-1.- Continued.

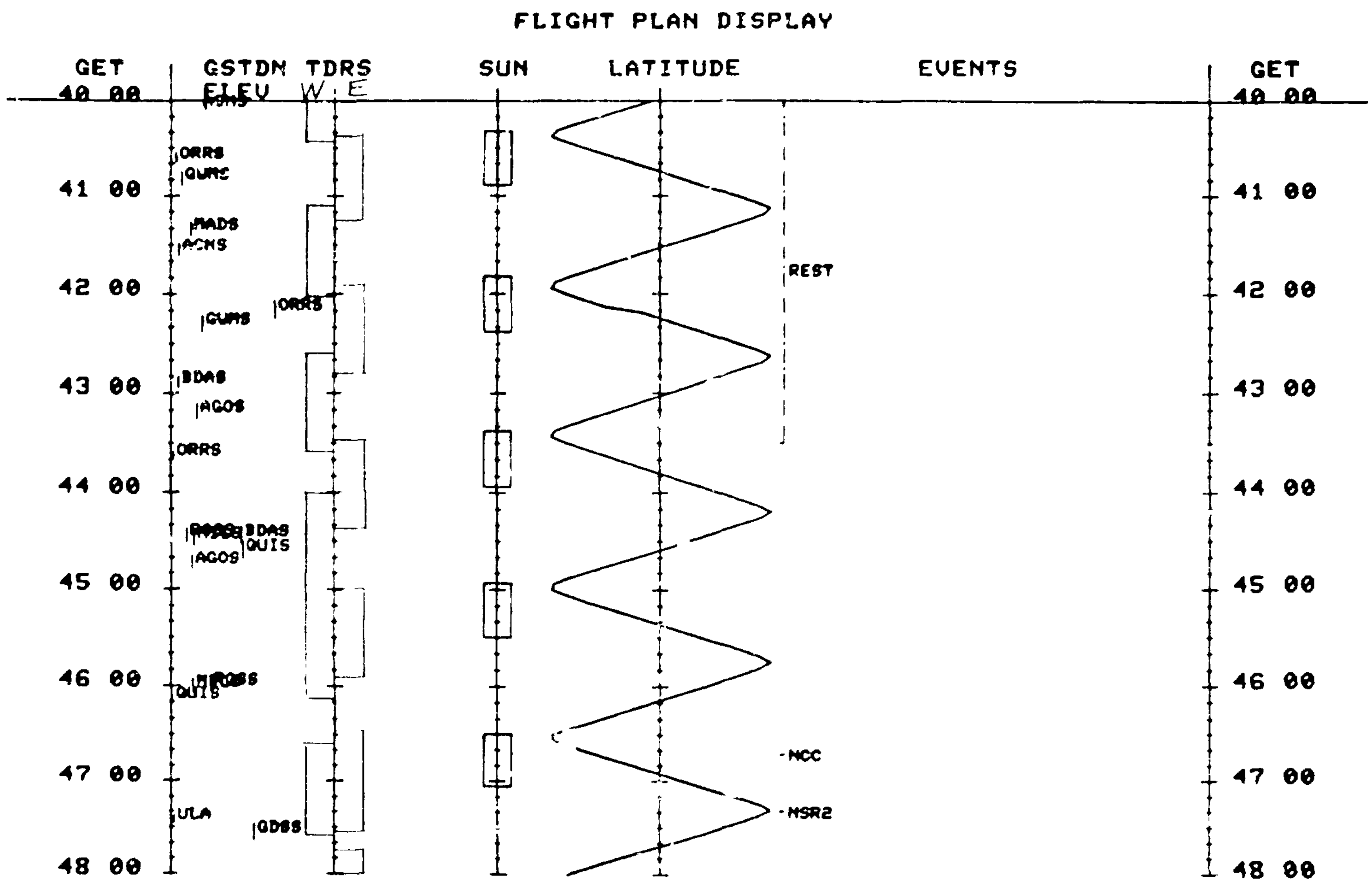

Figure A-1.- Continued.

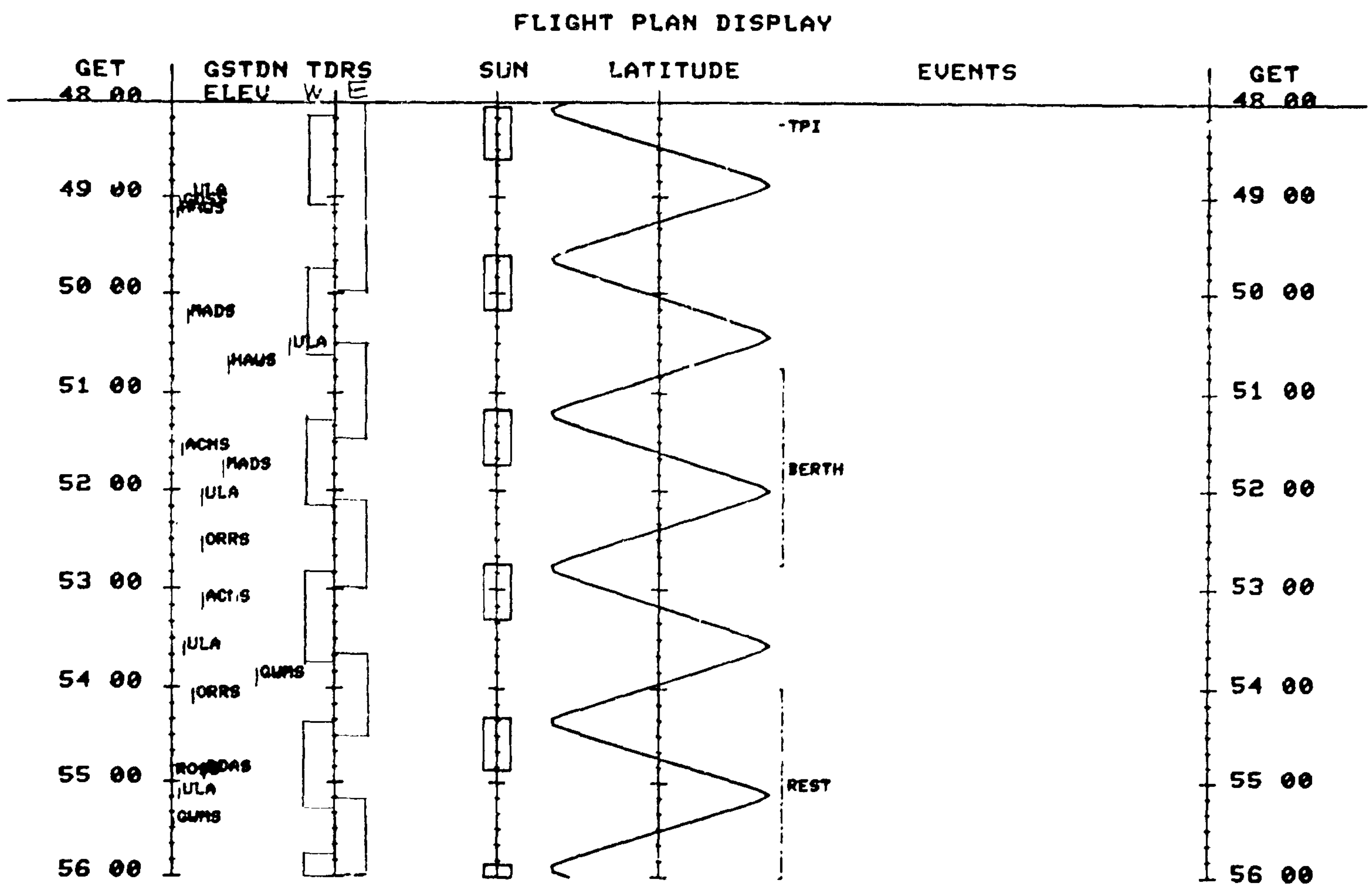

Figure A-1.- Continued.

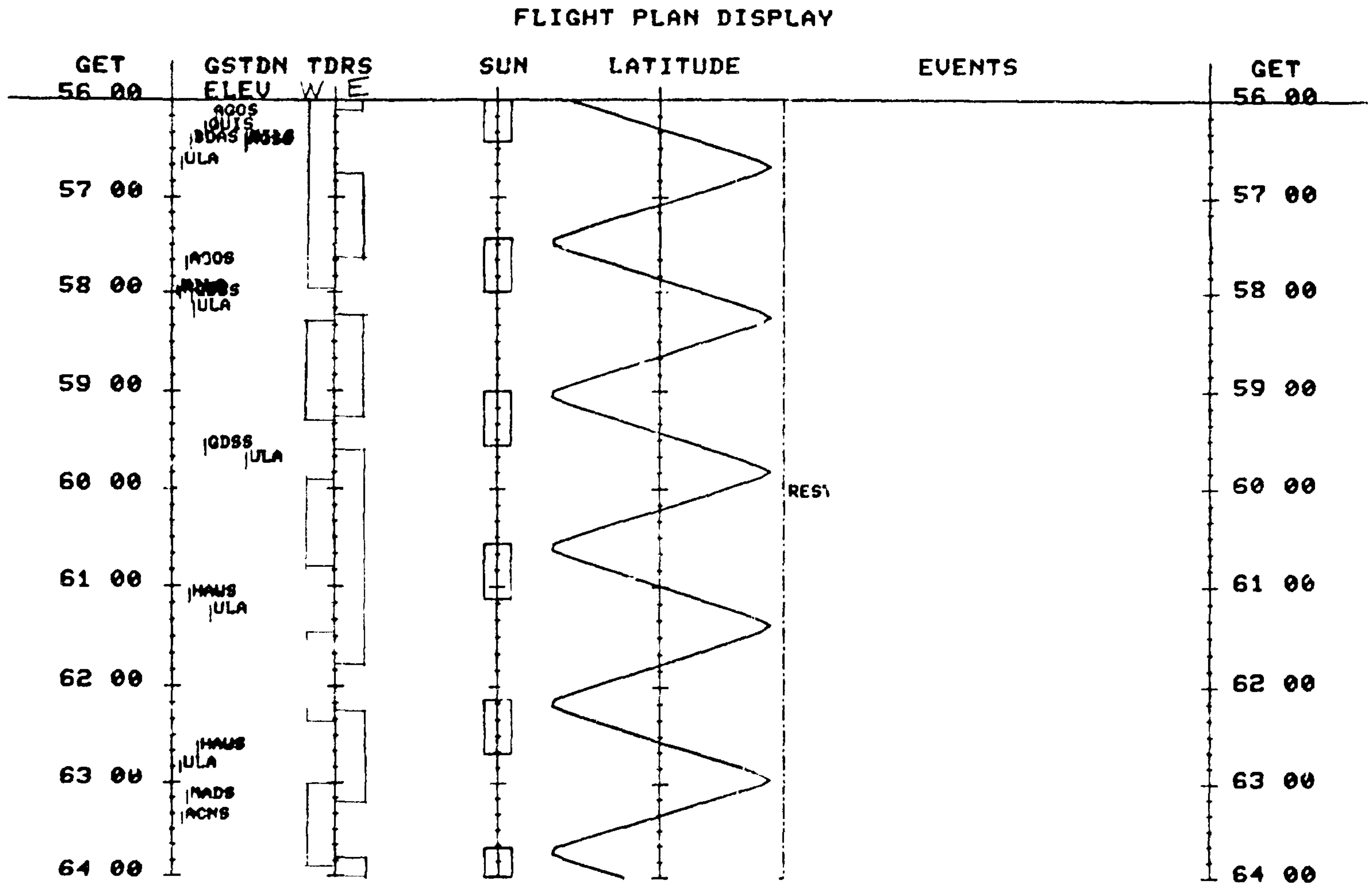

Figure A-1.- Continued.

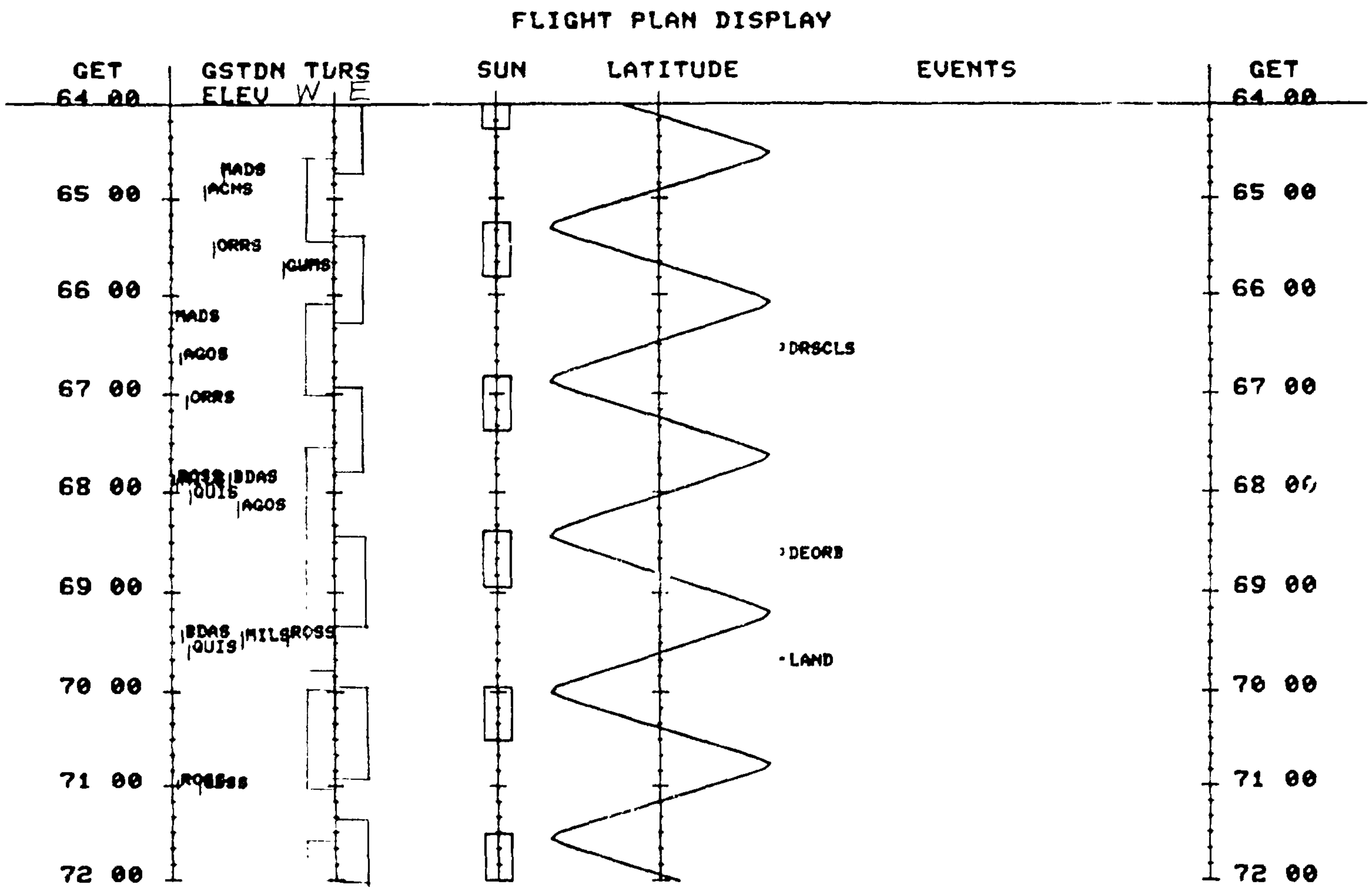

Figure A-1.- Concluded.

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