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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEMINI PROGRAM MISSION REPORT

GEMINI XI

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MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

ORF

OCTOBER 1966

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GEMINI FLIGHT HISTORY

Mission	Description	Launch date	Major accomplishments
Gemini I	Unmanned 64 orbits Qualification	Apr. 8, 1964	Demonstrated structural integrity. Demonstrated launch vehicle systems performance.
Gemini II	Unmanned Suborbital Qualification	Jan. 19, 1965	Demonstrated spacecraft systems performance.
Gemini III	Manned 3 orbits Qualification	Mar. 23, 1965	Demonstrated manned qualification of the Gemini spacecraft.
Gemini IV	Manned Four days Long duration	June 3, 1965	Demonstrated spacecraft systems performance and crew capability for four days in space. Demonstrated EVA.
Gemini V	Manned Eight days Long duration	Aug. 21, 1965	Demonstrated long-duration flight. Demonstrated rendezvous radar capability and rendezvous maneuvers.
Gemini VI	Manned Two days Rendezvous (Canceled after, failure of GATV)	Oct. 25, 1965	Demonstrated dual countdown procedures (GAATV and GLV/Spacecraft). Demonstrated flight performance of the TLV and flight readiness of the GATV secondary propulsion system.
Gemini VII	Manned Fourteen days Long duration	Dec. 4, 1965	Demonstrated two-week duration flight and station keeping with GLV Stage II. Evaluated "shirt sleeve" environment. Acted as the rendezvous target for Spacecraft 6. Demonstrated controlled reentry to within seven miles of planned landing point.
Gemini VI-A	Manned One day Rendezvous	Dec. 15, 1965	Demonstrated on-time launch procedures. Demonstrated closed-loop rendezvous capability. Demonstrated station-keeping technique with Spacecraft 7.

(Continued inside back cover)

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GEMINI PROGRAM MISSION REPORT

GEMINI XI

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Deputy Director

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Gemini Agena Target Vehicle, showing tether after release.

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1.0 MISSION SUMMARY

Gemini XI was the ninth manned mission and the fifth rendezvous mission of the Gemini Program. The Gemini Atlas-Agena Target Vehicle was launched from Complex 14, Cape Kennedy, Florida, at 8:05:02 a.m. e.s.t. on September 12, 1966. The Gemini Space Vehicle was launched from Complex 19, Cape Kennedy, Florida, at 9:42:27 a.m. e.s.t. on September 12, 1966, with Astronaut Charles Conrad, Jr., as the Command Pilot and Astronaut Richard F. Gordon as the Pilot. The flight was successfully concluded on September 15, 1966, when the spacecraft was landed within 2.5 nautical miles of the prime recovery ship, the U.S.S. Guam, at 71:17:08. (NOTE: All times in this section are spacecraft ground elapsed time (g.e.t.) referenced to lift-off of the Gemini Space Vehicle, unless otherwise specified.) The flight crew elected to be retrieved by helicopter and were on the deck of the prime recovery ship approximately 24 minutes after landing. The crew completed their flight in excellent physical condition and demonstrated full control of the spacecraft and competent management of all aspects of the mission.

The primary objective, to rendezvous during the first revolution and dock, was achieved. The secondary objectives were (1) to conduct docking practice, (2) to conduct extravehicular activity, (3) to conduct eleven experiments, (4) to conduct docked maneuvers which included a high-apogee excursion, (5) to conduct a tethered vehicle test, (6) to demonstrate an automatic reentry, and (7) to park the Gemini Agena Target Vehicle. All the secondary objectives were achieved except that one of the eleven experiments (D016 Minimum Reaction Power Tool) was not attempted because the umbilical extravehicular activity was terminated prematurely.

The launch of the Gemini Atlas-Agena Target Vehicle was satisfactory and resulted in the Gemini Agena Target Vehicle achieving a nearly circular orbit with an apogee of 165.5 nautical miles and a perigee of 156.1 nautical miles.

The lift-off of the Gemini Space Vehicle occurred approximately 1 hour 37 minutes after the lift-off of the Gemini Atlas-Agena Target Vehicle. The powered flight of the Gemini Space Vehicle was satisfactory in all respects, and the spacecraft was separated from the launch vehicle approximately 20 seconds after second-stage engine cutoff. The Insertion Velocity Adjust Routine of the onboard computer was used to calculate the necessary velocity to be added to achieve the required orbit. The indicated velocity was applied by the Command Pilot and the spacecraft was placed in a satisfactory orbit from which a rendezvous during the first revolution could be achieved.

After insertion, five maneuvers were performed by the crew using onboard data to effect a first-orbit rendezvous with the Gemini Agena Target Vehicle. The terminal phase initiate maneuver and the first midcourse correction maneuver were based on onboard data from closed-loop computer solutions. Radar azimuth and elevation data became erratic after the first midcourse correction maneuver, and, as a result, the second midcourse correction had to be based on range and range-rate data from the radar and data from onboard optical tracking. These maneuvers were performed using optical rendezvous techniques and pre-prepared backup rendezvous charts. The rendezvous was achieved at 1 hour 25 minutes and docking was completed by the command pilot shortly after 1 hour 34 minutes.

Between the time of the first docking and approximately 4 hours 25 minutes, the crew performed various sequences of the Ion-Wake Measurement experiment, including one undocking and redocking by the pilot. At 4 hours 28 minutes, the first docked primary-propulsion-system firing was performed and consisted of a calibration maneuver of 111 ft/sec. Each crewman performed an additional practice docking prior to the first sleep period.

At 24 hours 2 minutes, the pilot opened the hatch and began the umbilical extravehicular activity. After setting up a camera and retrieving an experiment package, the pilot translated to the nose of the spacecraft and attached the tether from the Gemini Agena Target Vehicle to the docking bar. This operation was very difficult and tiring. As a result, the extravehicular activity was terminated because of pilot fatigue and the hatch was closed at 24 hours 35 minutes. The Apollo-sump-tank cameras and the Hand Held Maneuvering Unit were not retrieved from the adapter.

At 25 hours 37 minutes, the pilot opened the hatch and jettisoned the equipment that was no longer required for the mission. The remainder of the second day was spent performing various experiment sequences.

After awakening from the second sleep period, the crew began preparations for the primary-propulsion-system posigrade maneuver. This maneuver was performed at 40 hours 30 minutes and raised the apogee of the docked vehicles to 741 nautical miles. During the next two revolutions, photographs were taken for several experiments. Radiation measurements indicated that the crew were not exposed to increased radiation levels during the two high-apogee revolutions. At 43 hours 53 minutes, a primary-propulsion-system retrograde maneuver was performed which lowered the apogee of the docked vehicles to approximately 164 nautical miles.

The crew began preparations for the standup extravehicular activity at 44 hours. At 46 hours 7 minutes, the pilot opened the hatch again and started the standup extravehicular activity. Both night passes during the 2 hours 8 minutes of standup extravehicular activity were spent taking experiment photographs.

The spacecraft was undocked at approximately 49 hours 55 minutes to begin the tether evaluation. At 50 hours 13 minutes, the crew initiated a rotational rate to the tethered vehicles. Minor difficulties were encountered in initiating the rotational rate because of the undamped behavior of the tether under tension and because of attitude oscillations of the spacecraft. The initial rate achieved was 38 deg/min, and the plane of rotation was inclined to the orbit plane by approximately 40 degrees. The oscillations continued but were slowly damping, and the rotating combination became very stable after about 20 minutes. At 51:42:05, the crew increased the rotational rate to about 55 deg/min. Spacecraft attitude oscillations were again experienced which, in turn, excited attitude oscillations in the Gemini Agena Target Vehicle. The crew used the control system in an attempt to damp the oscillations of the spacecraft and were fairly successful in achieving stabilization in the roll and yaw axes, but the pitch axis oscillations increased slightly during this period. The system again became very stable, making the rotation of two tethered vehicles appear to be an economical and feasible method of long-term, unattended station keeping. At approximately 53 hours, the crew fired the aft-firing thrusters to remove the tether tension and then jettisoned the docking bar, releasing the tether.

After the tether was jettisoned, a separation maneuver of 9.7 ft/sec and a stand-off maneuver of 10.2 ft/sec were performed to place the spacecraft in a coincident orbit in preparation for the rendezvous to be performed after the third sleep period.

Fuel-cell stack 2C failed at 54 hours 31 minutes. The remaining five stacks shared the total load and operated satisfactorily; however, during two periods—one when operating the Night Image Intensification equipment, and the other when powering up the computer—it was necessary to activate one of the spacecraft main batteries to assure that satisfactory voltage levels were maintained. The Night Image Intensification experiment was performed at various times until approximately 57 hours 20 minutes, at which time preparations were begun for the third sleep period.

At 65 hours 27 minutes, a series of maneuvers was initiated to complete the coincident-orbit rendezvous, and the crew was station keeping with the target vehicle again at 66 hours 40 minutes. A 3 ft/sec final separation maneuver was performed at approximately 66 hours 52 minutes, and preparations were begun for retrofire and reentry.

Retrofire occurred at 70:41:36, and the crew performed all manual functions to prepare the spacecraft for reentry. At 400K feet, the command pilot rolled the spacecraft to the backup bank angle of 44 degrees left. The computer commanded a bank angle for full lift and a right roll to recover from the backup bank angle. The command pilot switched control to the reentry rate-command mode, rolled the spacecraft to full lift to match the indicators, and then damped all spacecraft oscillations. The crew agreed that the computer was operating properly at this time, and the pilot switched control to the reentry mode to enable automatic reentry control of the spacecraft. The command pilot followed all commands for control of the spacecraft with the attitude hand controller deactivated so that, if a problem had arisen, manual control of reentry could have been activated in a minimum amount of time. The landing point achieved by the automatically controlled reentry was about 2.5 miles from the prime recovery ship (U.S.S. Guam). After landing, the crew elected to be retrieved by helicopter and were on deck approximately 24 minutes after landing. The spacecraft was hoisted aboard the ship at 72 hours 16 minutes.

2.0 INTRODUCTION

A description of the Gemini XI mission and a discussion of the mission results are contained in this report. The report covers the time from the start of the simultaneous countdown of the Gemini Atlas-Agena Target Vehicle and the Gemini Space Vehicle to the date of publication of this report. Detailed discussions are found in the major sections related to each principal area of effort. Some redundancy may be found between the various sections when it is required for a logical presentation of the subject matter.

Data were reduced from telemetry, onboard records, and ground-based radar tracking, but were reduced only in areas of importance. The evaluation of all vehicles consisted of analyzing the flight results and comparing them with expected or predicted results and with results of ground tests and previous missions.

Section 6.1, FLIGHT CONTROL, is based on observations and evaluations made in real time and may not coincide with the results of the postflight analyses.

Brief descriptions of experiments not described in previous mission reports and preliminary results of all experiments flown on this mission are presented in section 8.0.

The primary objective of the Gemini XI mission was to rendezvous during the first revolution and dock.

The secondary objectives were as follows:

(a) Conduct docking practice

(b) Conduct extravehicular operations

(c) Conduct experiments

(d) Conduct docked maneuvers (high-apogee excursion)

(e) Conduct tethered vehicle test

(f) Demonstrate automatic reentry

(g) Park Gemini Agena Target Vehicle

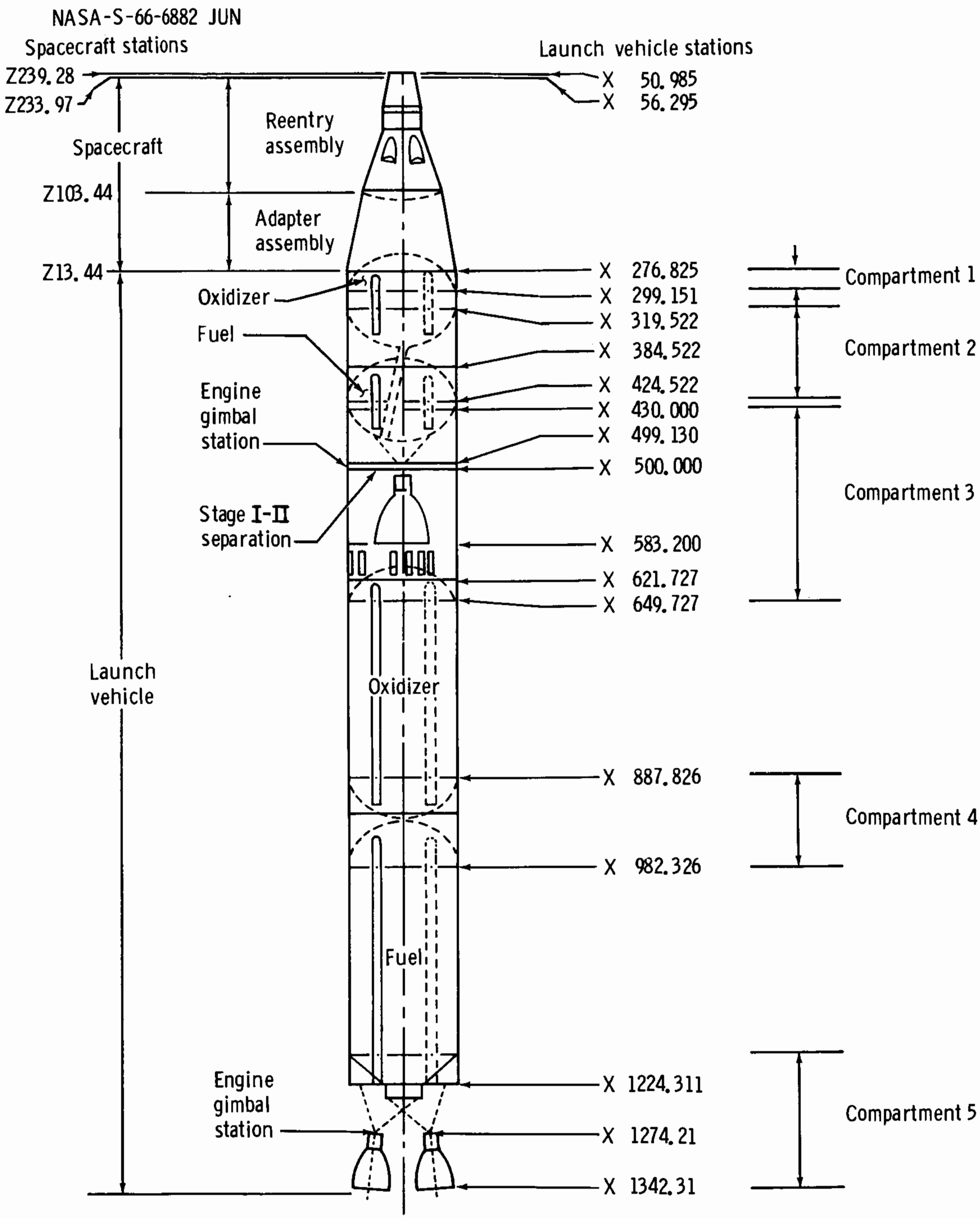
More detailed analyses of the performance of the launch vehicles and the guidance systems were continuing at the time of publication of this report. Supplemental reports, listed in section 12.4, will be issued to provide documented results of these analyses.

The results of previous Gemini missions are reported in references 1 through 11.

3.0 VEHICLE DESCRIPTION

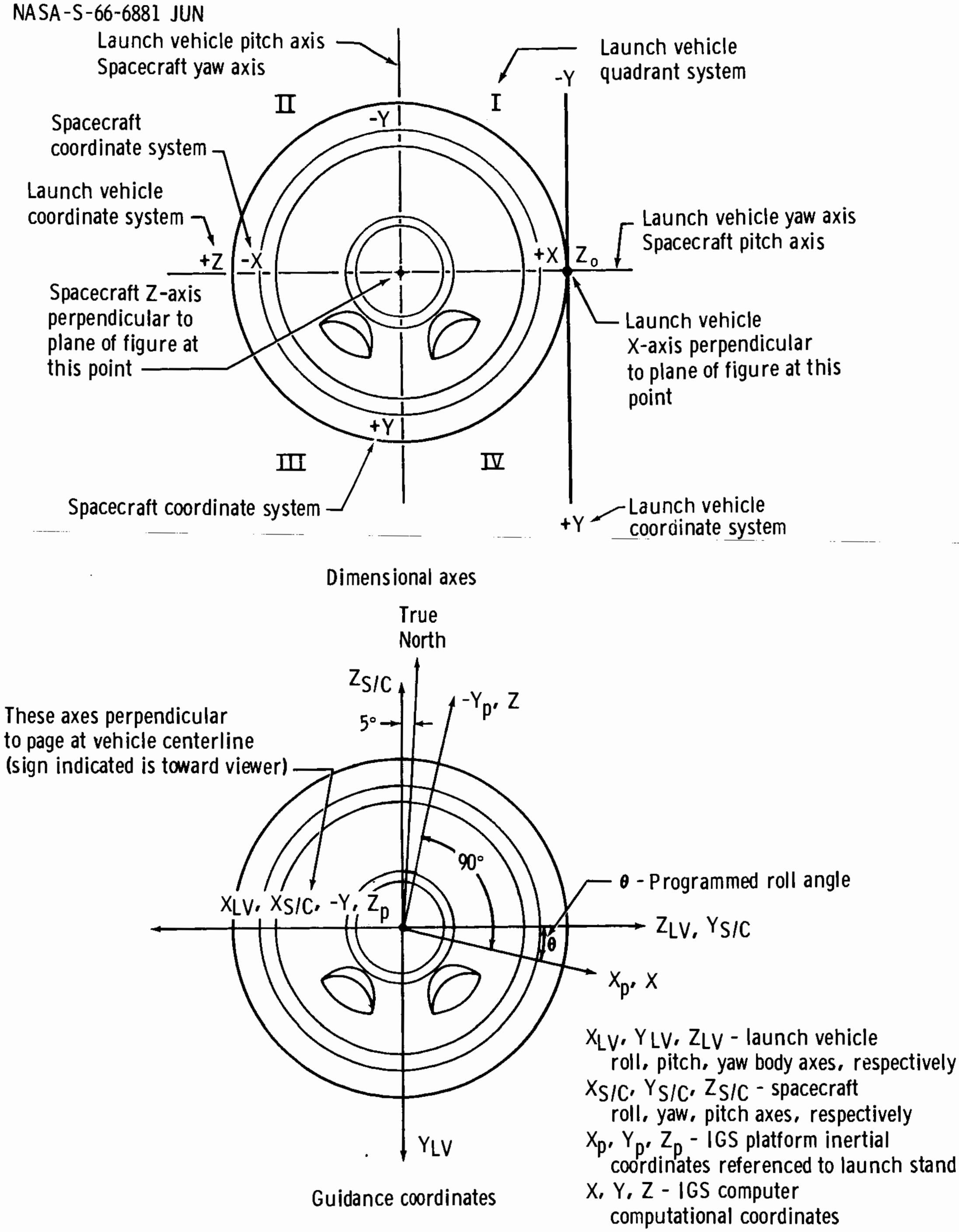
The manned vehicle for the Gemini XI mission consisted of Spacecraft 11 and Gemini Launch Vehicle (GLV) 11. The Gemini Atlas-Agena Target Vehicle (GAATV) consisted of Gemini Agena Target Vehicle (GATV) 5006 and Target Launch Vehicle (TLV) 5306.

The general arrangement and major reference coordinates of the Gemini Space Vehicle are shown in figure 3.0-1. Section 3.1 of this report describes the spacecraft configuration; section 3.2 describes the GLV configuration; and section 3.3 provides the Gemini Space Vehicle weight and balance data. The general arrangement and major reference coordinates of the GAATV are shown in figure 3.0-2. Section 3.4 describes the GATV configuration, including the Target Docking Adapter (TDA); section 3.5 describes the TLV configuration; and section 3.6 provides the GAATV weight and balance data.



(a) Launch configuration.

Figure 3.0-1. - GLV/spacecraft relationships.



(b) Dimensional axes and guidance coordinates.
Figure 3.0-1. - Concluded.

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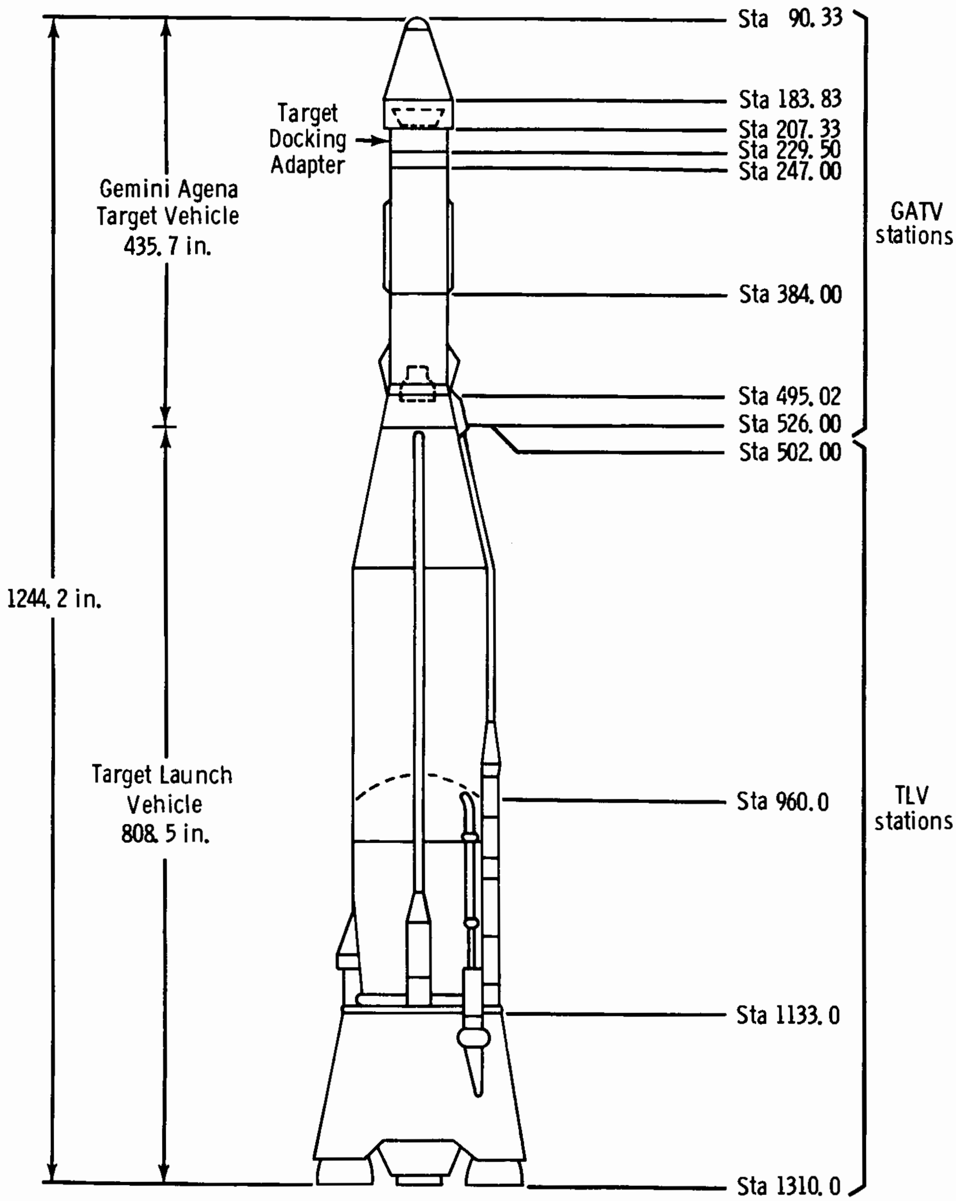
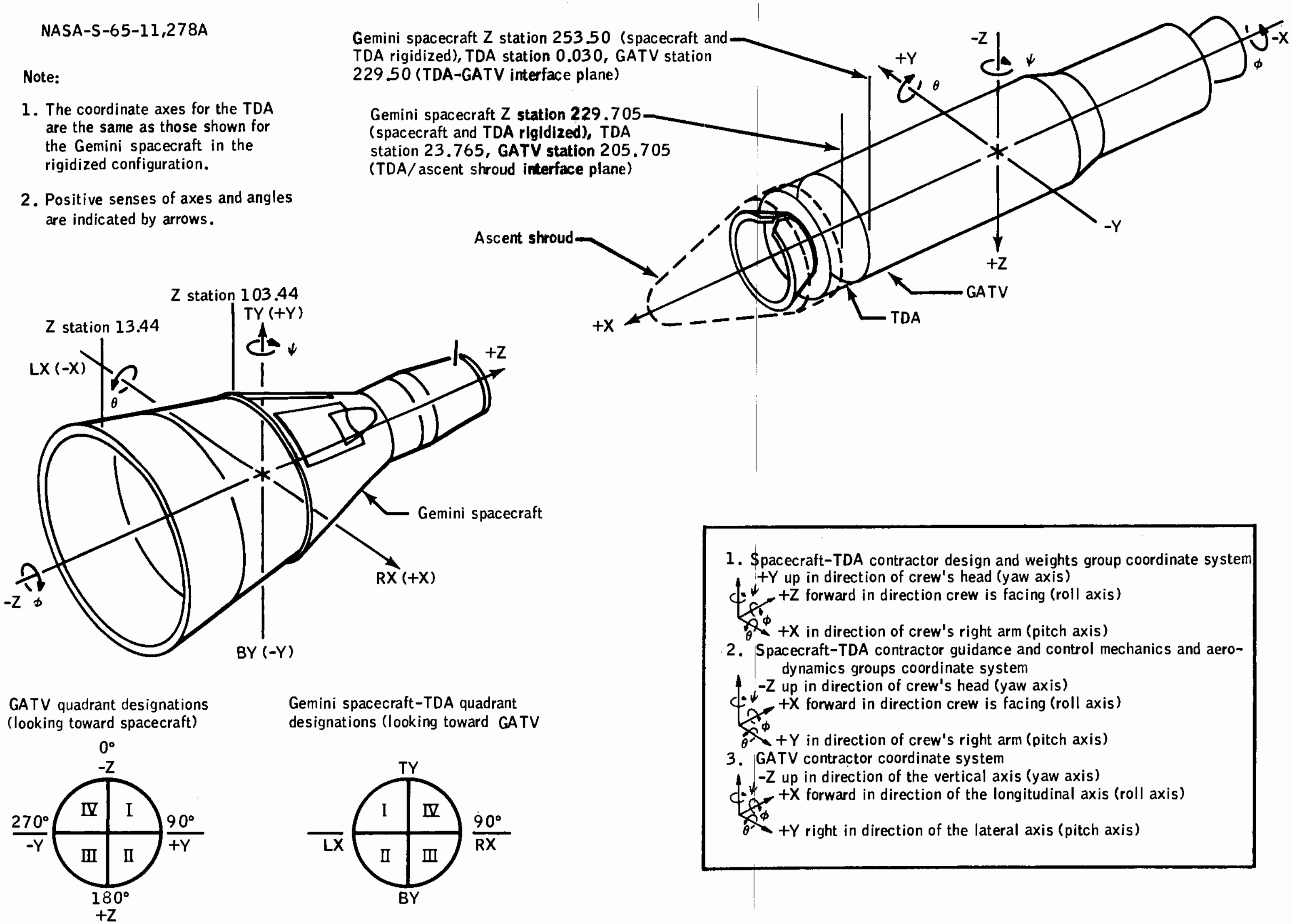


(a) Launch configuration.

Figure 3.0-2. - TLV/GATV relationship.



(b) Dimensional axes and guidance coordinates, GATV-TDA.
Figure 3.0-2. - Continued.

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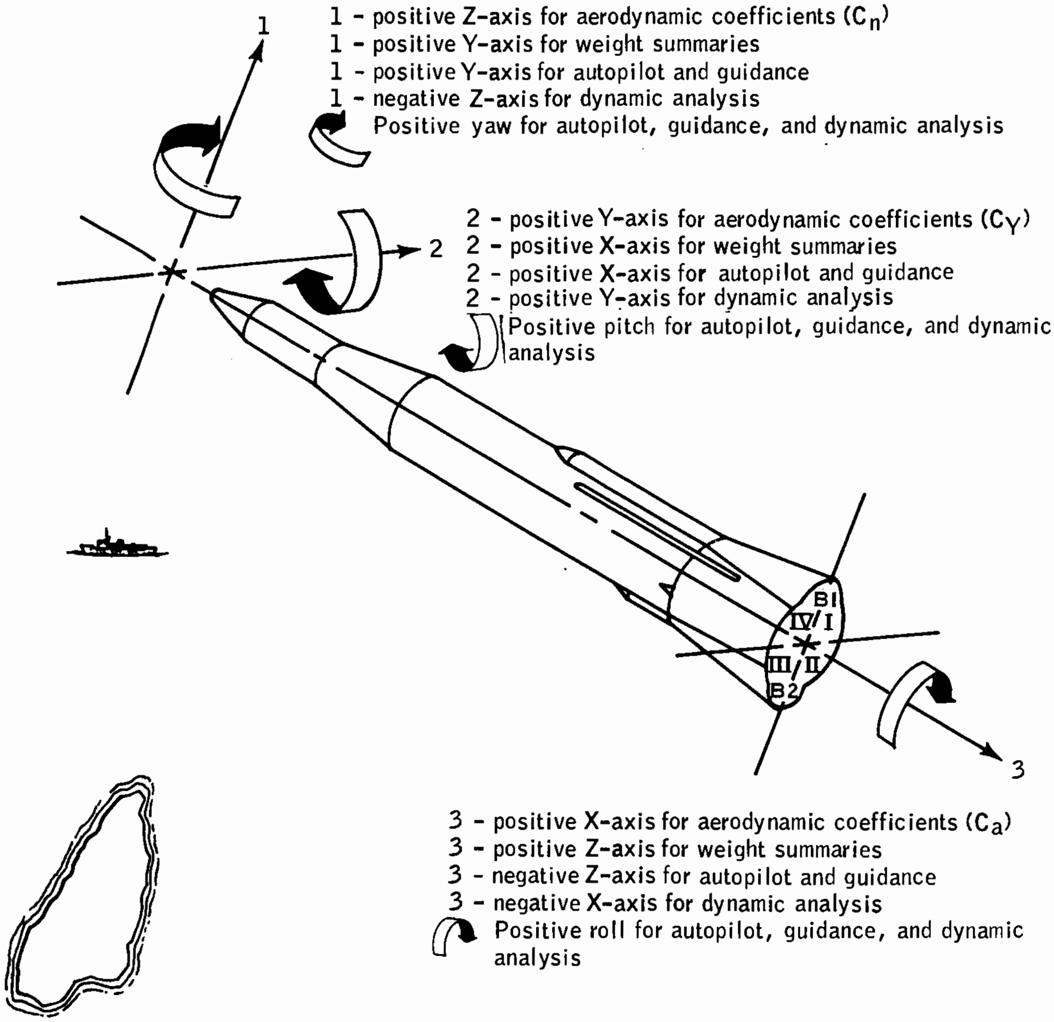

Vehicle shown in flight attitude

(c) Dimensional axes and guidance coordinates, TLV.

Figure 3.0-2. - Concluded.

3.1 GEMINI SPACECRAFT

The general configuration of the structure and major systems of Spacecraft 11 (fig. 3.1-1) was the same as that of spacecraft flown on previous rendezvous missions. Reference 2 provides a detailed description of the basic spacecraft (Spacecraft 2) and references 3 through 11 describe the modifications incorporated into the subsequent spacecraft. Spacecraft 11 closely resembled Spacecraft 10 (ref. 11), and only the significant differences (table 3.1-1) are included in this report. A detailed description of Spacecraft 11 is contained in reference 12.

3.1.1 Spacecraft Structure

The major changes to the spacecraft structure were the incorporation of the Apollo sump tank equipment, the provision of a clamp for securing the 100-foot spacecraft/GATV tether to the docking bar, and the modifications required to accommodate the different experiments (section 8.0).

3.1.1.1 Apollo sump tank test.- A transparent plastic 1/8-scale model of the sump tank used in the Apollo spacecraft service propulsion system was mounted in the center of the adapter equipment section. The tank contained an inert gas with a coloring material added to improve the contrast for color photos. The tank was enclosed in a sheet-metal shroud with eight incandescent bulbs to provide backlighting, a mirror to provide two views of the tank from one camera position, and a clock. Two 16-mm cameras with wide-angle lenses were mounted on a separate bracket on the retrograde-rocket access panel. The camera mount included a release mechanism which was to have permitted the pilot to retrieve the cameras during the extravehicular activity (EVA). The control switch for the lights and cameras was on the crew-station instrument panel (paragraph 3.1.2.3).

3.1.1.2 Tether attachment clamp.- A clamp was provided to attach to the docking bar and secure the spacecraft end of the 100-foot Dacron-webbing tether between the GATV and the spacecraft (fig. 3.1-2).

3.1.2 Major Systems

No significant changes were made to the following major systems:

(a) Communication

(b) Environmental Control

(c) Guidance and Control

(d) Time Reference

(e) Propulsion

(f) Pyrotechnic

(g) Landing

(h) Postlanding and Recovery.

3.1.2.1 Instrumentation and Recording System.- The only significant change to the Instrumentation and Recording System was the addition of the instrumentation for the Apollo sump tank test. This instrumentation consisted of a temperature sensor installed in the tank and three accelerometers installed adjacent to the tank. These measurements were incorporated into the delayed-time telemetry system.

3.1.2.2 Electrical System.- Wiring changes in the Electrical System were required to supply power to the lights and cameras used with the Apollo sump tank test.

3.1.2.3 Crew-station furnishings and equipment.- In addition to the changes required by the different experiments (section 8.0), the following modifications were incorporated into the crew-station furnishings and equipment.

3.1.2.3.1 Controls and displays: The crew-station controls and displays were modified as follows (fig. 3.1-3):

(a) The Orbital Attitude and Maneuver System/Reentry Control System (OAMS/RCS) pressure/temperature select switch was modified so that the OAMS regulated helium pressure could be indicated.

(b) A switch was provided to enable the crew to jettison the docking index bar independent of the adapter retrograde section jettison function. This capability was required to permit singular release of the GATV tether.

(c) A previously unused position on the oxygen high-rate switch was used to control the cameras and lights for the Apollo sump tank test.

3.1.2.3.2 Sun filters: Polaroid sun filters were provided for installation on the inside of both hatch windows to minimize sun interference during the launch phase.

3.1.2.3.3 Stowage provisions: The stowage provisions were essentially unchanged. The individual stowage containers are shown in figure 3.1-4, and table 3.1-II lists the major items of equipment stowed in the containers at launch.

3.1.2.3.4 Crew furnishings: Guards were added to the lap-belt buckles on the ejection seats to prevent the belts from folding over and jamming as occurred to the command pilot's belt during the Gemini X mission.

3.1.2.4 Extravehicular equipment.- No significant changes were made to the space suits, the Extravehicular Life Support System (ELSS), or the Hand Held Maneuvering Unit (HHMU). The EVA visor was of the same configuration as the one used on the Gemini IX-A mission. The 50-foot umbilical was shortened to 30 feet to relieve stowage congestion. The following modifications were incorporated to facilitate the planned retrieval of the cameras for the Apollo sump tank test:

(a) Foot restraints were added in the adapter assembly and were intended to secure the pilot's feet while he was facing forward into the adapter equipment section. These restraints were to be used also when removing the HHMU from its stowage area.

(b) A large fold-out flap was installed in the adapter equipment section thermal curtain to provide access to the Apollo sump tank module.

(c) An auxiliary light was added inside the thermal curtain to illuminate the Apollo sump tank work area. This light was connected to the same circuit as the EVA handhold lights in the adapter assembly.

TABLE 3.1-I.- SPACECRAFT 11 MODIFICATIONS

System	Significant differences between Spacecraft 11 and Spacecraft 10
Structure	(a) The Apollo sump tank equipment was installed. (b) A tether-attachment clamp was provided for the docking bar.
Instrumentation and Recording	A temperature sensor and three accelerometers were added for Apollo sump tank measurements.
Crew-station furnishings and equipment	(a) The capability was provided for OAMS regulated helium pressure indication. (b) A switch position was provided for Apollo sump tank cameras and lights. (c) A docking bar jettison switch was installed. (d) Two additional Polaroid sun filters were provided for the hatch windows. (e) Guards were added to the lap-belt buckles.
EVA equipment	(a) The EVA visor configuration was the same as that used on the Gemini IX-A mission. (b) The umbilical cable was 30 feet long instead of 50 feet. (c) Foot restraints were added in the adapter equipment section. (d) The opening was enlarged in the thermal curtain. (e) A light was added inside the thermal curtain.

TABLE 3.1-II.- CREW-STATION STOWAGE LIST

Stowage area (see fig. 3.1-4)	Item	Quantity
Centerline stowage container	Mirror mounting bracket	1
	18-mm lens, 16-mm camera	1
	75-mm lens, 16-mm camera	1
	16-mm sequence camera with film magazine	1
	70-mm camera	1
	16-mm film magazines	7
	70-mm film magazines	3
	5-mm lens, 16-mm camera	1
	50-mm lens with filter, 70-mm camera	1
	Ring viewfinder	1
	f/2.8 lens, general purpose	1
Left sidewall containers	Personal hygiene towels	2
	Penlight	1
	Glareshield	1
	Voice tape cartridges	5
	Tissue dispenser	1
	Pilot's preference kit	1
	Food, one-man meal	1
	Postlanding kit	1
	Spot meter and exposure dial	1
Left aft stowage container	ELSS hose, long	1
	ELSS hose, short	1
	16-mm film magazines	6
	70-mm camera	1

TABLE 3.1-II.- CREW-STATION STOWAGE LIST - Continued.

Stowage area (see fig. 3.1-4)	Item	Quantity
Left aft stowage container - concluded	Dual Y-connectors	2
	Hose nozzle interconnectors	2
	ELSS restraint assemblies	2
	Pressure gloves, thermal	1 pr.
	Radiation measuring system	1
	Electrical cable and tether, standup EVA	1
Left pedestal pouch	Waste container	1
	Velcro patches, 12 by 1 inches	4
	Velcro patches, 12 by 2 inches	2
	Defecation device	1
Left footwell	30-foot umbilical	1
Right sidewall containers	Tissue dispenser	1
	Personal hygiene towels	2
	Blood-pressure inflator, manual	1
	Food, one-man meal	1
	Penlight	1
	Glareshield	1
	Pilot's preference kit	1
	Voice tape cartridges	8
	Hatch closing device	1
Right aft stowage container	70-mm camera, superwide angle	1
	16-mm sequence camera with film magazine	1
	70-mm film magazines	4
	Defecation devices	4

TABLE 3.1-II.- CREW-STATION STOWAGE LIST - Continued

Stowage area (see fig. 3.1-4)	Item	Quantity
Right aft stowage container - concluded	EVA remote control cable, 16-mm camera	1
	Circuit breaker and light, 16-mm camera	1
	Food, one-man meals	5
	Ultraviolet lens, prism, and grating	1
	Illuminated sight	1
	Adapter, EVA sequence camera	1
Right pedestal pouch	Velcro, 12 by 2 inches	1
	Waste container	1
	Velcro, 12 by 1 inches	5
	Defecation device	1
Right footwell	Orbital path display assembly	1
	Celestial display - Mercator	1
	Celestial display - polar	1
	Flight data books	2
Orbital utility pouch	Circuit breaker and light, 16-mm camera	1
	Lightweight headset	1
Right and left circuit-breaker fairings	Oral temperature probes	2
	Latex roll-on cuffs	6
	Urine receivers with removable cuff	2
Center stowage rack	ELSS chestpack	1
Left and right hatch pouches	Food, one-man meals	11

TABLE 3.1-II.- CREW-STATION STOWAGE LIST - Concluded

Stowage area (see fig. 3.1-4)	Item	Quantity
Hatch torque box	Sextant, miniature hand-held	1
Water management console	Roll-on cuff receiver assembly (urine system)	1
Left and right dry-stowage bags	Auxiliary window shades	2

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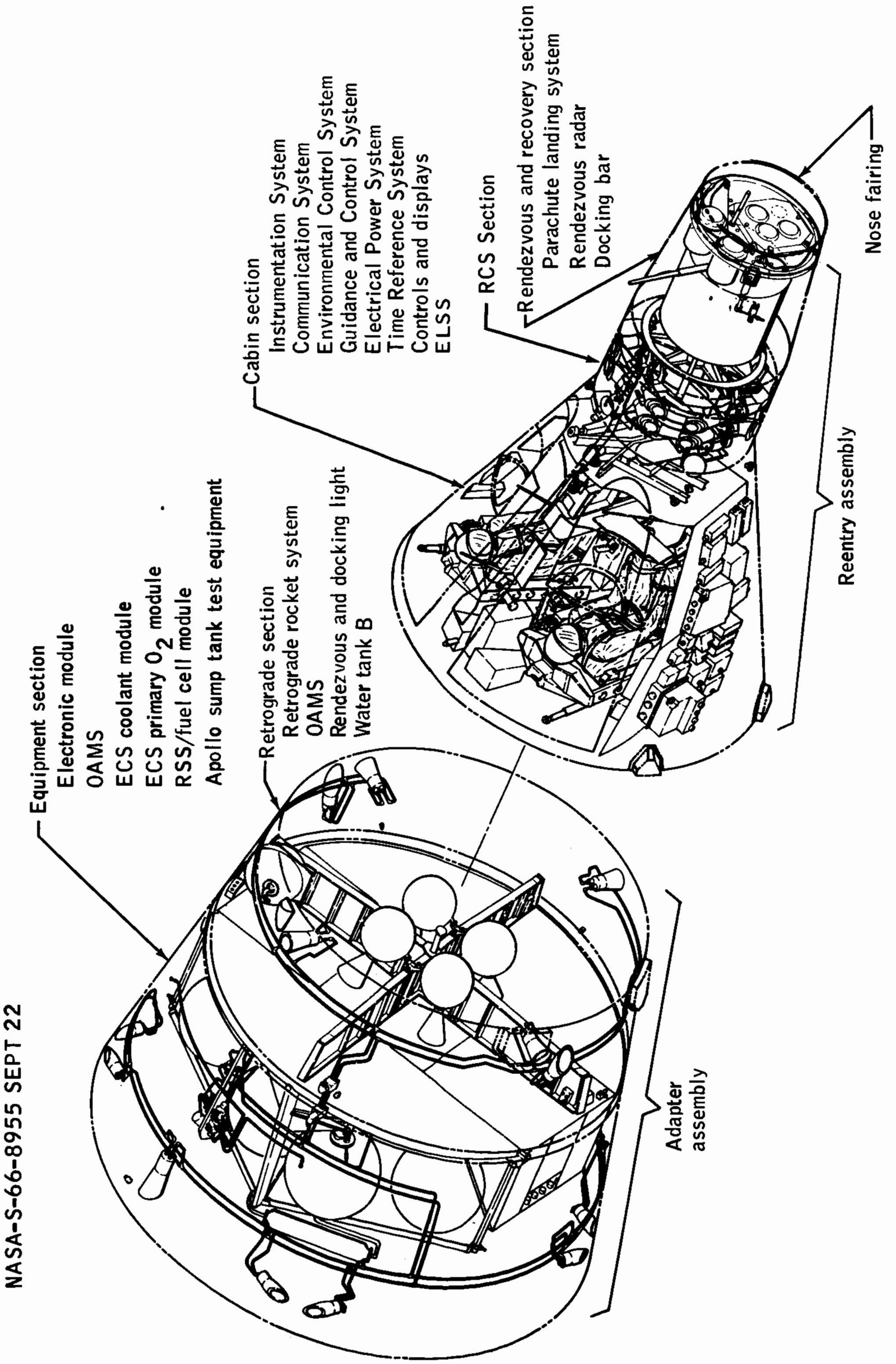

Figure 3.1-1. - Spacecraft arrangement and nomenclature.

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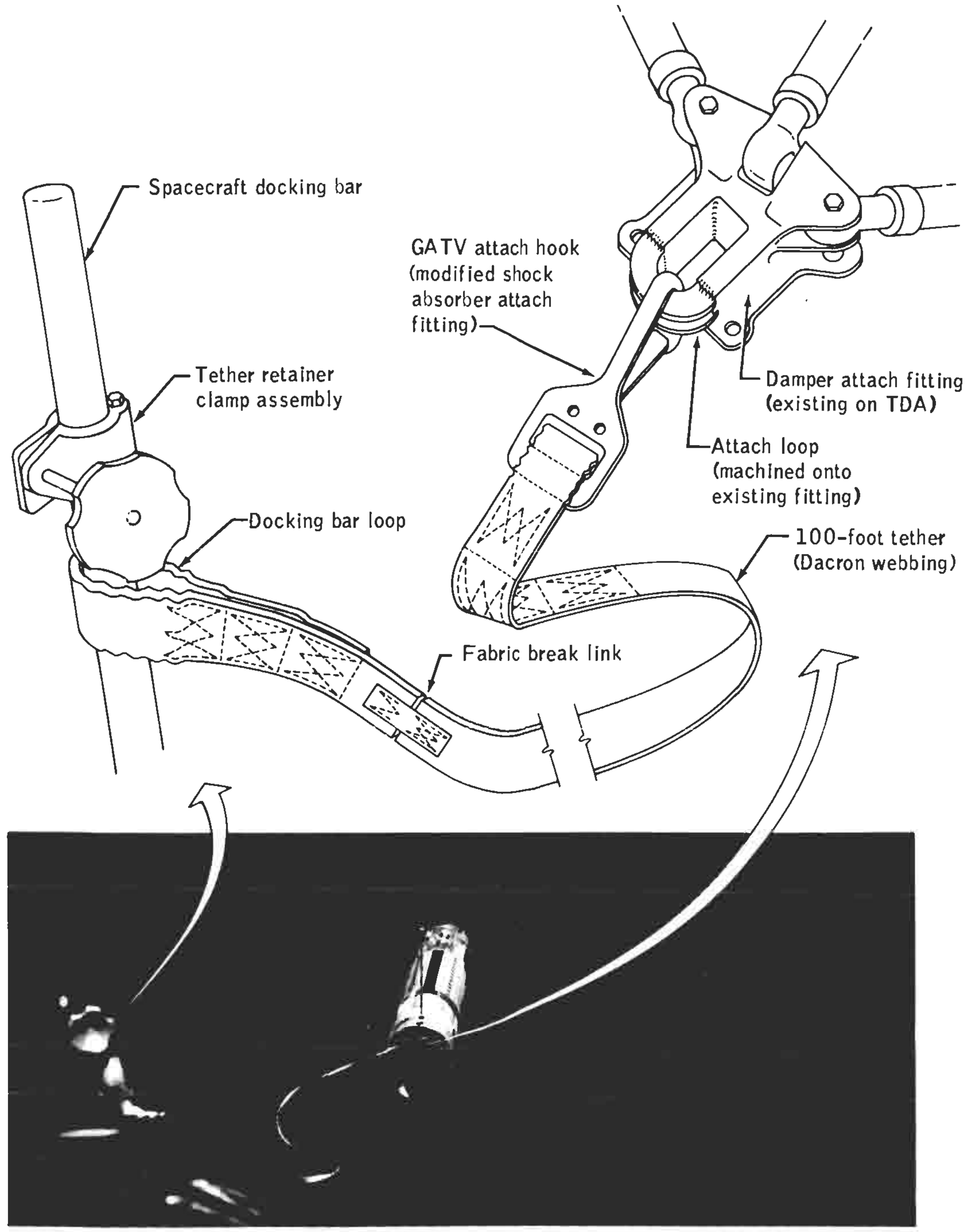

Figure 3.1-2. - Tethered vehicle evaluation equipment.

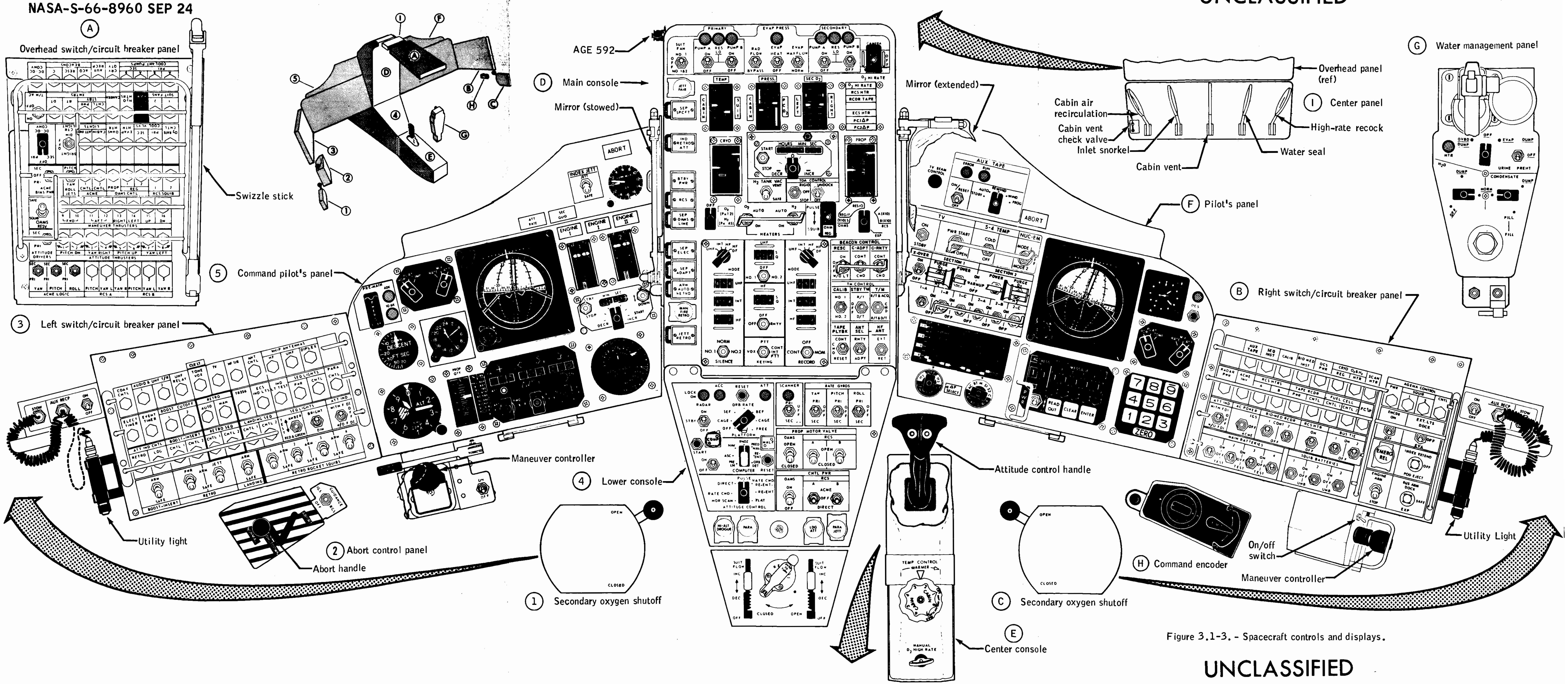

Figure 3.1-3. - Spacecraft controls and displays.

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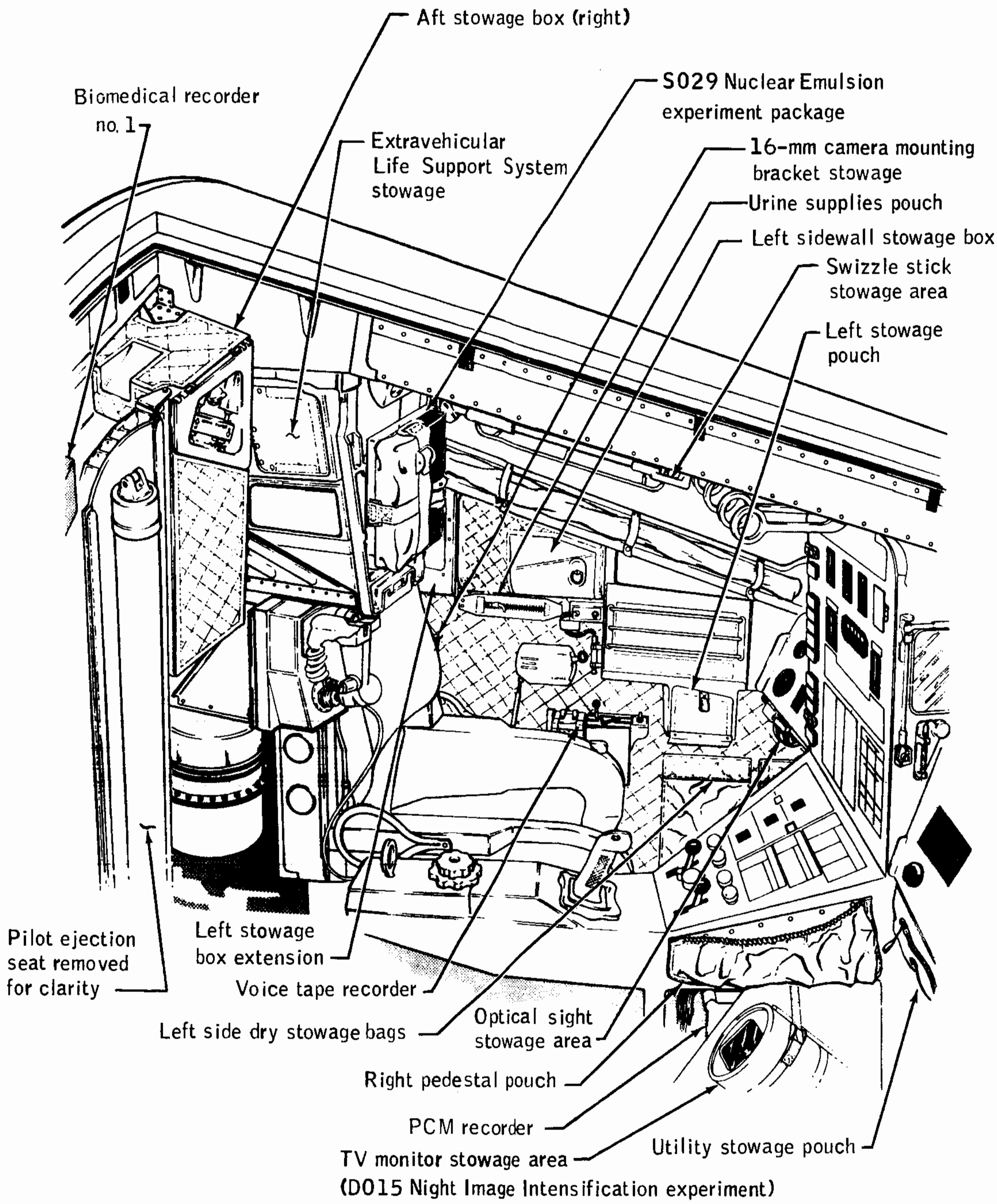

(a) View looking into command pilot's side.

Figure 3.1-4. - Spacecraft interior stowage areas.

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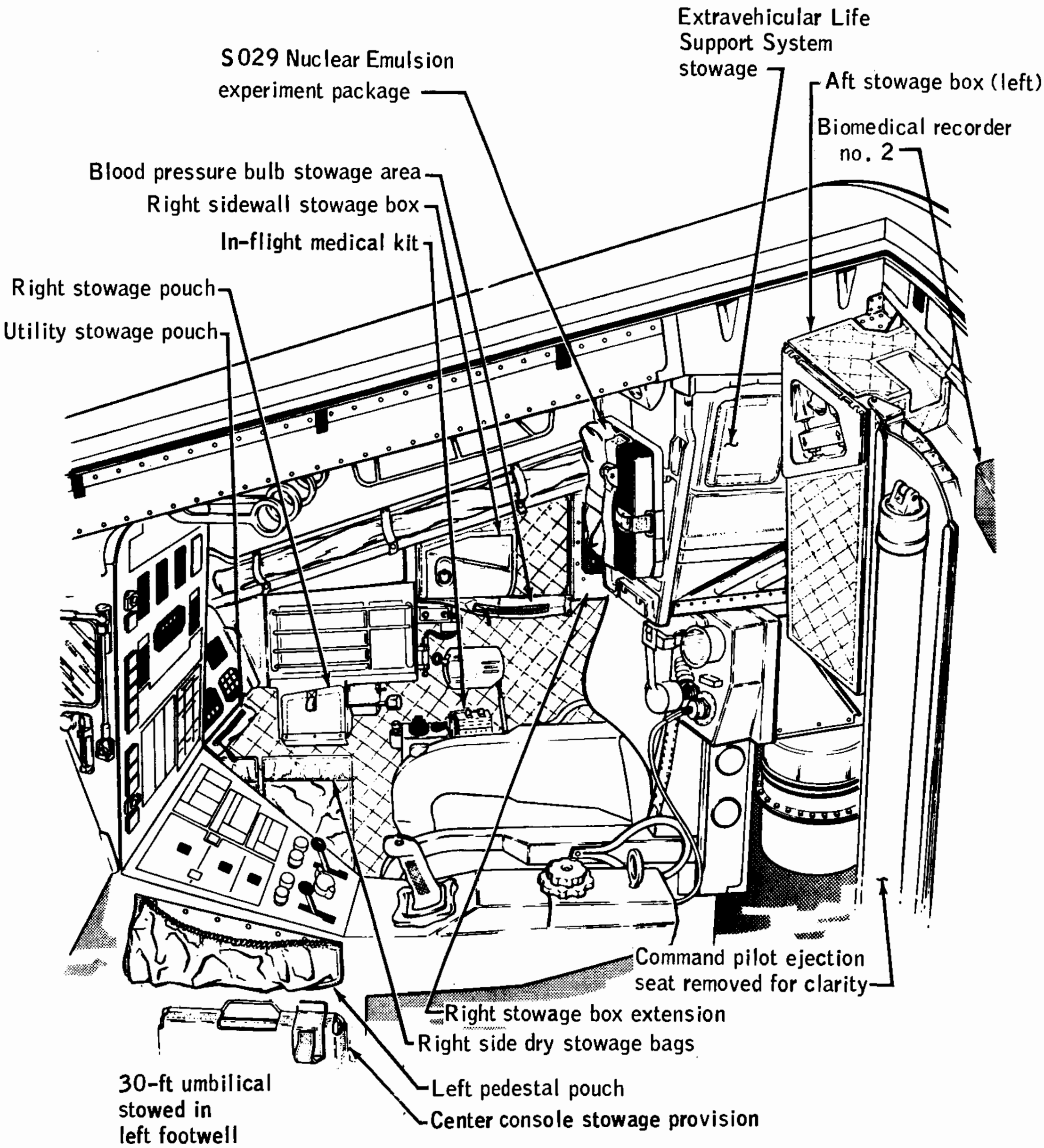

(b) View looking into pilot's side.

Figure 3.1-4. - Concluded.

3.2 GEMINI LAUNCH VEHICLE

Gemini Launch Vehicle (GLV) 11 was of the same basic configuration as the GLV's used for all previous Gemini missions, and there were no significant differences between GLV-11 and GLV-10.

3.3 GEMINI SPACE VEHICLE WEIGHT AND BALANCE DATA

Weight and balance data for the Gemini XI Space Vehicle are as follows:

Condition	Weight (including spacecraft), lb (a)	Center-of-gravity location, in. (a), (b)		
		X	Y	Z
Stage I ignition	347 283	774.7	-0.050	59.975
Lift-off	343 469	775.0	-0.050	59.975
First-stage engine cutoff (BECO)	87 367	442.0	-0.175	59.950
Second-stage start of steady-state combustion	74 618	343.0	-0.050	59.93
Second-stage engine cutoff (SECO)	14 177	281.0	-0.140	59.695

[a]Weights and center-of-gravity data were obtained from the GLV contractor.

[b]Refer to figure 3.0-1 for the Gemini Space Vehicle coordinate system. Along the X-axis, the center of gravity is referenced to GLV station 0.00. Along the Y-axis, the center-of-gravity location is referenced to buttock line 0.00 (vertical centerline of horizontal vehicle). Along the Z-axis, the center of gravity is referenced to waterline 0.00 (60 inches below the horizontal centerline of the horizontal vehicle).

Spacecraft 11 weight and balance data are as follows:

Condition	Weight, lb	Center-of-gravity location, in. (a)		
		X	Y	Z
Launch, gross weight	8374	-0.95	1.87	103.87
Retrograde	5577	0.23	-1.36	129.72
Reentry (0.05g)	4734	0.16	-1.52	136.92
Main parachute deployment	4340	0.13	-1.64	130.06
Touchdown (no parachute)	4230	0.14	-1.70	127.97

[a]Refer to figure 3.0-1 for spacecraft coordinate system. The X-axis and the Y-axis are referenced to the centerline of the spacecraft. The Z-axis is referenced to a plane located 13.44 inches aft of the launch vehicle/spacecraft separation plane.

3.4 GEMINI AGENA TARGET VEHICLE

Gemini Agena Target Vehicle (GATV) 5006 was of the same configuration as GATV 5005 used for the Gemini X mission (ref. 11). The only significant differences were in the Target Docking Adapter (TDA) and these were as follows:

(a) A 100-foot-long Dacron webbing to tether the GATV to the spacecraft was stowed in a fiber glass container.

(b) A hook (fig. 3.1-2) was installed for attaching the tether to the GATV.

(c) Two handholds were installed adjacent to the tether container for use by the extravehicular pilot.

(d) A stowage area was provided for the spacecraft docking bar mirror.

(e) The micrometeorite collection package for Experiment S010 was not installed.

(f) The electrostatic discharge devices (three beryllium fingers) were removed.

3.5 TARGET LAUNCH VEHICLE

Target Launch Vehicle (TLV) 5306 was an Atlas Standard Launch Vehicle (SLV-3) and was of the same configuration as TLV 5305 used for the Gemini X mission (ref. 11).

3.6 GEMINI ATLAS-AGENA TARGET VEHICLE

WEIGHT AND BALANCE DATA

Weight and balance data for the Gemini Atlas-Agena Target Vehicle are as follows:

Condition	Weight (including GATV), lb	Center-of-gravity location, in. (a)		
		X	Y	Z
Ignition	280 487	--	--	--
Lift-off	278 080	821.1	-0.5	-0.4
Booster engine cutoff (BECO)	73 701	849.5	-1.7	-1.5
Sustainer engine cutoff (SECO)	26 294	549.4	-2.0	-3.3
Vernier engine cutoff (VECO)	26 075	544.1	-2.1	-3.4

[a]Refer to figure 3.0-2(c) for GAATV coordinate system.

Gemini Agena Target Vehicle weight and balance data are as follows:

Condition	Weight, lb	Center-of-gravity location, in. (a), (b)		
		X	Y	Z
Launch (including shroud)	18 105	--	--	--
Separation	17 694	337.0	0.0	-0.1
Insertion weight (after insertion firing)	7 198	343.3	0.0	-0.1

[a]Refer to figure 3.0-2(b) for GATV coordinate system.

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4.0 MISSION DESCRIPTION

4.1 ACTUAL MISSION

The Gemini XI mission was initiated when the Gemini Atlas-Agena Target Vehicle (GAATV) lifted off at 13:05:01.725 G.m.t. on September 12, 1966. The Gemini Agena Target Vehicle (GATV) achieved a nearly circular orbit with a perigee of 156 nautical miles and an apogee of 166 nautical miles. One hour 37 minutes 24.821 seconds after the GAATV lift-off, the Gemini Space Vehicle was launched within the 2-second launch window available for an M=1 (first spacecraft revolution) rendezvous with the GATV. The mission is outlined in figure 4.1-1, which shows both the planned and the actual mission activities.

Maneuvers for the M=1 rendezvous were successfully accomplished as planned, and, at 1 hour 25 minutes ground elapsed time (g.e.t.), the crew reported station keeping with the GATV at a range of 50 feet. Docking was accomplished about nine minutes later.

After docking, the crew performed various sequences of the D003 Mass Determination experiment, S026 Ion-Wake Measurement experiment, and S009 Nuclear Emulsion experiment. The S029 Libration Regions Photography experiment originally scheduled for this period was not performed because, as a result of the 3-day delay to the mission, the Milky Way obscured the libration region. As an alternate to this experiment, the crew took pictures of the gegenschein and of two comets. Each crewman successfully conducted two dockings, one in daylight and one in darkness.

Following conclusion of the first eat and sleep period, the S011 Airglow Horizon Photography experiment and the Apollo sump tank test were conducted.

Preparations for the umbilical extravehicular activity (EVA) were initiated at 20 hours 10 minutes g.e.t. Four hours later, the pilot egressed the cabin, retrieved the S009 Nuclear Emulsion experiment package, and attached the GATV tether to the spacecraft docking bar. This task was difficult and very tiring, and the umbilical EVA period was terminated early due to pilot fatigue. Approximately one hour after termination of the EVA, the hatch was reopened and the umbilical EVA equipment was jettisoned. Because of the shortened EVA period, the D016 Minimum Reaction Power Tool Evaluation experiment and Apollo sump tank camera retrieval were not performed. The second eat and sleep period followed the equipment jettison.

In revolution 26, the GATV primary propulsion system (PPS) was used to increase the apogee of the docked vehicles to 741.5 nautical miles. While the docked vehicles were at this altitude, sequences of photographic experiments S011 Airglow Horizon Photography, S005 Synoptic Terrain Photography, and S006 Synoptic Weather Photography were conducted. The S026 Ion-Wake Measurement and S004 Radiation and Zero-G Effects on Blood and Neurospora experiments were also conducted during this period. In revolution 28, the GATV PPS was used to lower the apogee to 164.2 nautical miles.

Preparations for the standup EVA began at approximately 44 hours 40 minutes g.e.t., about 1 hour and 20 minutes before the scheduled start of the EVA. The cabin was depressurized and the standup EVA was accomplished as planned. During the standup EVA period, the S013 Ultraviolet Astronomical Camera experiment was performed and several photographs were taken for the S005 Synoptic Terrain Photography experiment.

One revolution after the conclusion of the standup EVA, a tether evaluation was initiated when the crew undocked the spacecraft from the GATV and deployed the tether. The gravity-gradient mode of the tether evaluation was not completed because the desired starting conditions could not be obtained in the allocated time. A successful rotational mode of 38 deg/min was started, and, about an hour and a half later, the rate was increased to approximately 55 deg/min. The evaluation was concluded about an hour after the speed-up by maneuvering the spacecraft to remove the tension from the tether and then jettisoning the docking bar, releasing the tether. The quantity of propellants used during planned activities was less than expected and a coincident-orbit rendezvous was planned in real time. After station keeping for a short period, a separation maneuver was performed using the spacecraft propulsion system. A calibration sequence of the D003 Mass Determination experiment was conducted in conjunction with the separation maneuver. Subsequently, a stand-off maneuver was performed to place the spacecraft in a coincident orbit with a lagging phase angle to the GATV. The D015 Night Image Intensification experiment was performed during the following two night periods prior to the beginning of the third eat and sleep period. After this period, sequences of the S030 Dim Sky Photographs/Orthicon and S004 Radiation and Zero-G Effects on Blood and Neurospora experiments were conducted.

During revolution 41, the initial intercept maneuver for the coincident-orbit rendezvous with the GATV was accomplished. At this time the spacecraft was approximately 24 nautical miles behind the GATV. The rendezvous was culminated at 66 hours 40 minutes g.e.t., when station keeping with the GATV was initiated at a range of 40 feet. Approximately one hour after a final separation maneuver of 3 ft/sec, the crew deactivated the S004 Radiation and Zero-G Effects on Blood and Neurospora experiment.

The spacecraft preretrofire orbit was such that a true anomaly adjust maneuver was not required. Retrofire was initiated automatically and occurred at the planned time of 70:41:36 g.e.t. Reentry was nominal using automatic control of the Reentry Control System (RCS), and the spacecraft landed less than three nautical miles from the planned landing point and within two and a half nautical miles of the prime recovery ship, the U.S.S. Guam. The crew elected to be brought aboard the U.S.S. Guam by helicopter, and 24 minutes after landing they were on the deck of the ship.

After spacecraft landing, the GATV secondary propulsion system (SPS) was used to accomplish two height-adjust maneuvers during revolutions 47 and 48 and an SPS Unit II overspecification maneuver during revolution 58. The planned firing of the PPS to propellant depletion was not initiated because of unpredictable vehicle attitudes caused by faulty signals from the GATV horizon sensor. The final orbit-adjust maneuver could not be performed because all of the attitude control gas was used during an attempt to locate the trouble in the horizon sensor.

At 12:45 G.m.t., September 16, 1966, the Mission Control Center-Houston and the Manned Space Flight Network terminated full support of the GATV. The Texas network station continued to monitor the GATV until the morning of September 19, 1966, at which time ground station coverage of the Gemini XI mission was terminated. The last GATV orbit tracked during the mission had a perigee of 179.2 nautical miles and an apogee of 189.6 nautical miles.

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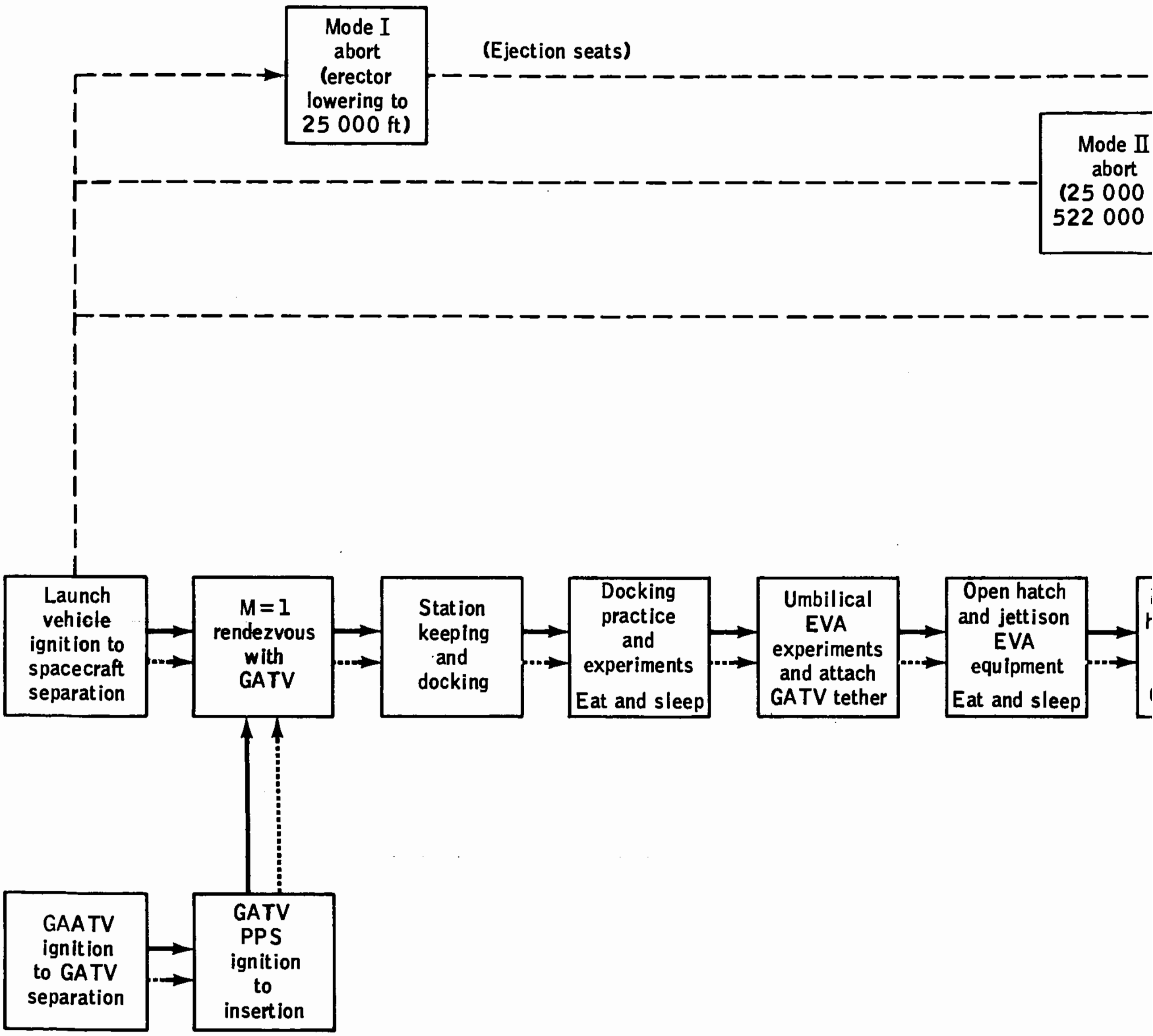

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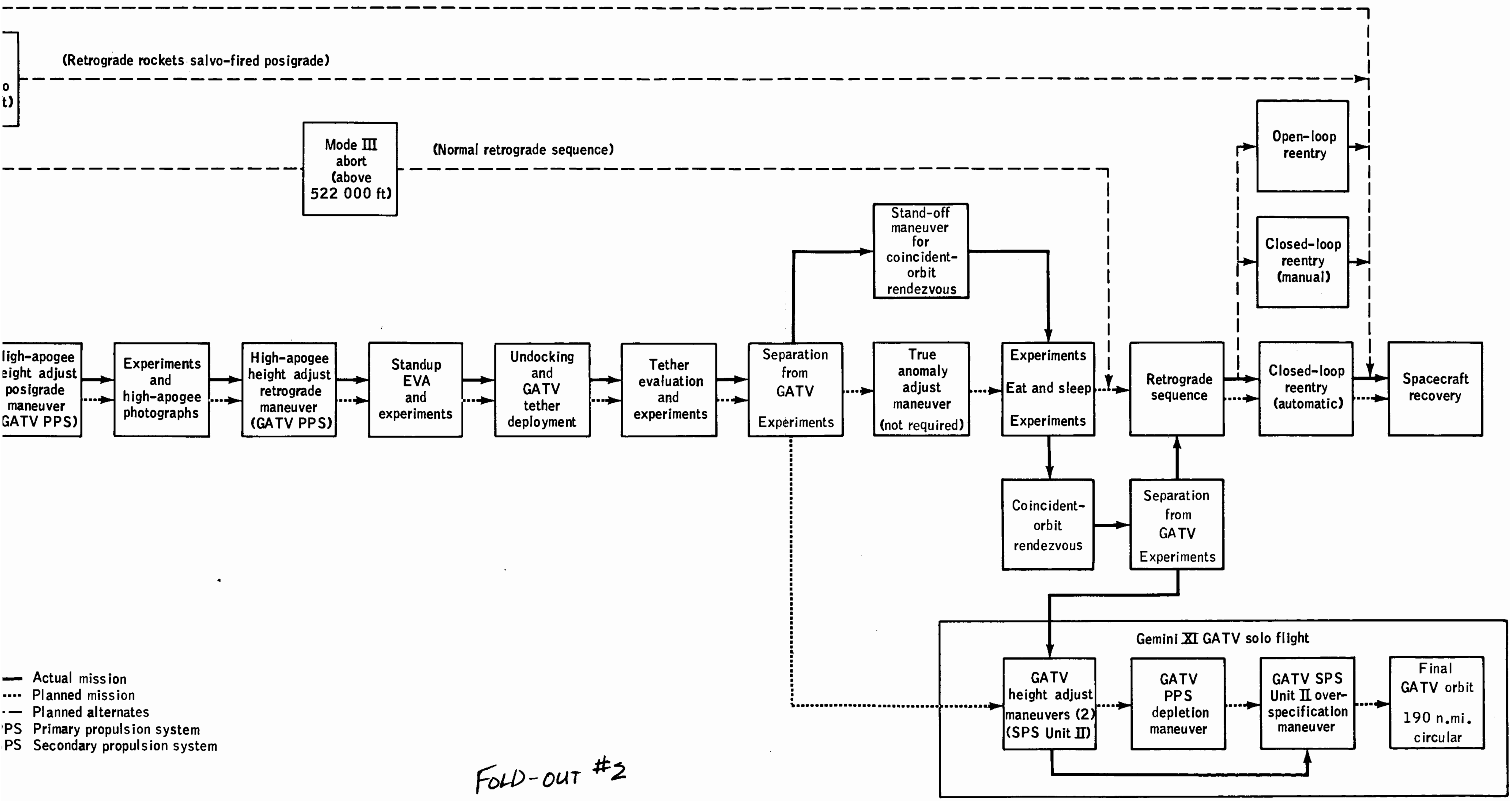

Figure 4-1. - Planned and actual Gemini XI mission with planned alternates included.

4.2 SEQUENCE OF EVENTS

The time at which major events were planned and executed are presented in tables 4.2-I and 4.2-II for the Gemini Space Vehicle and in tables 4.2-III and 4.2-IV for the Gemini Atlas-Agena Target Vehicle.

TABLE 4.2-I.- SEQUENCE OF EVENTS FOR GEMINI SPACE VEHICLE LAUNCH PHASE

Event	Time from lift-off, sec		Difference, sec
	Planned	Actual	
Stage I engine ignition signal (87FS1)	-3.40	-3.24	+0.16
Stage I MDTCPS makes, subassembly 1	-2.30	-2.31	-0.01
Stage I MDTCPS makes, subassembly 2	-2.30	-2.31	-0.01
Shutdown lockout (backup)	-0.10	-0.09	+0.01
Lift-off (pad disconnect separation)	14:42:26.546 G.m.t.		
Roll program start (launch azimuth = 99.9°)	8.40	8.46	+0.06
Roll program end	20.48	20.43	-0.05
Pitch program rate no. 1 start	23.04	22.99	-0.05
Pitch program rate no. 1 end, no. 2 start	88.32	88.13	-0.19
First IGS update initiated	100.00	100.00	0.00
Control system gain change no. 1	104.96	104.73	-0.23
Pitch program rate no. 2 end, no. 3 start	119.04	118.77	-0.27
Second IGS update initiated	140.00	140.00	0.00
Stage I engine shutdown circuitry armed	144.64	144.35	-0.29
Stage I MDTCPS unmake	152.82	153.24	+0.42
BECO (Stage I engine shutdown (87FS2))	152.90	153.30	+0.40
Staging switches actuate	152.90	153.30	+0.40
Signals from Stage I rate gyro package to Flight Control System discontinued	152.90	153.30	+0.40
Hydraulic switchover lockout	152.90	153.30	+0.40
Telemetry ceases, Stage I	152.90	153.30	+0.40
Staging nuts detonate	152.90	153.30	+0.40
Stage II engine ignition signal (91FS1)	152.90	153.30	+0.40
Control system gain change	152.90	153.30	+0.40
Stage II engine MDFJPS make	153.80	153.98	-0.18
Stage separation begin	154.20	142.02	+0.18
Pitch program rate no. 3 end	162.56	162.20	-0.36
RGS guidance enable	162.56	162.20	-0.36
First guidance command signal received by TARS	169.00	168.35	-0.65
Stage II engine shutdown circuitry armed	317.44	316.71	-0.73
SECO (Stage II engine shutdown (91FS2))	339.68	340.30	+0.62
Redundant Stage II shutdown	339.68	340.33	+0.65
Stage II MDFJPS break	339.98	340.44	+0.46
Spacecraft separation (shape charge fired)	359.68	361.02	+1.34
OAMS on	359.68	360.30	+0.62
OAMS off[a]	389.68	465.30	+75.62

[a]During a 105-second time interval, several maneuvers were made: a separation maneuver of 2 seconds, an Insertion Velocity Adjust Routine (IVAR) maneuver of 53 seconds, and a radial maneuver of 15 seconds.

TABLE 4.2-II.- SEQUENCE OF EVENTS FOR GEMINI SPACECRAFT

ORBITAL AND REENTRY PHASES

Event	Ground elapsed time, hr:min:sec		Difference, sec
	Planned[a]	Actual	
Plane change maneuver	00:29:40	00:29:40	0
Terminal phase initiate maneuver	00:49:43	00:49:58	+15
First midcourse correction	--	01:03:41	--
Second midcourse correction	--	01:15:43	--
Braking maneuver	01:20:53	01:17:41	-192
Docked calibration maneuver (GATV PPS)	04:28:48	04:28:48	0
Docked height adjust maneuver (GATV PPS)	40:30:15	40:30:15	0
Docked height adjust maneuver (GATV PPS)	43:52:55	43:52:55	0
Separation maneuver	53:24:56	53:24:58	+2
Stand-off maneuver	54:37:27	54:37:28	+1
Terminal phase initiate maneuver	65:27:21	65:27:22	+1
First midcourse correction	66:30:36	66:30:36	0
Braking maneuver	66:38:57	66:34:43	-254
Separation maneuver	66:55:00	66:52:31	-149
Adapter equipment section separation	70:40:36	70:39:46	-50
Retrofire initiation	70:41:36	70:41:36	0
Begin blackout	71:04:24	71:04:00	-24
End blackout	71:09:22	71:09:34	+12
Drogue parachute deployment	71:11:15	71:11:29	+14
Pilot parachute deployment, main parachute initiation	71:12:50	71:13:08	+18
Landing	71:16:50	71:17:08	+18

[a]The planned values for the orbital phase are the latest information forwarded to the crew prior to each maneuver.

TABLE 4.2-III.- SEQUENCE OF EVENTS FOR GAATV LAUNCH PHASE

Event	Time from lift-off, sec		Difference, sec
	Planned	Actual	
Lift-off	13:05:01.725 G.m.t.		
Booster engine cutoff (BECO)	130.00	130.80	+0.80
Booster engine separation (BECO + 3.0 sec)	133.00	133.80	+0.80
Primary sequencer (D-timer) start	276.91	278.00	+1.09
Sustainer engine cutoff (SECO)	280.44	279.60	-0.84
Vernier engine cutoff (VECO)	298.79	298.00	-0.79
TLV/GATV separation (retrorocket fire)	301.00	301.13	+0.13
Initiate horizon sensor roll control	303.50	302.80	-0.70
Start 90 deg/min pitch-down	337.91	339.00	+1.09
Stop 90 deg/min pitch-down	350.91	352.00	+1.09
Start 3.99 deg/min orbital pitch rate	350.91	352.00	+1.09
SPS ignition	352.91	354.08	+1.17
Open PPS gas generator valve	370.91	372.04	+1.13
PPS ignition (90-percent chamber pressure)	371.41	373.21	+1.80
SPS thrust cutoff	372.91	374.03	+1.12
Fire jettison nose shroud squibs	380.91	382.80	+1.89
Velocity meter cutoff	557.16	558.37	+1.21
PPS thrust cutoff backup	565.00	568.03	+3.03

TABLE 4.2-IV.- SEQUENCE OF EVENTS FOR GATV ORBITAL PHASE

Event	Ground elapsed time, hr:min:sec		Difference, sec
	Planned[a]	Actual	
Docked plane change maneuver (GATV PPS)	04:28:48	04:28:48	0
Docked height adjust maneuver (GATV PPS)	40:30:15	40:30:15	0
Docked height adjust maneuver (GATV PPS)	43:52:55	43:52:55	0
Height adjust maneuver (GATV SPS)	75:32:25	75:32:26	+1
Height adjust maneuver (GATV SPS)	76:15:37	76:15:38	+1
Plane change maneuver (GATV SPS)	92:15:58	92:15:58	0

[a]The planned values are the latest times computed on the ground.

4.3 FLIGHT TRAJECTORIES

In this section, the launch and orbital trajectories referred to as planned are either preflight calculated nominal trajectories (refs. 13 through 15) or trajectories based on nominal outputs from the Real Time Computer Complex (RTCC) at the Mission Control Center-Houston (MCC-H) using planned attitudes and sequences as determined in real time in the Auxiliary Computer Room (ACR). The actual trajectories are based on Manned Space Flight Network tracking data and actual attitude and sequences as determined from airborne instrumentation. For all trajectories except the launch phase, the Patrick Air Force Base atmosphere was used for altitudes below 25 nautical miles, and the 1959 ARDC model atmosphere was used for altitudes above 25 nautical miles. The current atmosphere, as measured up to 25 nautical miles altitude at the time of launch, was used for the launch phase. The earth model for all trajectories contained geodetic and gravitational constants representing the Fischer ellipsoid. Ground tracks of the first two spacecraft revolutions, the coincident-orbit rendezvous revolution, and the period from retrofire to spacecraft landing are shown in figure 4.3-1. The Gemini Space Vehicle launch trajectory and related information and the spacecraft orbit, rendezvous, and reentry data are presented in figures 4.3-2 through 4.3-5. The Gemini Atlas-Agena Target Vehicle (GAATV) launch trajectory data are presented in figure 4.3-6.

4.3.1 Gemini Space Vehicle

4.3.1.1 Launch.- The Gemini Space Vehicle was launched on a rendezvous launch azimuth of 99.9 degrees. The nominal azimuth calculated prior to the GAATV launch was 100.05 degrees, but minor deviations in the GAATV launch trajectory required a shift of 0.15 of a degree in launch azimuth to effect a nominal rendezvous. The flight-controller plotboards indicated a satisfactory launch trajectory. The launch trajectory data shown in figure 4.3-2 are based on the real-time output of the Range Safety Impact Prediction Computer (IP 3600) and the Guided Missile Computer Facility (GMCF). The IP 3600 used data from the Missile Trajectory Measurement System (MISTRAM) and from the FPS-16 radar. The GMCF used data from the GE MOD III radar. Data from these tracking facilities were used during the time periods shown in the following table:

Facility	Time from lift-off, sec
IP 3600 (FPS-16)	0 to 8
GMCF (GE MOD III)	8 to 390

The actual launch trajectory, compared with the planned launch trajectory (fig. 4.3-2), was nominal in altitude, slightly off in flight-path angle, and low in velocity during first stage powered flight. At first stage engine cutoff (BECO), the altitude and velocity were low by 184 feet and 131 ft/sec, respectively, and the flight-path angle was high by 0.09 of a degree. After BECO, the Radio Guidance System (RGS) corrected the errors accumulated during first stage flight and guided the second stage to a satisfactory insertion of the spacecraft. At second stage engine cutoff (SECO), the altitude, flight-path angle, and velocity were low by 333 feet, 0.01 of a degree, and 3 ft/sec, respectively. At spacecraft separation, the altitude and flight-path angle were low by 262 feet and 0.01 of a degree, respectively, but the velocity was low by 8 ft/sec which indicates that the added ΔV from tail-off was 5 ft/sec less than expected.

Table 4.3-I contains a comparison of planned and actual conditions at BECO, SECO, spacecraft separation, and insertion. The actual conditions at BECO and the preliminary conditions at SECO were obtained from C-band tracking data as output from the IP 3600. The preliminary conditions at spacecraft separation and insertion were obtained by integrating the tracking vector from the Ascension Island ground station back through the insertion maneuver. The actual conditions at SECO, spacecraft separation, and insertion were obtained by integrating the best-estimated-trajectory vector back through the insertion maneuver and the actual tail-off impulse as determined from telemetry records of Inertial Guidance System data. (NOTE: The best-estimated trajectory was based on tracking data obtained during the first revolution.)

The GE MOD III tracking data and the MISTRAM radar tracking data after SECO were used to compute a go/no-go for spacecraft insertion by averaging 10 seconds of data starting at SECO + 5 seconds. The go/no-go conditions obtained from GE MOD III showed no difference in velocity and a flight-path angle that was low by 0.05 of a degree, when compared with the more accurate orbital ephemeris data. The conditions obtained by MISTRAM showed the velocity to be high by 4 ft/sec and the flight-path angle to be low by 0.09 of a degree, when compared with the later ephemeris data.

4.3.1.2 Orbit.- The main objective of the Gemini XI mission was to rendezvous during the first spacecraft revolution and dock with the GATV; therefore, the orbit phase will be described in more detail in the rendezvous section, paragraph 4.3.1.2.1 Table 4.3-II and figure 4.3-3 show the planned and actual orbital elements after each maneuver, and table 4.3-III shows the orbital elements for selected revolutions from insertion to retrofire. The planned elements shown in tables 4.3-II 4.3-IV were obtained from Gemini tracking network data as calculated in real time by the RTCC. The actual elements were obtained after the mission by integrating the Gemini tracking network vectors after each midcourse and terminal phase maneuver.

4.3.1.2.1 First rendezvous: The planned trajectory and the actual trajectory for the first revolution (M=1) rendezvous are presented in figure 4.3-4. The planned, ground-commanded, and actual maneuvers are presented in table 4.3-IV. The planned trajectory for the rendezvous was obtained from the real-time solution based on the vector from the Eglin Air Force Base Station for GATV revolution 1 and on the vector from the Ascension Island tracking station for spacecraft revolution 1.

Due to the limited tracking during the M=1 rendezvous, the planned and ground-commanded maneuvers were identical. The actual trajectory during the initial rendezvous was reconstructed utilizing anchor vectors (obtained from the best estimated trajectory) and the actual maneuvers (derived from the Inertial Guidance System (IGS) postflight analysis) applied as instantaneous changes in velocity.

After spacecraft orbital insertion, ground computations, based on the vector from the Antigua Island tracking station, indicated a nearly nominal situation for obtaining a first-orbit rendezvous, except for an azimuth bias on the radar data which indicated a required out-of-plane maneuver of 100 ft/sec at terminal phase initiate (TPI). These data from the Antigua station were considered in error because all data obtained during the launch phase indicated no out-of-plane dispersions.

The initial rendezvous was recomputed using the vector from the Ascension station for spacecraft revolution 1, and a very small out-of-plane maneuver at TPI was indicated. This information was passed to the crew for the TPI backup solution.

At spacecraft insertion, the range between Spacecraft 11 and the GATV was 232 nautical miles. At 29 minutes 40 seconds g.e.t., a 3 ft/sec out-of-plane maneuver was initiated. This maneuver had not been computed on the ground because, by the time the data from the Antigua station had been determined to be erroneous, not enough time remained for the computation.

The TPI maneuver was initiated at 49 minutes 58.2 seconds g.e.t., approximately 90 seconds prior to the relative apogee. The range from the spacecraft to the GATV was approximately 21 nautical miles. A total ΔV of 143.9 ft/sec was applied. In computer coordinates, the actual ΔV applied resulted in a ΔV_X of 141.0 ft/sec, a ΔV_Y of 28.3 ft/sec, and a ΔV_Z of 4.8 ft/sec. The ground-commanded TPI solution indicated that TPI should occur at 49 minutes 43 seconds g.e.t. with a ΔV of 140.8 ft/sec to be applied. In computer coordinates, the ground-commanded ΔV resulted in a ΔV_X of 139.6 ft/sec, a ΔV_Y of 17.0 ft/sec, and a ΔV_Z of minus 6.6 ft/sec.

For the first midcourse correction, the spacecraft onboard computer called for 1 ft/sec forward, 4 ft/sec up, and 4 ft/sec right in spacecraft body coordinates. The actual first midcourse correction applied resulted in a ΔV_X of 2.0 ft/sec, a ΔV_Y of minus 3.4 ft/sec, and a ΔV_Z of minus 3.9 ft/sec, which resolves into 1.3 ft/sec forward, 3.5 ft/sec up, and 4.1 ft/sec right, assuming a boresighted target. This correction was initiated at 1:03:41 g.e.t.

The second midcourse correction was initiated at 1:15:43 g.e.t. The backup computation for this correction was used because the radar angle data appeared to be in error, thus causing the onboard computer solution to be in error. The onboard charts predicted 2.0 ft/sec forward and 1.0 ft/sec up in spacecraft body coordinates. When actually applied, this correction was ΔV_X of minus 0.9 ft/sec, ΔV_Y of minus 1.8 ft/sec, and ΔV_Z of minus 0.5 ft/sec in computer coordinates, which resolves into 1.7 ft/sec forward, 0.9 ft/sec up, and 0.8 ft/sec right.

The terminal phase finalize (TPF) maneuver was initiated at 1:17:41 g.e.t., and braking thrusts were applied intermittently over the next eight minutes. At 1 hour 25 minutes g.e.t., the spacecraft was less than 50 feet from the GATV, and station keeping had been initiated. The total propellant cost of the M=1 rendezvous, including all maneuvers and attitude control between spacecraft separation and station keeping, was approximately 405 pounds. Approximately 113 pounds was used for the final braking maneuver. This total cost of 405 pounds compares to a 1-sigma fuel penalty.

4.3.1.2.2 Second rendezvous: The planned trajectory and the actual trajectory for the second (coincident orbit) rendezvous with the GATV are presented in figure 4.3-4. The planned, ground-commanded, and actual maneuvers are presented in table 4.3-IV.

The planned trajectories for both vehicles for the second rendezvous were obtained from the real-time solution based on the vector from the Pretoria tracking station for GATV revolution 34. (That is, the spacecraft and the GATV were assumed to be in the same orbit prior to the separation maneuver). The ground-commanded maneuvers were determined from various vectors for the spacecraft and GATV as the planned maneuvers were updated after each actual maneuver. The actual trajectory during the rendezvous was reconstructed utilizing anchor vectors obtained from the best estimated trajectory, and the actual maneuvers as derived from IGS postflight analysis. The onboard radar was not operational during the second rendezvous, and no radar data are available to compare with the simulated actual trajectory.

The coincident-orbit rendezvous was initiated at 53:24:57.5 g.e.t., with a 9.3 ft/sec posigrade and radially upward separation maneuver. The separation maneuver provided the spacecraft with a negative phase rate so that the spacecraft started trailing the GATV. The separation maneuver was followed by a stand-off maneuver at 54:37:28 g.e.t. This 9.7 ft/sec retrograde and radially upward maneuver was supposed to have placed the spacecraft in the same orbit as the GATV and with no relative rates between the two vehicles. Tracking immediately following the stand-off maneuver indicated that the separation and stand-off maneuvers had provided the spacecraft with a 16.6 nautical mile trailing displacement with no relative rates. The planned maneuver was to place the spacecraft 15 nautical miles behind the GATV with no relative rates. Later calculations based on data from the Hawaii station for GATV revolution 36 and from the Ascension station for spacecraft revolution 37 indicated that the spacecraft trailed the GATV by 20.8 nautical miles instead of the 16.6 nautical miles. Data from the Hawaii station for GATV revolution 36 and from the Ascension station for spacecraft revolution 38 indicated the same 20.8 nautical mile range and that the predicted range at the time of TPI would be 23.9 nautical miles. Data for revolution 36 from both the Hawaii and Canary Island stations predicted a range of 23.8 nautical miles at TPI. Data from the Carnarvon station for GATV revolution 41 and from the Woomera station for spacecraft revolution 41 predicted a range of 25.1 nautical miles at TPI. Data from the Carnarvon station for GATV revolution 41 and from the Antigua station for spacecraft revolution 41 predicted a range of 24.9 nautical miles at TPI.

These variations in the range predicted at TPI indicate that the ground solutions were in error in velocity or that some venting or other perturbation caused this anomaly. However, by the time of the vector from the Carnarvon station for GATV revolution 41 and the vector from the Antigua station for spacecraft revolution 41, the ground solution was very accurate. These vectors were used for the computation of the 292-degree ωt (angle of orbit travel to rendezvous) TPI solution, which was passed to the crew from the Canary Island station during spacecraft revolution 41. The ground-commanded maneuver required an initiation time of 65:27:21 g.e.t. The computer coordinates for the maneuver were a ΔV_X of minus 8.7 ft/sec, a ΔV_Y of 12.1 ft/sec, and a zero ΔV_Z. The actual maneuver was performed at 65:27:22 g.e.t. with a ΔV_X of minus 8.8 ft/sec, a ΔV_Y of 11.9 ft/sec, and a ΔV_Z of minus 0.1 ft/sec. This maneuver proved to be very accurate: the vector from the Carnarvon station for GATV revolution 42 and from the Woomera station (which was after TPI) for spacecraft revolution 41 indicated a rendezvous miss distance of only 0.2 of a nautical mile.

Because the onboard radar was not operational, the ground computed a 34-degree correction after receiving the vector from the Texas station for GATV revolution 42 and the vector from the Grand Turk station for spacecraft revolution 42. A 34-degree correction of 6.0 ft/sec forward and 2.4 ft/sec right was passed to the crew to be applied at 66:30:36 g.e.t. The 2.4 ft/sec right was disregarded and the crew applied the 6.0 ft/sec forward. The actual maneuver applied at 66:30:36 was a ΔV_X of 1.2 ft/sec, a ΔV_Y of minus 5.8 ft/sec, and a ΔV_Z of 0.12 ft/sec.

The TPF or braking maneuver began at 66:34:43 g.e.t. and continued intermittently over the next three minutes. At 66 hours 40 minutes g.e.t., the spacecraft was less than 100 feet from the GATV, and station keeping had been initiated. The total translation cost of the terminal phase, including TPI and braking, was approximately 66 pounds of propellant.

4.3.1.3 Reentry.- The planned and actual reentry trajectories are shown in figure 4.3-5. The planned trajectory was determined by integrating the vector taken by the Antigua ground station in revolution 43 through the planned retrofire sequences determined by the RTCC, and then using the Math Flow 7 reentry guidance scheme described in reference 16. The Antigua vector, taken one revolution before retrofire, was selected because the retrofire time transmitted to the spacecraft was based on that solution. The actual trajectory was obtained by integrating the vector taken from the White Sands ground station from after retrofire to landing using the Math Flow 7 reentry guidance technique.

The times of the reconstructed reentry trajectory events agree very well with the times of the actual reentry events. The reconstructed time of guidance initiate and roll command agrees within one second of the actual event as recorded by telemetry; the communication blackout times agree within ten seconds of actual blackout; the maximum acceleration loads compare with telemetry data within 0.4g at analogous times; and parachute deployment altitudes at recorded sequence times are in accord with those reported in section 5.1.11. Table 4.3-II contains a comparison of reentry dynamic parameters and landing points. The actual landing point was approximately three nautical miles from the planned landing point. (See section 5.1.5 for a more detailed account of the spacecraft landing coordinates.)

4.3.2 Gemini Atlas-Agena Target Vehicle

4.3.2.1 Launch.- The GAATV was launched on a flight azimuth of 83.32 degrees. Sustainer steering was used to obtain the desired longitude of the ascending node and inclination angle. No booster steering was required. The flight-controller and range-safety plotboards all indicated a satisfactory Target Launch Vehicle (TLV) flight.

The GATV performed as planned, executing the 90 deg/min pitch-down rate after separation and continuing this rate until the D-timer started the minus 3.99 deg/min orbital geocentric pitch rate. The GATV achieved a nearly circular orbit with a perigee of 153.5 nautical miles and an apogee of 163.1 nautical miles.

The launch trajectory data presented in figure 4.3-6 are based on the real-time output of the GMCF, IP 3600, and the Bermuda (BDA) tracking radar. Data from these tracking facilities were used during the time periods listed in the following table:

Facility	Time from lift-off, sec
GMCF (GE MOD III)	0 to 298
IP 3600, BDA (FPS-16, FPQ-6, TPQ-18)	298 to 321
IP 3600, BDA (FPS-16, TPS-18)	321 to 402
IP 3600, BDA (FPS-16)	402 to 609

The actual launch trajectory, as compared with the planned trajectory in figure 4.3-6, was essentially nominal. The differences indicated in table 4.3-V are not representative of errors or dispersions (see section 5.5.5) because the TLV is targeted for coast-ellipse orbital elements, rather than for a specific position and velocity. Table 4.3-VI presents the targeting parameters and osculating elements at TLV vernier engine cutoff (VECO) and GATV insertion.

4.3.2.2 Orbit.- The GATV was placed into the desired orbit for the planned Gemini Space Vehicle launch and spacecraft rendezvous (see paragraph 4.3.1.2.1). Table 4.3-V contains a comparison of the planned and actual insertion conditions of the GATV. The actual conditions were obtained by integrating the vector taken by the Canary Island ground station in the first revolution back to the time of GATV primary propulsion system (PPS) cutoff.

After the conclusion of the spacecraft flight, the GATV secondary propulsion system (SPS) was used to place the GATV in a nearly circular orbit for possible use as a passive target during later missions. Table 4.3-VII contains the maneuvers performed by the PPS while the spacecraft and GATV were in the docked configuration, and by the SPS after spacecraft retrofire. Table 4.3-VIII presents the GATV orbital parameters for selected revolutions from insertion through the parking orbit maneuvers.

4.3.3 Gemini Launch Vehicle Second Stage

The second stage of the Gemini Launch Vehicle was inserted into an orbit with apogee and perigee altitudes of 126.6 and 86.6 nautical miles, respectively. The Gemini network tracking radars and the North American Air Defense (NORAD) network tracking equipment were able to skin-track the second stage during the ensuing 24-hour orbital lifetime. The Goddard Space Flight Center predicted reentry in revolution 16, with a predicted impact point in the Atlantic Ocean off the coast of West Africa.

TABLE 4.3-I.- PLANNED AND ACTUAL GEMINI SPACE VEHICLE AND SPACECRAFT TRAJECTORY PARAMETERS

Condition	Planned[a]	Actual	
		Preliminary	Final
BECO			
Time from lift-off, sec	152.90	153.30	153.30
Geodetic latitude, deg north	28.36	28.36	28.36
Longitude, deg west	79.64	79.65	79.65
Altitude, ft	208 151	207 967	207 967
Altitude, n. mi.	34.2	34.2	34.2
Range, n. mi.	48.9	48.2	48.2
Space-fixed velocity, ft/sec	9 871	9 740	9 740
Space-fixed flight-path angle, deg	19.44	19.53	19.53
Space-fixed heading angle, deg east of north	99.15	98.95	98.95
SECO			
Time from lift-off, sec	339.68	340.30	340.30
Geodetic latitude, deg north	27.04	27.03	27.02
Longitude, deg west	71.97	72.02	71.94
Altitude, ft	527 241	527 073	526 908
Altitude, n. mi.	86.8	86.7	86.7
Range, n. mi.	465.0	462.0	468.9
Space-fixed velocity, ft/sec	25 633	25 628	25 630
Space-fixed flight-path angle, deg	0.01	-0.02	0.00
Space-fixed heading angle, deg east of north	100.91	100.91	100.93
Spacecraft separation			
Time from lift-off, sec	359.68	361.02	361.02
Geodetic latitude, deg north	26.77	26.76	26.74
Longitude, deg west	70.54	70.51	70.46
Altitude, ft	526 945	526 680	526 683
Altitude, n. mi.	86.7	86.7	86.7
Range, n. mi.	543.1	547.0	549.6
Space-fixed velocity, ft/sec	25 714	25 707	25 706
Space-fixed flight-path angle, deg	0.00	0.00	0.01
Space-fixed heading angle, deg east of north	100.59	101.62	101.63

[a]For preflight-calculated nominal trajectories.

TABLE 4.3-I.- PLANNED AND ACTUAL GEMINI SPACE

VEHICLE AND SPACECRAFT TRAJECTORY PARAMETERS - Concluded

Condition	Planned[a]	Actual	
		Preliminary	Final
Spacecraft insertion			
Time from lift-off, sec	400.00	469.00	469.0
Geodetic latitude, deg north	26.18	25.03	25.01
Longitude, deg west	67.69	62.94	62.90
Altitude, ft	526 518	523 630	526 320
Altitude, n. mi.	86.6	86.2	86.6
Range, n. mi.	700.6	969.1	971.6
Space-fixed velocity, ft/sec	25 748	25 748	25 747
Space-fixed flight-path angle, deg	0.02	0.05	0.04
Space-fixed heading angle, deg east of north	102.93	105.11	105.13
Maximum conditions			
Altitude, statute miles	862.0	850.0	851.1
Altitude, n. mi.	750.0	739.4	741.5
Space-fixed velocity, ft/sec	26 305	26 317	26 317
Earth-fixed velocity, ft/sec	24 910	24 922	24 922
Exit acceleration, g	7.2	7.1	7.1
Exit dynamic pressure, lb/sq ft	745	756	756
Reentry deceleration, g (tracking data)	6.4	6.2	6.2
Reentry deceleration, g (telemetry data)	Not applicable	5.8	5.8
Reentry dynamic pressure, lb/sq ft	415.6	407	407
Landing point			
Latitude, north	24 deg 18 min	[b]24 deg 20 min	[c]24 deg 15.4 min
Longitude, west	70 deg 00 min	[b]69 deg 58 min	[c]70 deg 00 min

[a]For preflight-calculated nominal trajectories.

[b]Landing point based on IGS before drogue deploy.

[c]Landing point based on IGS at drogue deploy.

TABLE 4.3-II.- SPACECRAFT/GATV ORBITAL ELEMENTS BEFORE AND AFTER MANEUVERS

Maneuver	Condition	Before maneuver		After maneuver	
		Planned[a]	Actual[b]	Planned[a]	Actual[b]
M=1 rendezvous Plane change	Apogee, n. mi.	149.6	149.2	149.6	149.2
	Perigee, n. mi.	86.6	86.6	86.6	86.6
	Inclination, deg	28.89	28.85	28.89	28.85
	Period, min	88.93	88.92	88.93	88.92
Terminal phase initiate (TPI)	Apogee, n. mi.	149.6	150.6	166.0	165.7
	Perigee, n. mi.	86.6	86.6	150.3	150.6
	Inclination, deg	28.89	28.85	28.85	28.85
	Period, min	88.89	88.99	90.41	90.44
Terminal phase finalize (TPF)	Apogee, n. mi.	166.0	165.7	165.7	163.1
	Perigee, n. mi.	150.3	150.6	156.3	153.7
	Inclination, deg	28.85	28.85	28.86	28.85
	Period, min	90.41	90.44	90.53	90.55
GATV PPS calibration firing (docked)	Apogee, n. mi.	165.7	163.1	166.5	164.2
	Perigee, n. mi.	156.3	153.7	157.6	154.6
	Inclination, deg	28.86	28.85	28.85	28.85
	Period, min	90.53	90.55	90.56	90.55
GATV PPS orbit adjust no. 1 (docked)	Apogee, n. mi.	166.5	164.6	739.4	741.5
	Perigee, n. mi.	157.6	152.2	156.5	156.3
	Inclination, deg	28.85	28.85	28.82	28.85
	Period, min	90.56	90.49	101.42	101.52
GATV PPS orbit adjust no. 2 (docked)	Apogee, n. mi.	739.4	741.5	164.1	164.2
	Perigee, n. mi.	156.5	156.3	156.4	156.0
	Inclination, deg	28.82	28.85	28.86	28.83
	Period, min	101.42	101.52	90.49	90.45
Separation	Apogee, n. mi.	164.1	164.2	165.5	165.6
	Perigee, n. mi.	156.4	156.0	155.5	155.7
	Inclination, deg	28.86	28.83	28.85	28.82
	Period, min	90.49	90.45	90.50	90.47

[a]Planned elements were obtained in real time from the RTCC. Apogee and perigee altitudes are referenced to a spherical earth with Pad 19 as the radius. Period and inclination are osculating elements.

[b]Actual elements are based on the Fischer ellipsoid earth model of 1960. Apogee and perigee are integrated values. Period and inclination are osculating elements.

TABLE 4.3-II.- SPACECRAFT/GATV ORBITAL ELEMENTS BEFORE AND AFTER MANEUVERS - Concluded

Maneuver	Condition	Before maneuver		After maneuver	
		Planned[a]	Actual[b]	Planned[a]	Actual[b]
Stand-off	Apogee, n. mi.	165.5	165.6	164.3	163.8
	Perigee, n. mi.	155.5	155.7	156.0	152.7
	Inclination, deg	28.85	28.82	28.86	28.83
	Period, min	90.50	90.47	90.49	90.41
Coincident-orbit rendezvous TPI	Apogee, n. mi.	164.3	163.8	163.4	161.8
	Perigee, n. mi.	156.0	152.7	150.4	148.3
	Inclination, deg	28.86	28.83	28.83	28.84
	Period, min	90.49	90.41	90.36	90.33
TPF	Apogee, n. mi.	163.4	161.8	164.3	164.0
	Perigee, n. mi.	150.4	148.3	153.9	155.6
	Inclination, deg	28.83	28.84	28.83	28.83
	Period, min	90.36	90.33	90.45	90.45
Separation	Apogee, n. mi.	164.3	164.0	163.7	163.0
	Perigee, n. mi.	153.9	155.6	152.5	151.0
	Inclination, deg	28.83	28.83	28.86	28.84
	Period, min	90.45	90.45	90.41	90.38

[a]Planned elements were obtained in real time from the RTCC. Apogee and perigee altitudes are referenced to a spherical earth with Pad 19 as the radius. Period and inclination are osculating elements.

[b]Actual elements are based on the Fischer ellipsoid earth model of 1960. Apogee and perigee are integrated values. Period and inclination are osculating elements.

TABLE 4.3-III.- SPACECRAFT ORBITAL ELEMENTS

Revolution	Condition	Planned[a]	Actual[b]
1 (Insertion)	Apogee, n. mi.	149.6	149.2
	Perigee, n. mi.	86.6	86.6
	Inclination, deg	28.89	28.85
	Period, min	88.93	88.92
2 (After first rendezvous)	Apogee, n. mi.	165.7	163.1
	Perigee, n. mi.	156.3	153.7
	Inclination, deg	28.86	28.85
	Period, min	90.53	90.55
16	Apogee, n. mi.	166.4	164.0
	Perigee, n. mi.	154.6	156.3
	Inclination, deg	28.84	28.85
	Period, min	90.49	90.50
32	Apogee, n. mi.	164.0	164.0
	Perigee, n. mi.	156.3	152.6
	Inclination, deg	28.87	28.83
	Period, min	90.49	90.45
44 (Retrofire)	Apogee, n. mi.	163.7	163.0
	Perigee, n. mi.	152.5	151.0
	Inclination, deg	28.86	28.84
	Period, min	90.41	90.38

[a]Planned elements were obtained in real time from the RTCC. Apogee and perigee altitudes are referenced to a spherical earth with Pad 19 as the radius. Period and inclination are osculating elements.

[b]Actual elements are based on Fischer ellipsoid earth model of 1960. Apogee and perigee are integrated values. Period and inclination are osculating elements.

TABLE 4.3-IV.- RENDEZVOUS MANEUVERS

Maneuver	Planned[a]	Ground-commanded[b]	Actual
First rendezvous			
Plane change			
Initiate time, g.e.t.	00:29:40	Not computed	00:29:40
ΔV, ft/sec	0.0		2.97
Pitch, deg	Not computed		-1.9
Yaw, deg	0.0		-83.8
V_X, V_Y, V_Z[c], ft/sec			0.3, 0.1, 2.9
Δt, sec			[d]4.0
Terminal phase initiate (TPI)			
Initiate time, g.e.t.	00:49:43	00:49:43	00:49:58
ΔV, ft/sec	140.8	140.8	143.9
Pitch, deg	-6.9	-6.9	-11.3
Yaw, deg	2.7	2.7	-1.9
V_X, V_Y, V_Z[c], ft/sec	139.6, 17.0, -6.6	139.6, 17.0, -6.6	140.0, 28.3, 4.8
Δt, sec	190	190	194.0
First midcourse correction			
Initiate time, g.e.t.	Not computed	Not sent	01:03:41
ΔV, ft/sec	Not computed	Not sent	6.19
Pitch, deg			[e]46.0
Yaw, deg			[e]6.3
V_X, V_Y, V_Z[c], ft/sec			-2.0, -3.4, -3.9
Δt, sec			26.0

[a]Planned elements were obtained in real time from the RTCC.

[b]Ground-commanded elements were refinements of planned values and represent the latest information passed to the crew.

[c]V_X, V_Y, V_Z are the velocity vector components in computer coordinates. V_X is positive in the direction of motion, V_Y is positive towards the center of the earth, and V_Z is positive to the left of the orbit path (North).

[d]The time interval (Δt) indicated here is the amount of time that was taken to perform the maneuver which includes the zeroing of the IVI.

[e]Approximate line-of-sight angles to target during corrections.

TABLE 4.3-IV.- RENDEZVOUS MANEUVERS - Continued

Maneuver	Planned[a]	Ground-commanded[b]	Actual
First rendezvous - Concluded			
Second midcourse correction			
Initiate time, g.e.t.	Not computed	Not sent	01:15:43
ΔV, ft/sec	Not computed	Not sent	2.06
Pitch, deg			[e]84.6
Yaw, deg			[e]17.5
V_X, V_Y, V_Z[c], ft/sec			-0.9, -1.8, -0.5
Δt, sec			8.0
Terminal phase finalize (TPF) (braking)			
Initiate time, g.e.t.	Not computed	Not sent	01:17:41
ΔV, ft/sec	Not computed	Not sent	[f]41
Pitch, deg			-
Yaw, deg			-
Δt, sec			[g]440

[a]Planned elements were obtained in real time from the RTCC.

[b]Ground-commanded elements were refinements of planned values and represent the latest information passed to the crew.

[c]V_X, V_Y, V_Z are the velocity vector components in computer coordinates. V_X is positive in the direction of motion, V_Y is positive towards the center of the earth, and V_Z is positive to the left of the orbit path (North).

[e]Approximate line-of-sight angles to target during corrections.

[f]This is the resultant ΔV applied during the braking; however, the total ΔV expended during the semi-optical approach was about 106 ft/sec.

[g]Braking lasted intermittently for about eight minutes.

TABLE 4.3-IV.- RENDEZVOUS MANEUVERS - Continued

Maneuver	Planned[a]	Ground-commanded[b]	Actual
Second rendezvous			
Separation			
Initiate time, g.e.t.	53:24:56	53:24:56	53:24:57.5
ΔV, ft/sec	8.8	8.8	9.33
Pitch, deg	-54.3	-54.3	-54.5
Yaw, deg	180.0	180.0	178.2
V_X, V_Y, V_Z[c], ft/sec	5.1, -7.1, 0.0	5.1, -7.1, 0.0	5.4, -7.6, 0.2
Δt, sec	15.0	15.0	15.0
Stand-off			
Initiate time, g.e.t.	54:37:27	54:37:27	54:37:28
ΔV, ft/sec	8.9	8.9	9.7
Pitch, deg	55.0	55.0	58.1
Yaw, deg	180.0	180.0	179.9
V_X, V_Y, V_Z[c], ft/sec	-5.0, -7.4, 0.0	-5.0, -7.4, 0.0	-5.4, -8.1, 0.2
Δt, sec	11.0	11.0	11.2
Terminal phase initiate (TPI)			
Initiate time, g.e.t.	65:27:29	65:27:21	65:27:22
ΔV, ft/sec	8.3	14.2	14.7
Pitch, deg	54.4	53.9	53.6
Yaw, deg	-0.8	0.0	-0.5
V_X, V_Y, V_Z[c], ft/sec	-4.8, 6.7, -0.7	-8.7, 12.1, 0.0	-8.8, 11.9, -0.1
Δt, sec	10.0	24.0	69.0

[a]Planned elements were obtained in real time from the RTCC.

[b]Ground-commanded elements were refinements of planned values and represent the latest information passed to the crew.

[c]V_X, V_Y, V_Z are the velocity vector components in computer coordinates. V_X is positive in the direction of motion, V_Y is positive towards the center of the earth, and V_Z is positive to the left of the orbit path (North).

TABLE 4.3-IV.- RENDEZVOUS MANEUVERS - Concluded

Maneuver	Planned[a]	Ground-commanded[b]	Actual
Second rendezvous - Concluded			
Midcourse correction			
Initiate time, g.e.t.	Not computed	66:30:36	66:30:36
ΔV, ft/sec		6.0	5.91
Pitch, deg		[e]91.0	[e]91.0
Yaw, deg		[e]5.0	[e]5.0
V_X, V_Y, V_Z[c], ft/sec		0.0, -6.0, 0.0	1.2, -5.8, 0.12
Δt, sec		10.0	7.0
Terminal phase finalize (TPF) (braking)			
Initiate time, g.e.t.	Not computed	Not sent	66:34:43
ΔV, ft/sec	Not computed	Not sent	[h]12.2
Pitch, deg			-
Yaw, deg			-
Δt, sec			[i]182.0

[a]Planned elements were obtained in real time from the RTCC.

[b]Ground-commanded elements were refinements of planned values and represent the latest information passed to the crew.

[c]V_X, V_Y, V_Z are the velocity vector components in computer coordinates. V_X is positive in the direction of motion, V_Y is positive towards the center of the earth, and V_Z is positive to the left of the orbit path (North).

[e]Approximate line-of-sight angles to target during corrections.

[h]This is the resultant ΔV applied during the braking; however, the total ΔV expended during the semi-optical approach was about 30 ft/sec.

[i]Braking lasted intermittently for approximately three minutes.

TABLE 4.3-V.- PLANNED AND ACTUAL TLV AND GATV TRAJECTORY PARAMETERS

Condition	Planned[a]	Actual	
		Preliminary	Final
BECO			
Time from lift-off, sec	130.00	130.44	130.44
Geodetic latitude, deg north	28.57	28.57	28.57
Longitude, deg west	79.76	79.75	79.75
Altitude, ft	194 957	194 752	194 752
Altitude, n. mi.	32.1	32.1	32.1
Range, n. mi.	41.8	43.2	43.2
Space-fixed velocity, ft/sec	9 720	9 791	9 791
Space-fixed flight-path angle, deg	21.57	21.12	21.12
Space-fixed heading angle, deg east of north	84.51	84.74	84.74
SECO			
Time from lift-off, sec	280.44	279.43	279.43
Geodetic latitude, deg north	28.92	28.91	28.91
Longitude, deg west	74.64	74.64	74.64
Altitude, ft	657 531	651 221	651 221
Altitude, n. mi.	108.2	107.2	107.2
Range, n. mi.	312.5	313.3	313.3
Space-fixed velocity, ft/sec	17 634	17 626	17 626
Space-fixed flight-path angle, deg	10.19	10.37	10.37
Space-fixed heading angle, deg east of north	87.60	87.39	87.39
VECO			
Time from lift-off, sec	298.79	298.05	298.05
Geodetic latitude, deg north	28.96	28.94	28.94
Longitude, deg west	73.76	73.84	73.84
Altitude, ft	712 145	706 908	706 908

[a]For preflight-calculated nominal trajectory.

TABLE 4.3-V.- PLANNED AND ACTUAL TLV AND GATV TRAJECTORY PARAMETERS - Continued

Condition	Planned[a]	Actual	
		Preliminary	Final
VECO - Concluded			
Altitude, n. mi.	117.2	116.3	116.3
Range, n. mi.	359.2	360.4	360.4
Space-fixed velocity, ft/sec . .	17 566	17 572	17 572
Space-fixed flight-path angle, deg	9.26	9.35	9.35
Space-fixed heading angle, deg east of north	88.06	88.07	88.07
PPS start			
Time from lift-off, sec	371.41	372.93	372.93
Geodetic latitude, deg north . .	29.02	29.00	29.00
Longitude, deg west	70.28	70.26	70.26
Altitude, ft	874 923	874 392	874 392
Altitude, n. mi.	144.0	143.9	143.9
Range, n. mi.	541.9	543.2	543.2
Space-fixed velocity, ft/sec . .	17 288	17 295	17 295
Space-fixed flight-path angle, deg	5.49	5.60	5.60
Space-fixed heading angle, deg east of north	89.89	89.84	89.84
GATV insertion			
Time from lift-off, sec	557.36	558.70	558.70
Geodetic latitude, deg north . .	28.53	28.50	28.50
Longitude, deg west	59.60	59.47	59.47
Altitude, ft	980 759	983 548	983 548
Altitude, n. mi.	161.4	161.9	161.9
Range, n. mi.	1 105.3	1 112.7	1 112.7
Space-fixed velocity, ft/sec . .	25 367	25 360	25 360

[a]For preflight-calculated nominal trajectory.

TABLE 4.3-V.- PLANNED AND ACTUAL TLV AND GATV TRAJECTORY PARAMETERS - Concluded

Condition	Planned[a]	Actual	
		Preliminary	Final
GATV insertion - Concluded			
Space-fixed flight-path angle, deg	0.00	0.07	0.07
Space-fixed heading angle, deg east of north	95.61	95.57	95.57
Maximum conditions			
Altitude, statute miles	862.0	850.0	851.1
Altitude, n. mi.	750.0	739.4	741.5
Space-fixed velocity, ft/sec . .	26 305	26 317	26 317
Earth-fixed velocity, ft/sec . .	24 910	24 922	24 922
Exit acceleration, g	6.3	6.3	6.3
Exit dynamic pressure, lb/sq ft	947	978	978

[a]For preflight-calculated nominal trajectory.

TABLE 4.3-VI.- PLANNED AND ACTUAL TLV CUTOFF AND GATV INSERTION CONDITIONS

Condition	Planned[a]	Actual	Difference
VECO targeting parameters			
Semimajor axis, n. mi.	2330.7	2330.4	-0.3
Eccentricity	0.5436	0.5437	+0.0001
Inclination, deg	28.86	28.84	-0.02
Inertial ascent node, deg	38.30	38.20	-0.10
VECO osculating elements			
Apogee altitude, n. mi.	158.06	157.97	-0.09
Perigee altitude, n. mi.	-2376.88	-2377.31	-0.43
Period, min	47.07	47.06	-0.01
Inclination, deg	28.86	28.84	-0.02
True anomaly, deg	172.04	171.96	-0.08
Argument of perigee, deg	-85.55	-85.47	-0.08
Insertion osculating elements			
Semimajor axis, n. mi.	3603.5	3602.5	-1.0
Eccentricity	0.0007	0.0013	+0.0006
Inclination, deg	28.88	28.84	-0.04
Inertial ascent node, deg	37.84	38.05	+0.21
Apogee altitude, n. mi.	166.45	165.39	-1.06
Perigee altitude, n. mi.	161.47	156.00	-5.47
Period, min	90.49	90.46	-0.03
True anomaly, deg[b]	6.87	77.40	+70.53
Argument of perigee, deg[b]	93.39	22.80	-70.59

[a]For preflight-calculated nominal trajectory.

[b]These elements are not well defined for circular orbits.

TABLE 4.3-VII.- GATV MANEUVERS

Condition	Planned[a]	Actual
First PPS maneuver		
Maneuver initiate, g.e.t., hr:min:sec	4:28:48	4:28:48
Δt_b, sec	71.0	72.0
ΔV, ft/sec	110.0	109.8
Pitch, deg	0.00	-0.56
Yaw, deg	-90.00	-88.73
Second PPS maneuver		
Maneuver initiate, g.e.t., hr:min:sec	40:30:15	40:30:15
Δt_b, sec	93.0	94.2
ΔV, ft/sec	920.0	918.0
Pitch, deg	0	0
Yaw, deg	0.00	+2.16
Third PPS maneuver		
Maneuver initiate, g.e.t., hr:min:sec	43:52:55	43:52:55
Δt_b, sec	90.0	91.5
ΔV, ft/sec	920.0	917.6
Pitch, deg	0	0
Yaw, deg	180.00	-178.70
First SPS maneuver		
Maneuver initiate, g.e.t., hr:min:sec	75:32:25	75:32:25
Δt_b, sec	16.0	16.0
ΔV, ft/sec	47.0	47.5
Pitch, deg	0.00	+0.34
Yaw, deg	0	0

[a]Latest values calculated on the ground.

TABLE 4.3-VII.- GATV MANEUVERS - Concluded

Condition	Planned[a]	Actual
Second SPS maneuver		
Maneuver initiate, g.e.t., hr:min:sec	76:15:37	76:15:37
Δt_b, sec	21.0	20.8
ΔV, ft/sec	63.0	63.2
Pitch, deg	0.00	+0.35
Yaw, deg	0.00	+0.06
Third SPS maneuver		
Maneuver initiate, g.e.t., hr:min:sec	92:15:58	92:15:58
Δt_b, sec	69.0	69.0
ΔV, ft/sec	213.0	216.0
Pitch, deg	0.00	+0.16
Yaw, deg	+90.0	[b]+93.9

[a]Latest values calculated on the ground.

[b]Due to horizon sensor problems, this angle was calculated from the apogee and perigee values in table 4.3-VIII.

TABLE 4.3-VIII.- GATV ORBITAL ELEMENTS

Revolution	Condition	Planned[a]	Actual[b]
1 (Insertion)	Apogee, n. mi.	165.0	163.1
	Perigee, n. mi.	156.6	153.5
	Inclination, deg	28.85	28.87
	Period, min	90.53	90.54
16	Apogee, n. mi.	166.4	164.3
	Perigee, n. mi.	154.6	152.1
	Inclination, deg	28.84	28.85
	Period, min	90.49	90.50
32	Apogee, n. mi.	164.0	164.0
	Perigee, n. mi.	156.3	155.6
	Inclination, deg	28.83	28.83
	Period, min	90.45	90.45
48	Apogee, n. mi.	164.2	163.7
	Perigee, n. mi.	156.2	152.8
	Inclination, deg	28.83	28.83
	Period, min	90.52	90.46
49 (After SPS Hohmann Transfer)	Apogee, n. mi.	191.8	191.2
	Perigee, n. mi.	187.6	186.0
	Inclination, deg	28.83	28.83
	Period, min	91.61	91.61
Parking orbit after SPS lateral firing	Apogee, n. mi.	191.0	189.6
	Perigee, n. mi.	181.3	179.2
	Inclination, deg	28.87	28.84
	Period, min	91.48	91.44

[a]Planned elements were obtained in real time from the RTCC. Apogee and perigee altitudes are referenced to a spherical earth with Pad 19 as the radius. Period and inclination are osculating elements.

[b]Actual elements are based on the Fischer ellipsoid earth model of 1960. Apogee and perigee are integrated values. Period and inclination are osculating elements.

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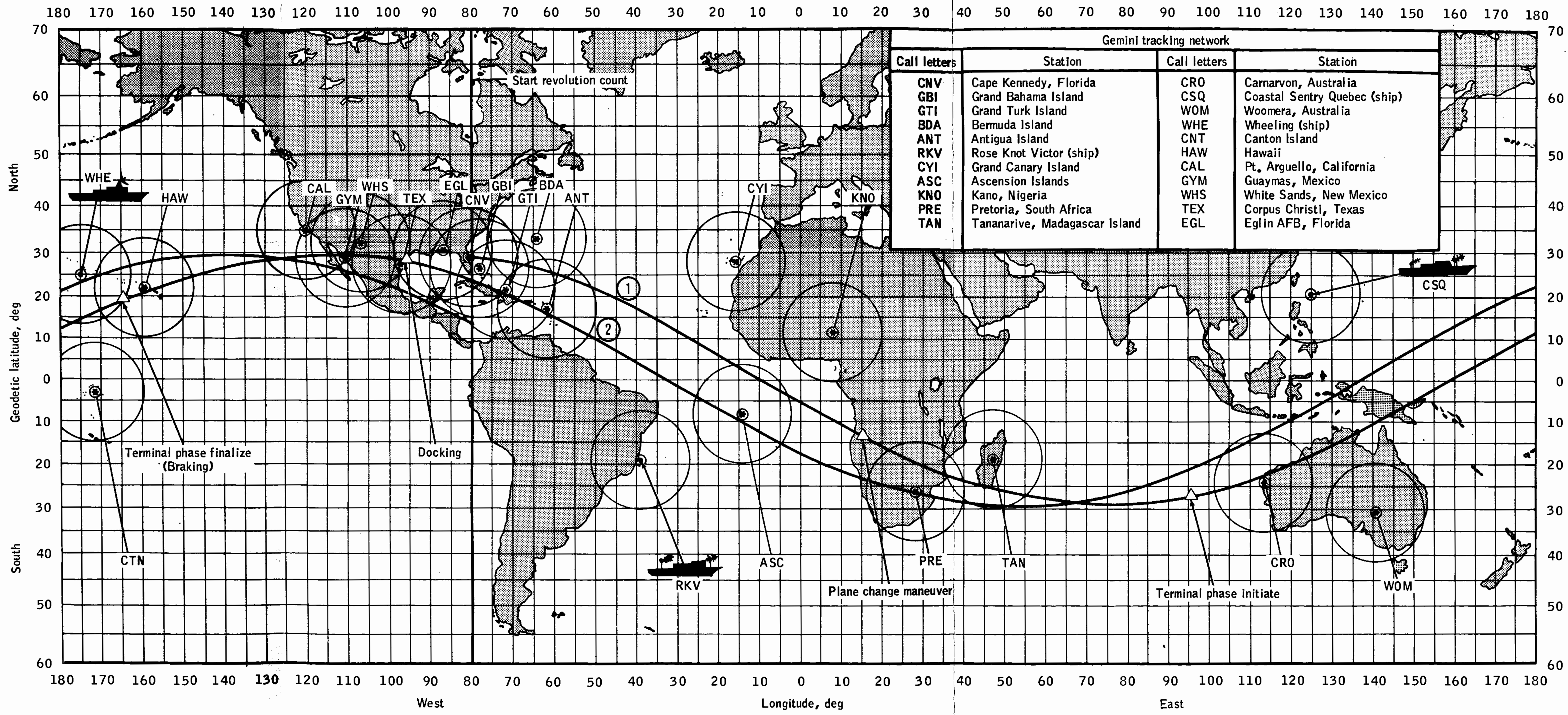


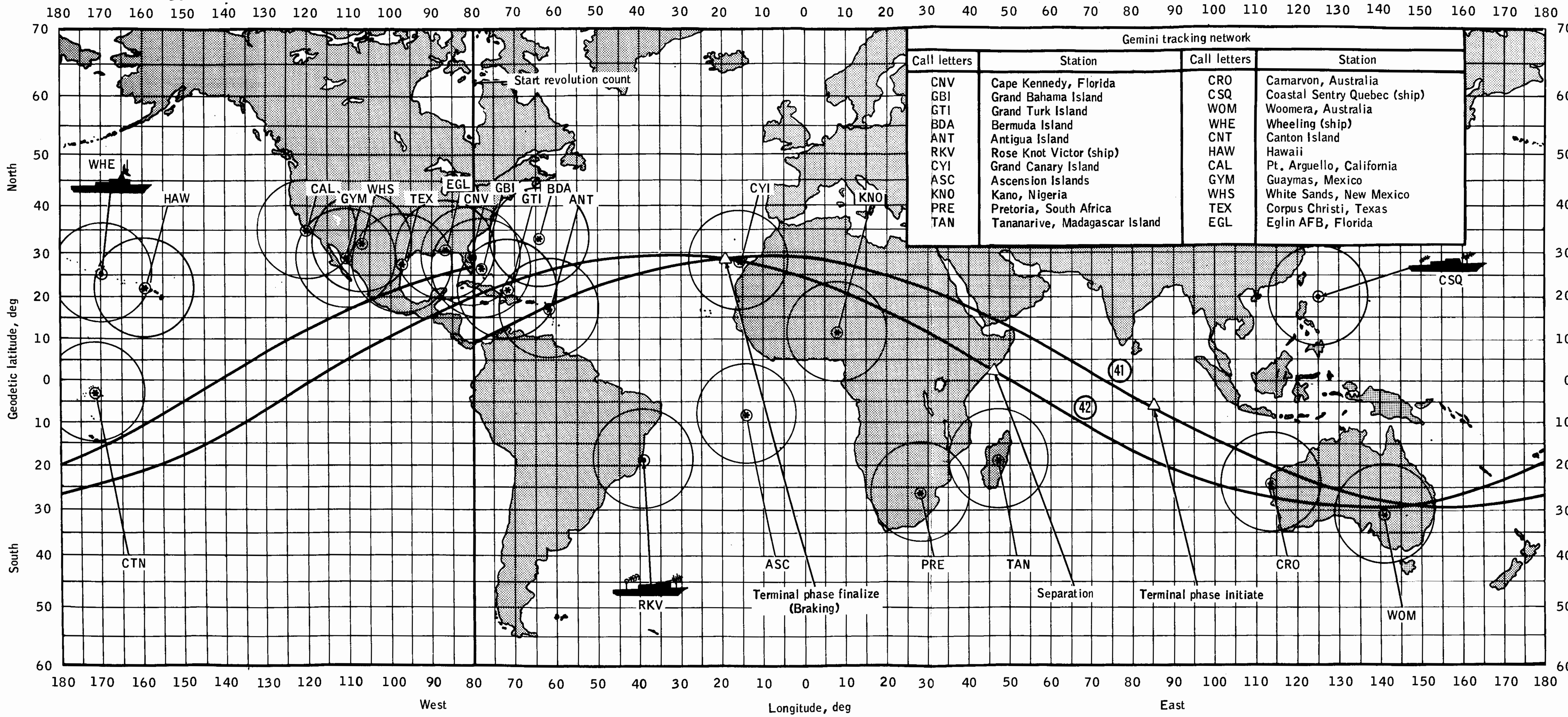
Gemini tracking network

Call letters	Station	Call letters	Station
CNV	Cape Kennedy, Florida	CRO	Carnarvon, Australia
GBI	Grand Bahama Island	CSQ	Coastal Sentry Quebec (ship)
GTI	Grand Turk Island	WOM	Woomera, Australia
BDA	Bermuda Island	WHE	Wheeling (ship)
ANT	Antigua Island	CNT	Canton Island
RKV	Rose Knot Victor (ship)	HAW	Hawaii
CYI	Grand Canary Island	CAL	Pt. Arguello, California
ASC	Ascension Islands	GYM	Guaymas, Mexico
KNO	Kano, Nigeria	WHS	White Sands, New Mexico
PRE	Pretoria, South Africa	TEX	Corpus Christi, Texas
TAN	Tananarive, Madagascar Island	EGL	Eglin AFB, Florida

(a) Revolutions 1 and 2.

Figure 4.3-1. - Ground track for the Gemini XI orbital mission.

NASA-S-66-8992 SEP 30

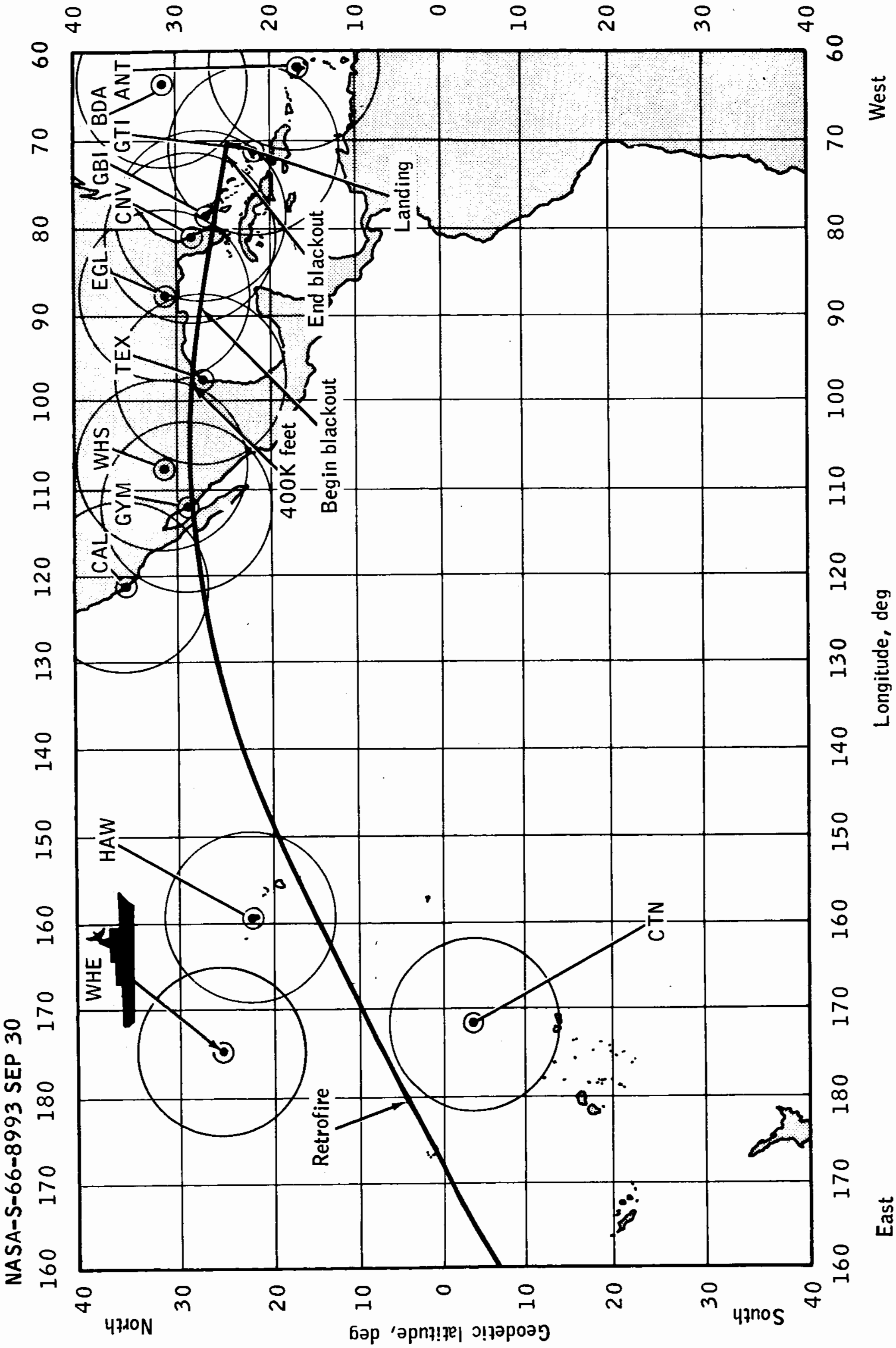


Gemini tracking network

Call letters	Station	Call letters	Station
CNV	Cape Kennedy, Florida	CRO	Carnarvon, Australia
GBI	Grand Bahama Island	CSQ	Coastal Sentry Quebec (ship)
GTI	Grand Turk Island	WOM	Woomera, Australia
BDA	Bermuda Island	WHE	Wheeling (ship)
ANT	Antigua Island	CNT	Canton Island
RKV	Rose Knot Victor (ship)	HAW	Hawaii
CYI	Grand Canary Island	CAL	Pt. Arguello, California
ASC	Ascension Islands	GYM	Guaymas, Mexico
KNO	Kano, Nigeria	WHS	White Sands, New Mexico
PRE	Pretoria, South Africa	TEX	Corpus Christi, Texas
TAN	Tananarive, Madagascar Island	EGL	Eglin AFB, Florida

(b) Revolutions 41 and 42.

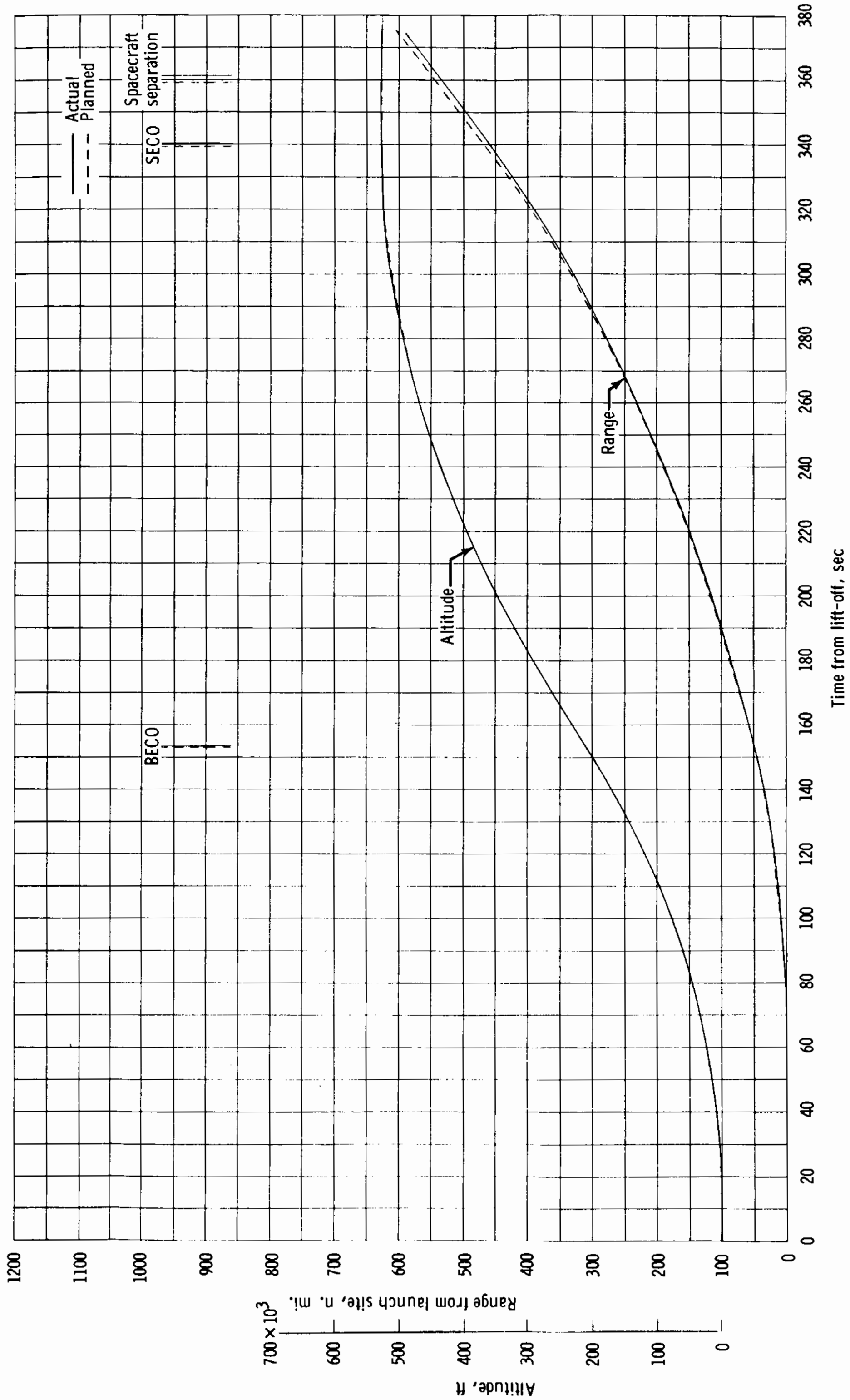
Figure 4.3-1. - Continued.



(c) Reentry.

Figure 4.3-1. - Concluded.

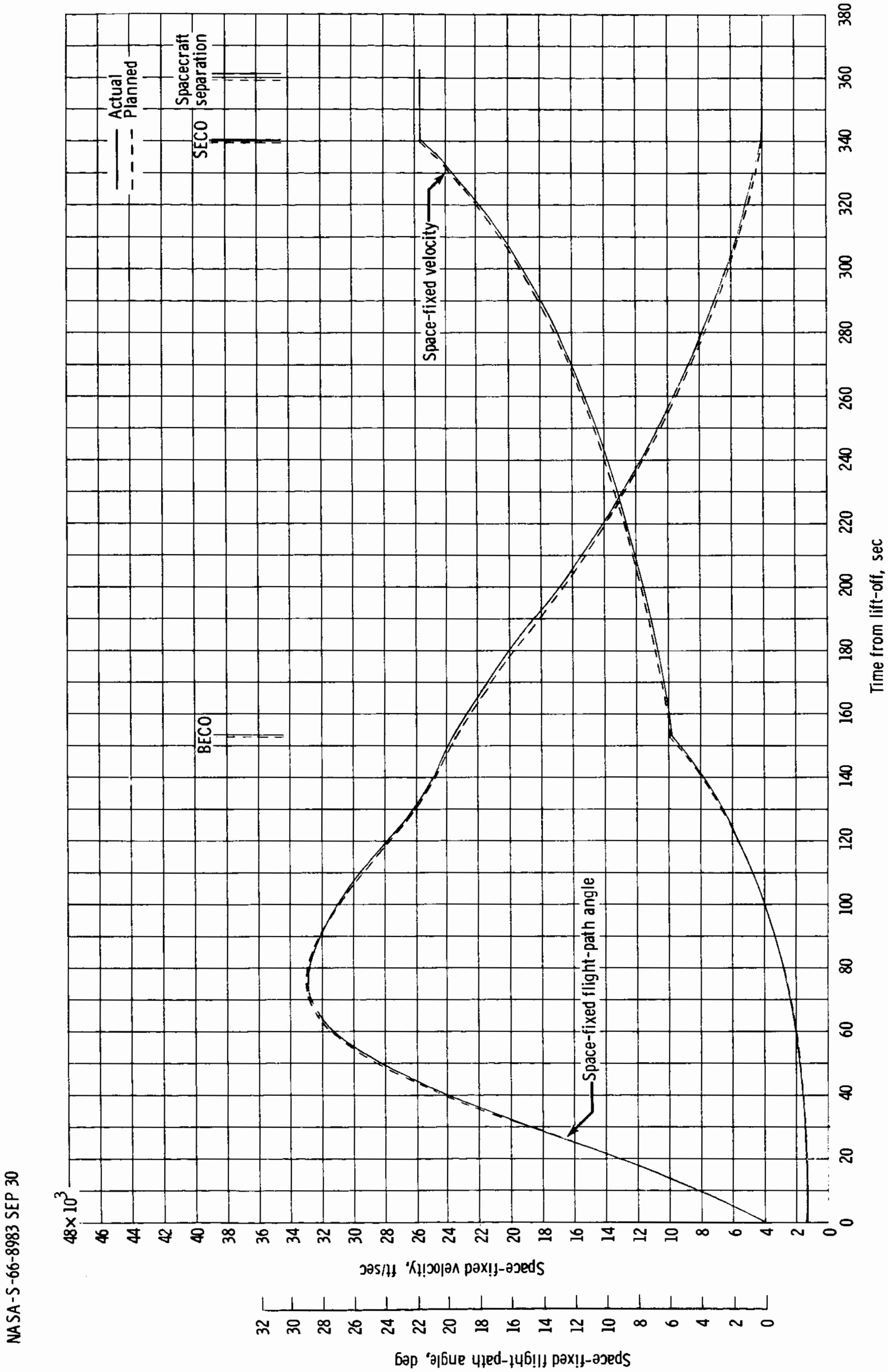
UNCLASSIFIED



NASA-S-66-8982 SEP 30

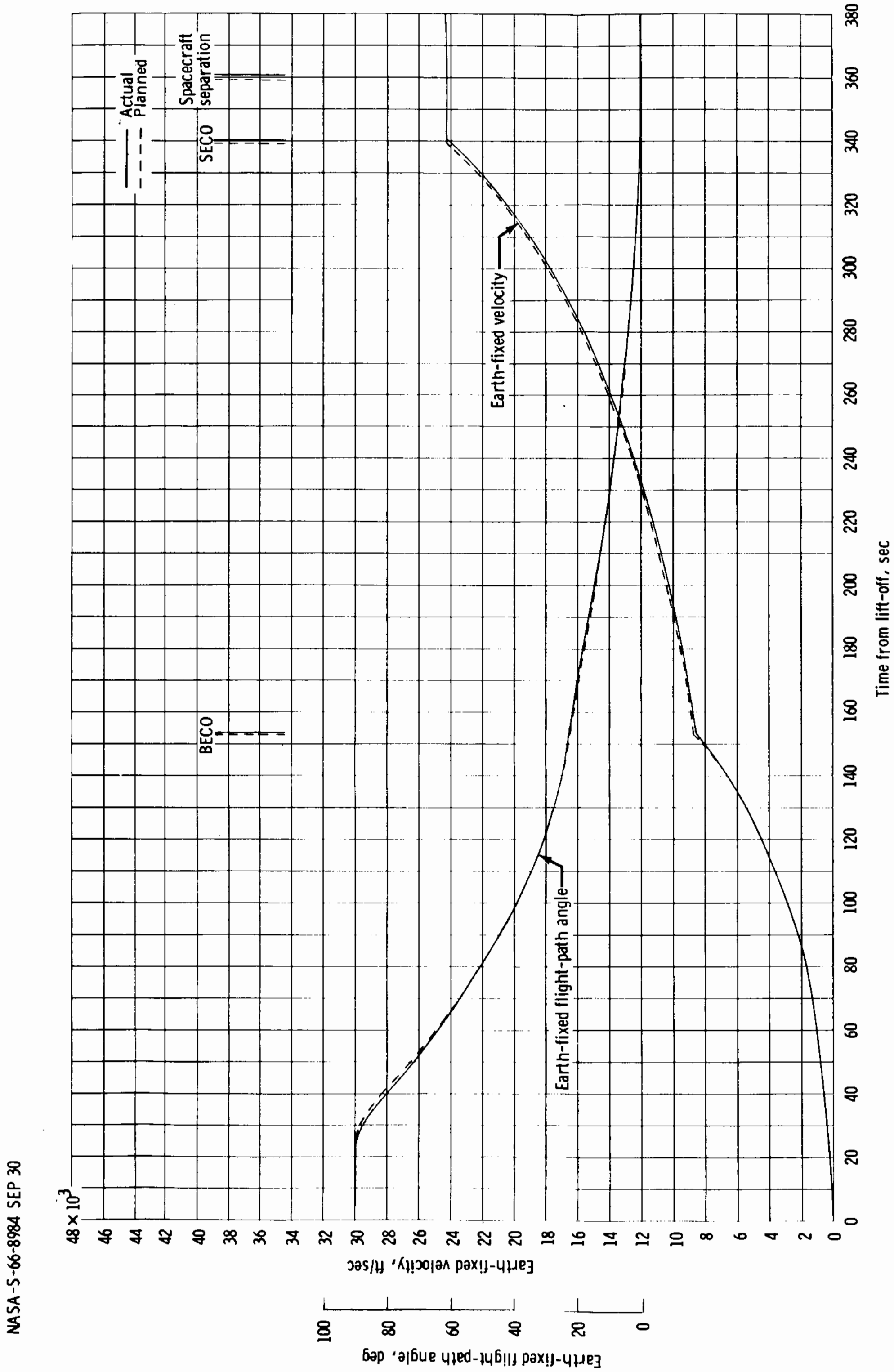
(a) Altitude and range.

Figure 4.3-2. - Trajectory parameters for GLV-spacecraft launch phase.



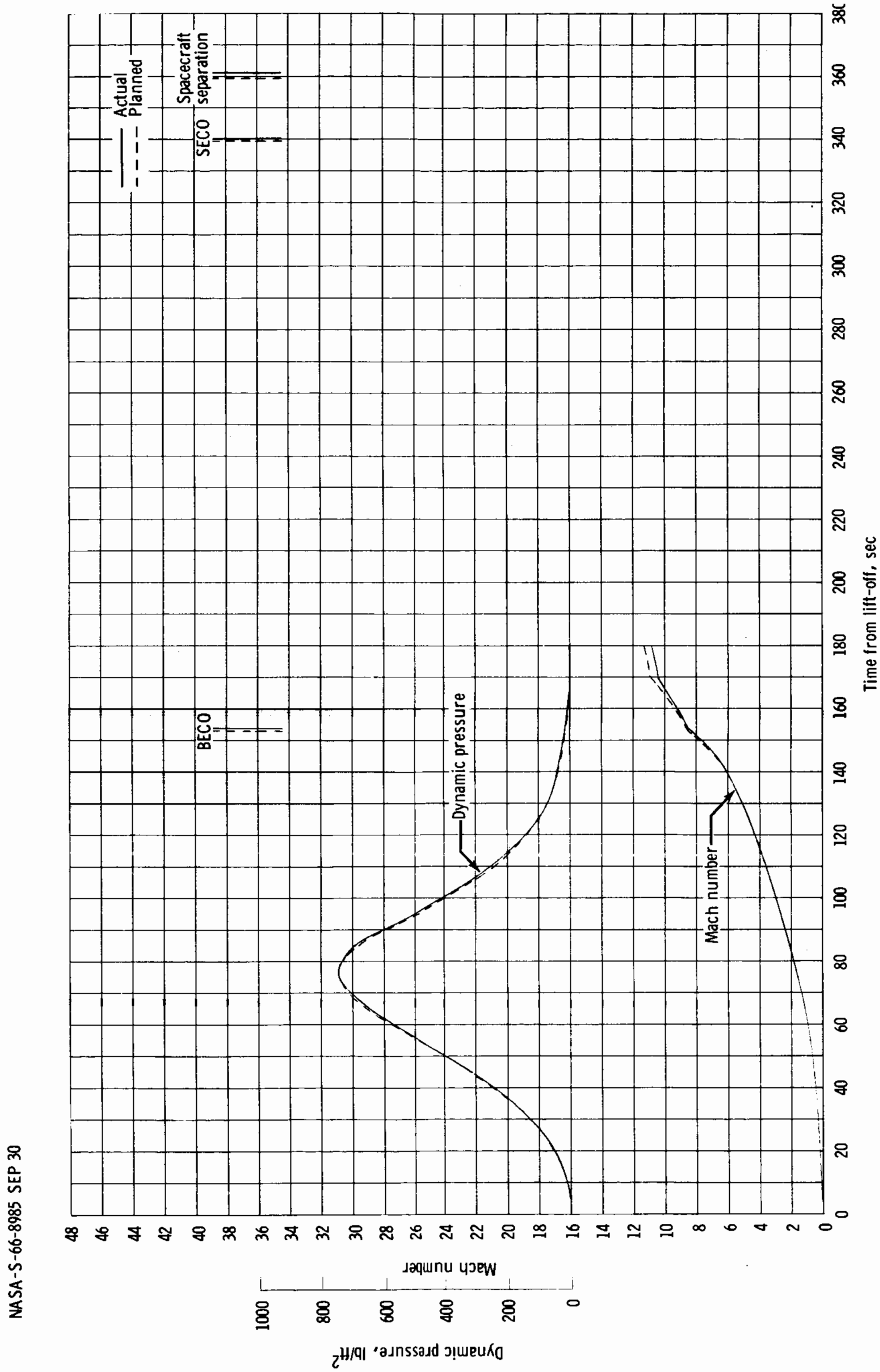
(b) Space-fixed velocity and flight-path angle.

Figure 4.3-2. - Continued.



(c) Earth-fixed velocity and flight-path angle.

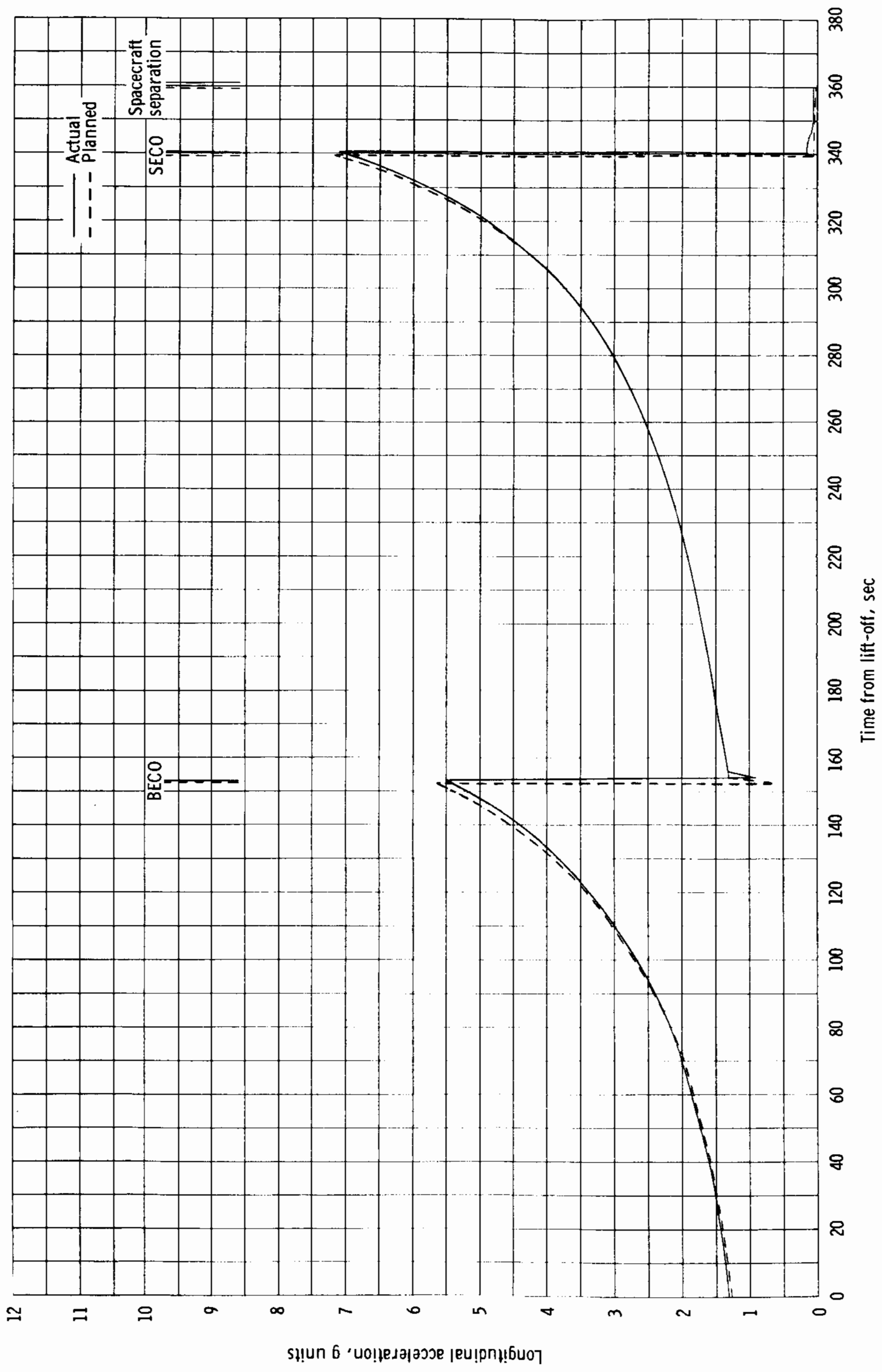
Figure 4.3-2. - Continued.



(d) Dynamic pressure and Mach number.

Figure 4.3-2. - Continued.

NASA-S-66-8986 SEP 30



(e) Longitudinal acceleration.

Figure 4.3-2.- Concluded.

NASA-S-66-8975 SEP 30

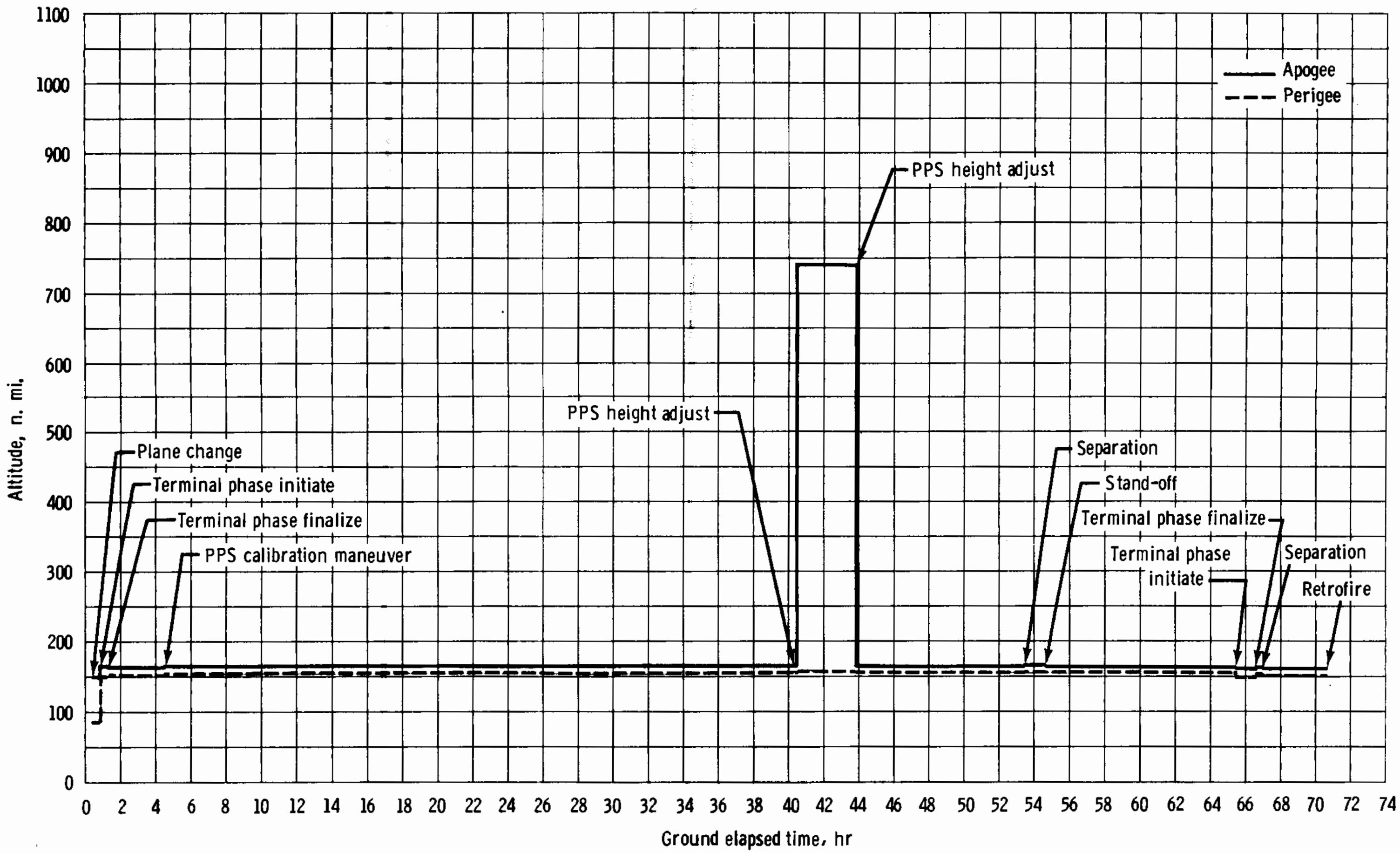


Figure 4.3-3. - Apogee and perigee altitudes for the Gemini XI mission.

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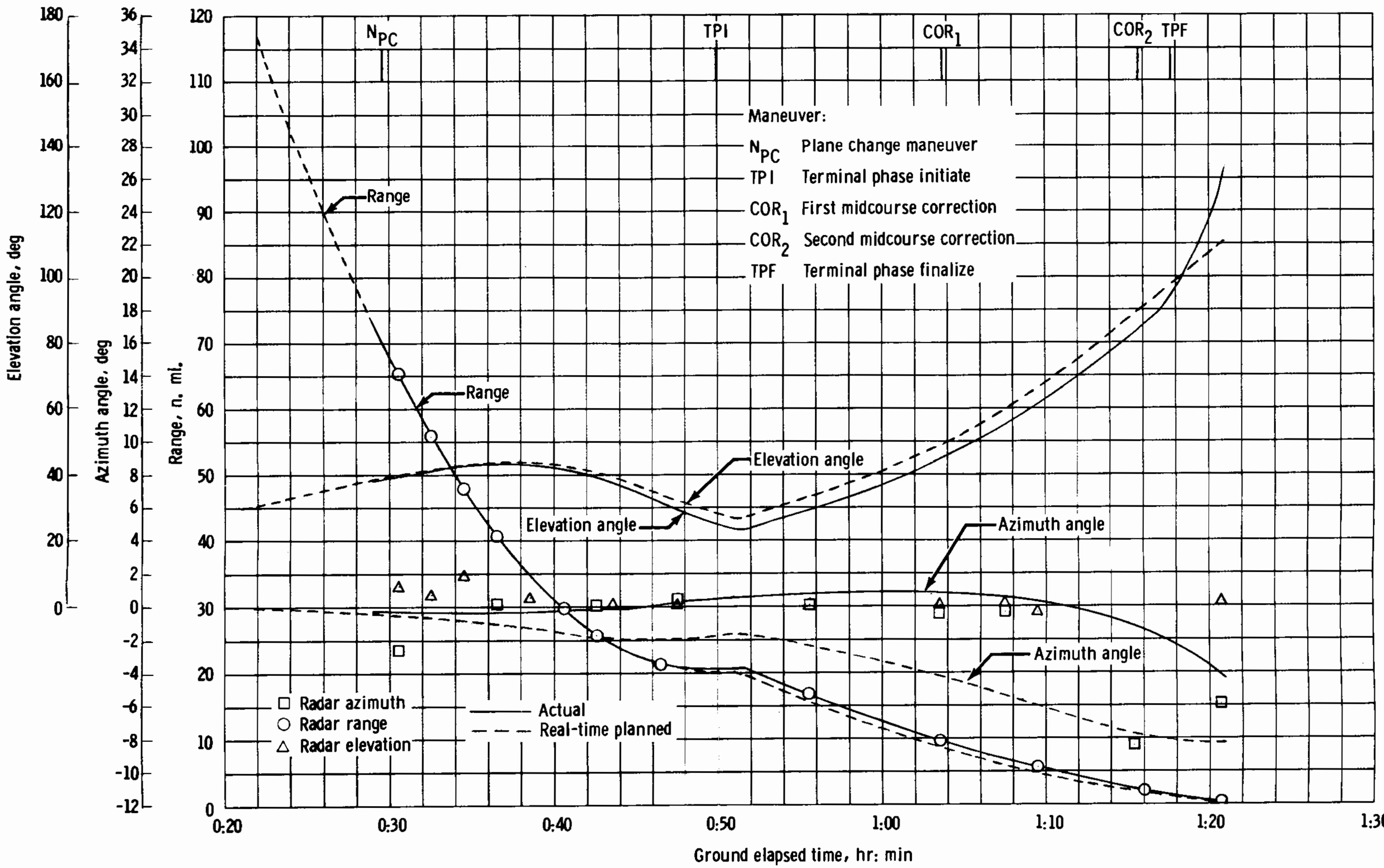
NASA-S-66-9063 OCT 13



(a) Relative range, azimuth, and elevation from Spacecraft 11 to Gemini XI GATV during first rendezvous.

Figure 4.3-4. - Rendezvous during the Gemini XI mission.

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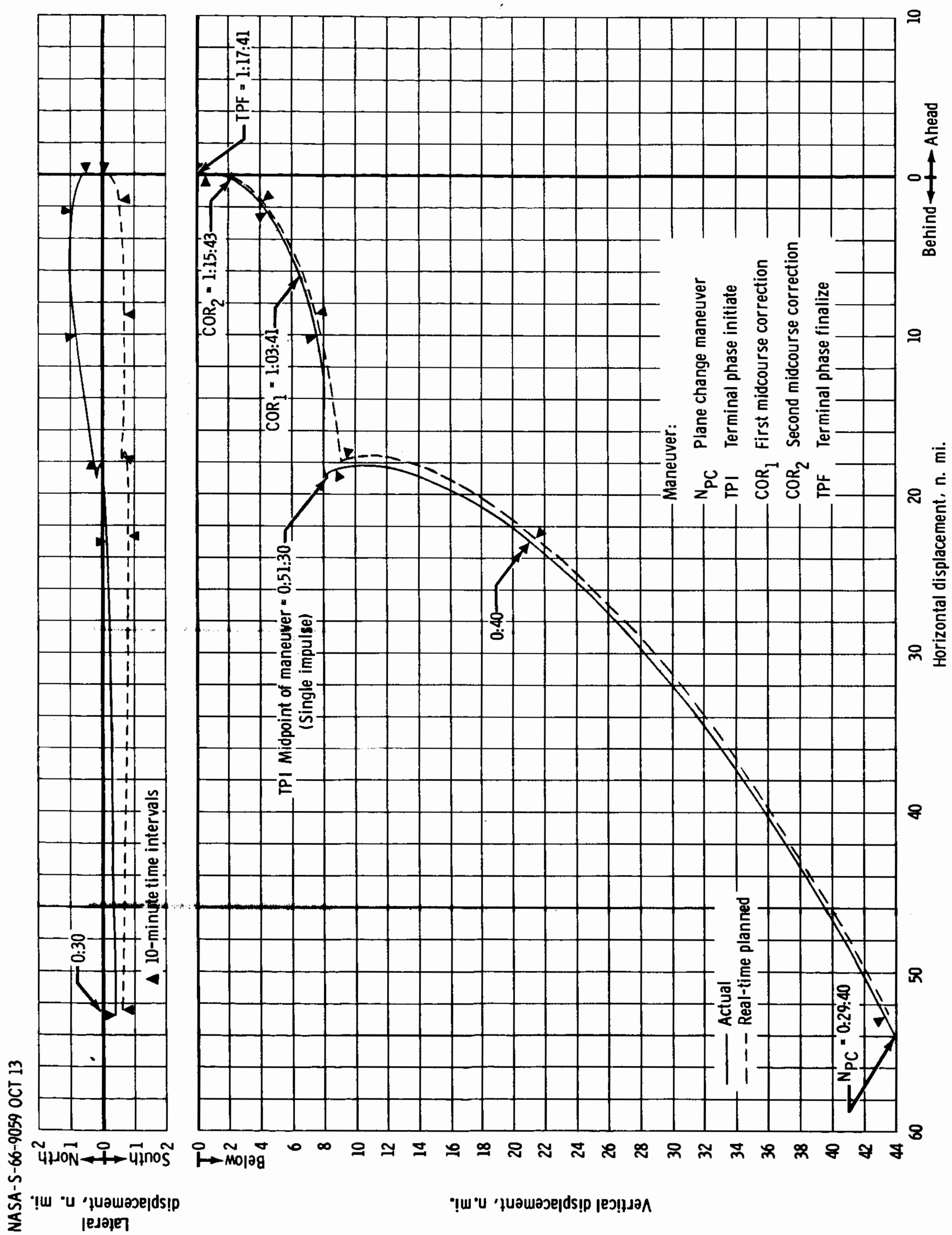

(b) Relative trajectory profile of first rendezvous measured from Gemini XI GATV to Spacecraft 11 in curvilinear coordinate system.

Figure 4.3-4. - Continued.

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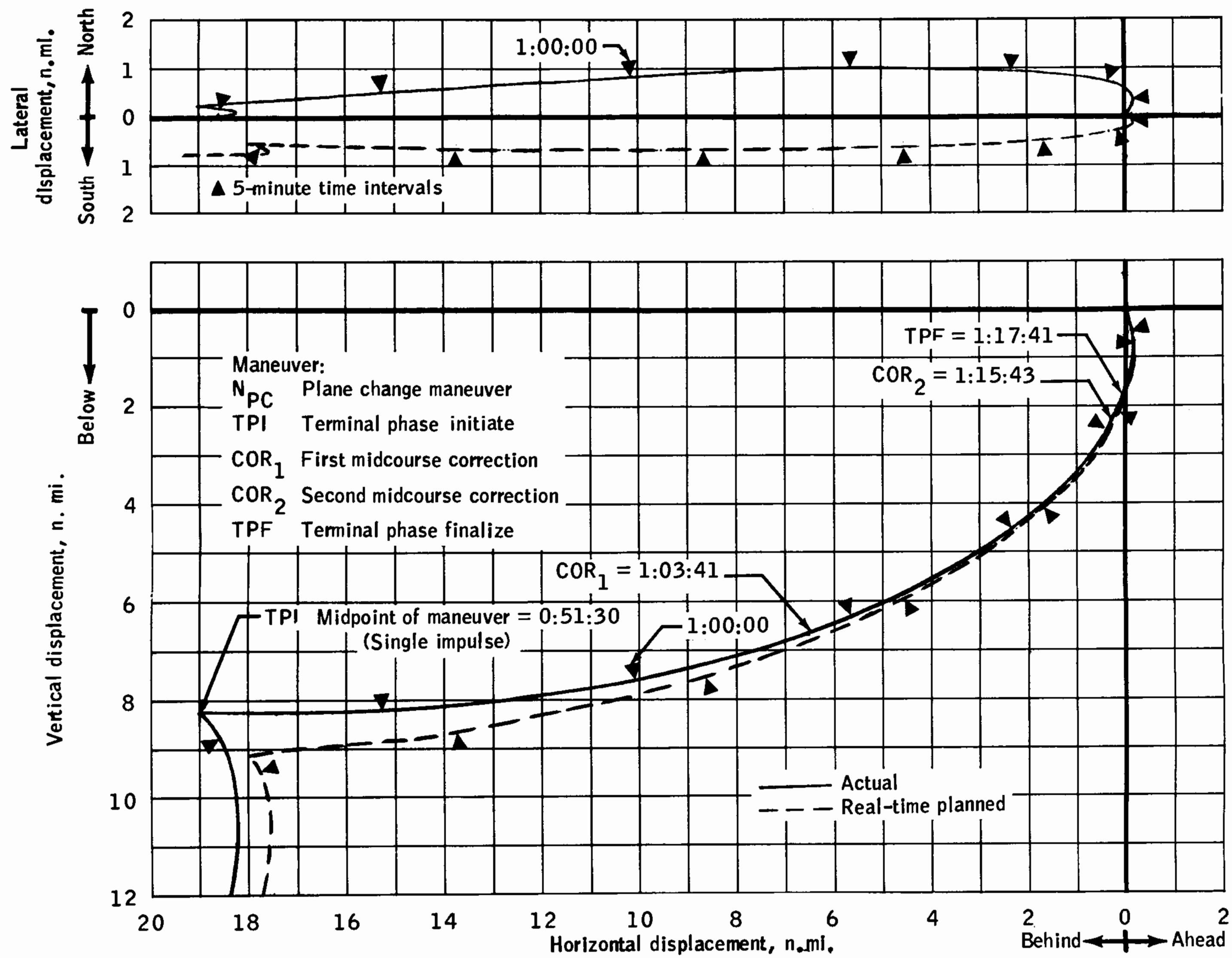
NASA-S-66-9064 OCT 13



(c) Relative trajectory profile of first rendezvous from TPI to TPF as measured from Gemini XI GATV to Spacecraft 11 in curvilinear coordinate system.

Figure 4.3-4. - Continued.

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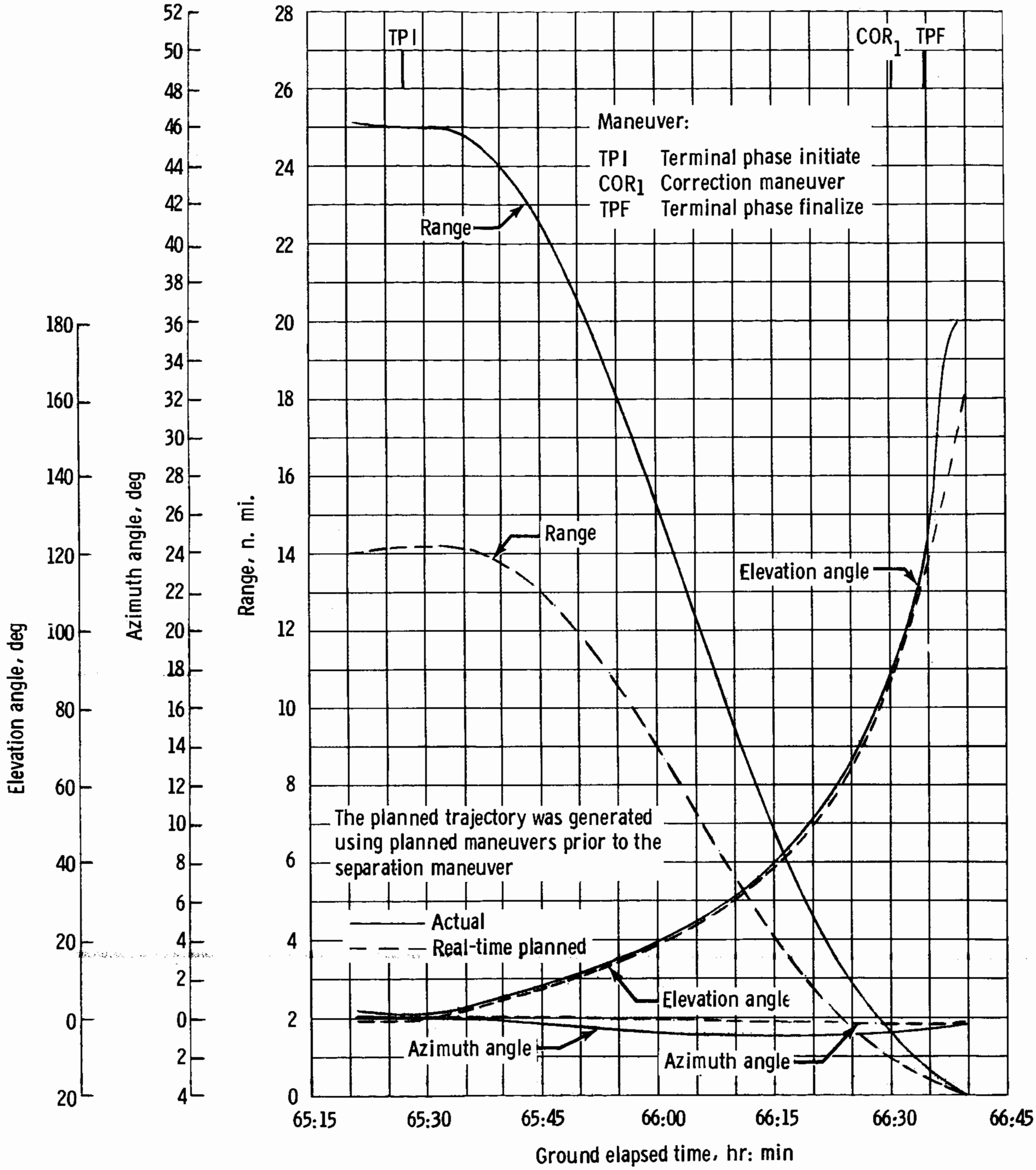
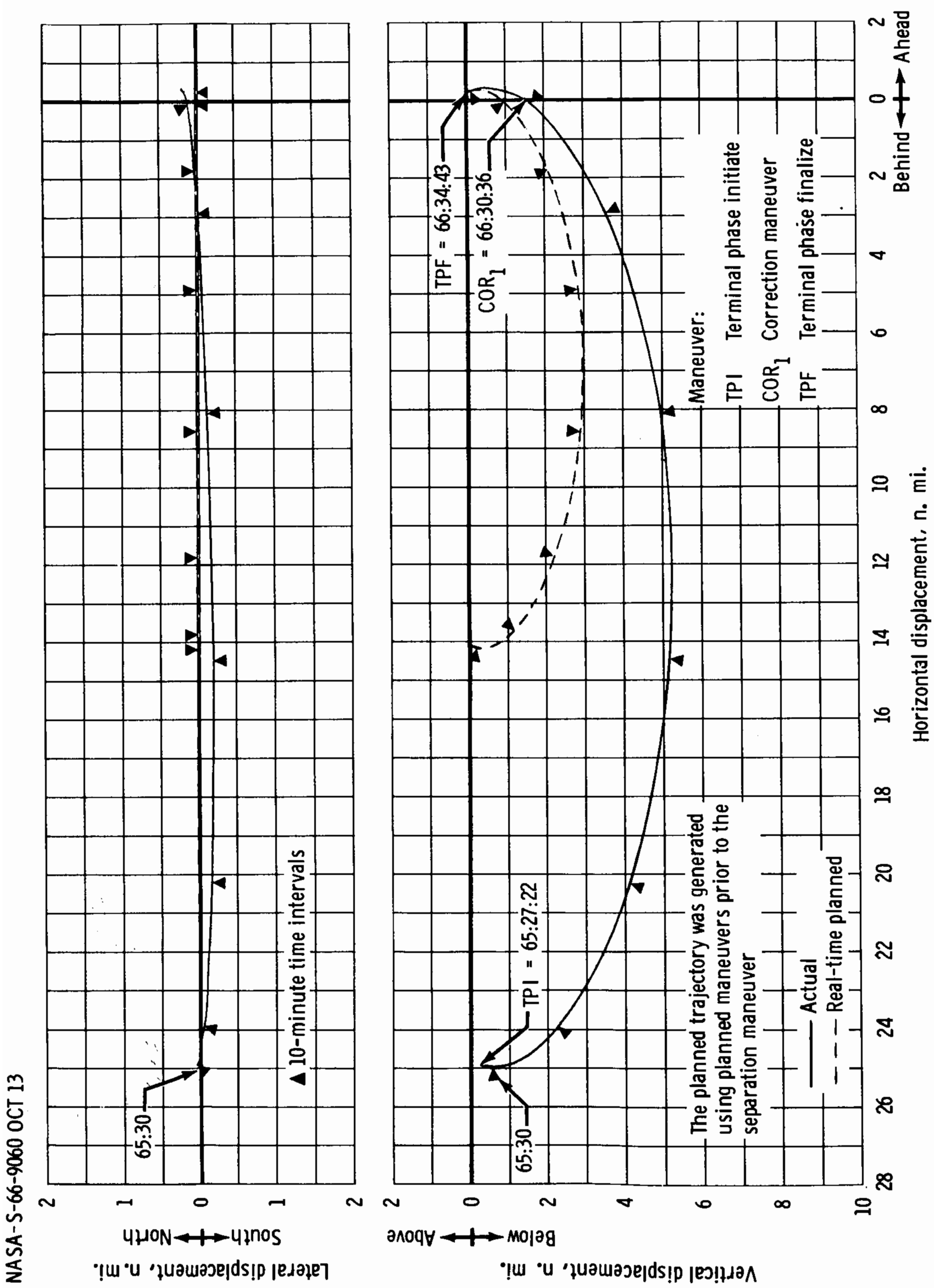
NASA-S-66-9062 OCT 13



(d) Relative range, azimuth, and elevation from Spacecraft 11 to Gemini XI GATV during second rendezvous.

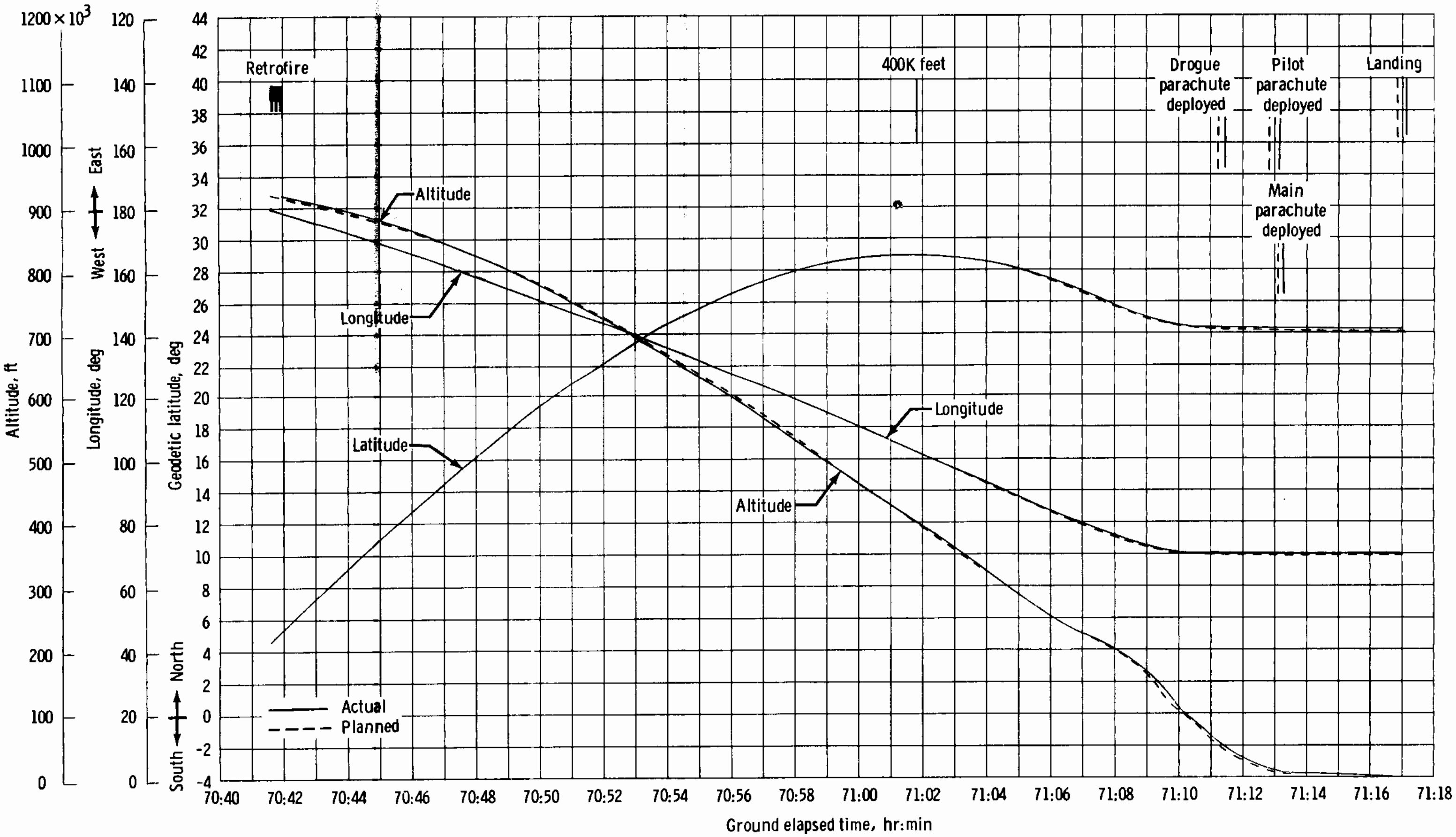
Figure 4.3-4. - Continued.



(e) Relative trajectory profile of second rendezvous from TPI to TPF as measured from Gemini XI GATV to Spacecraft 11 in curvilinear coordinate system.

Figure 4.3-4. - Concluded.

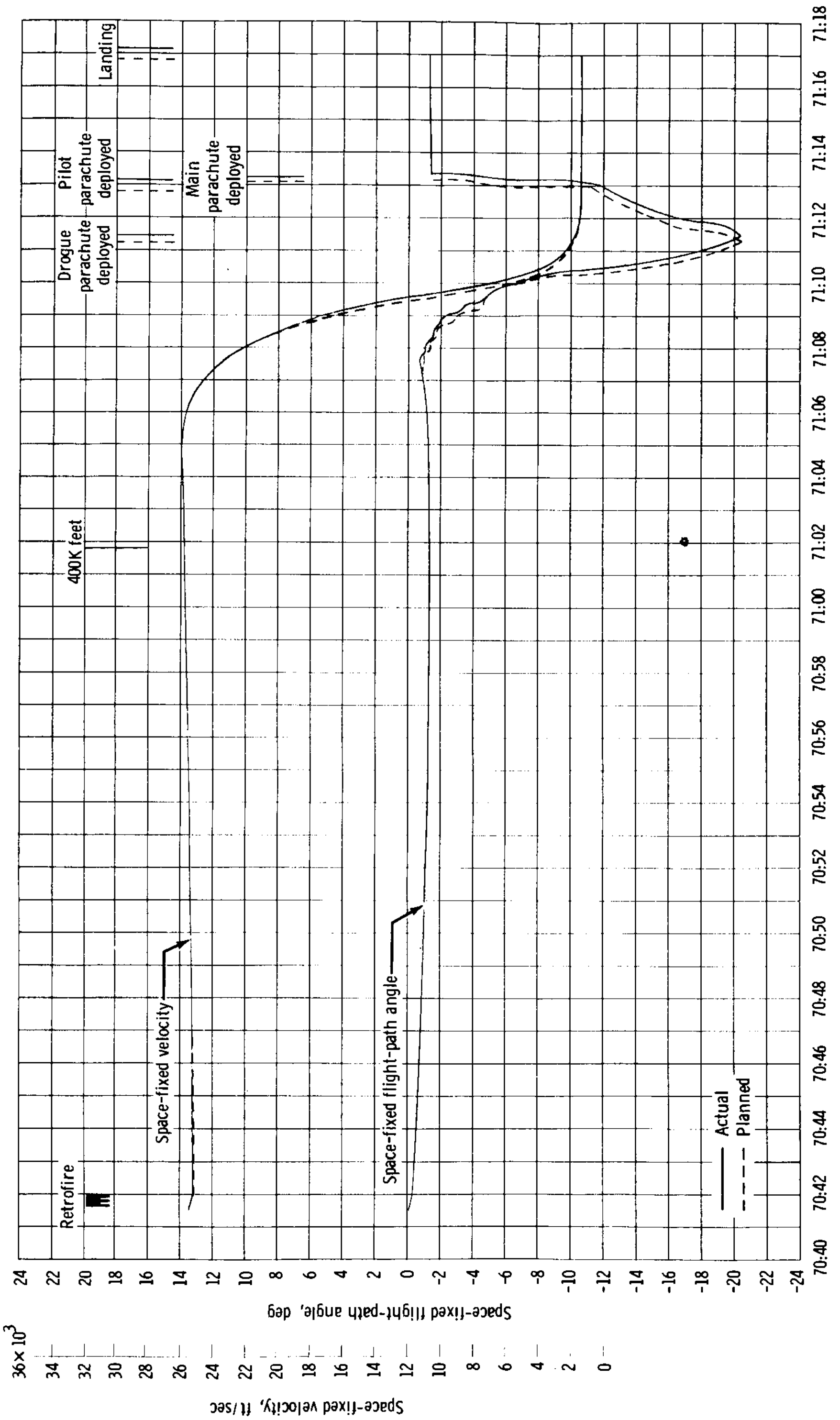
NASA-S-66-8976 SEP 30



(a) Latitude, longitude, and altitude.

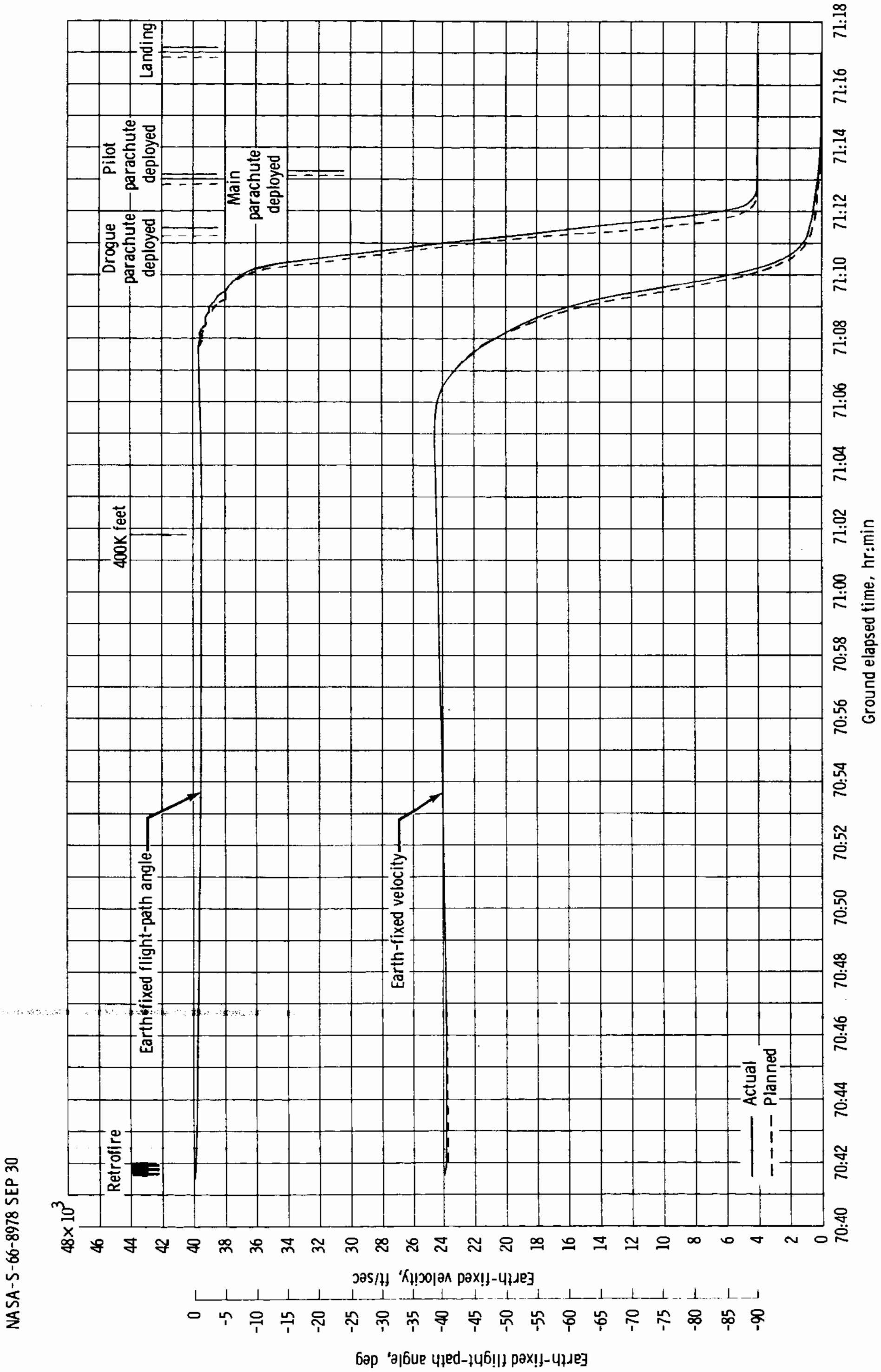
Figure 4.3-5. - Trajectory parameters for the Gemini XI mission reentry phase.

NASA-S-66-8977 SEP 30



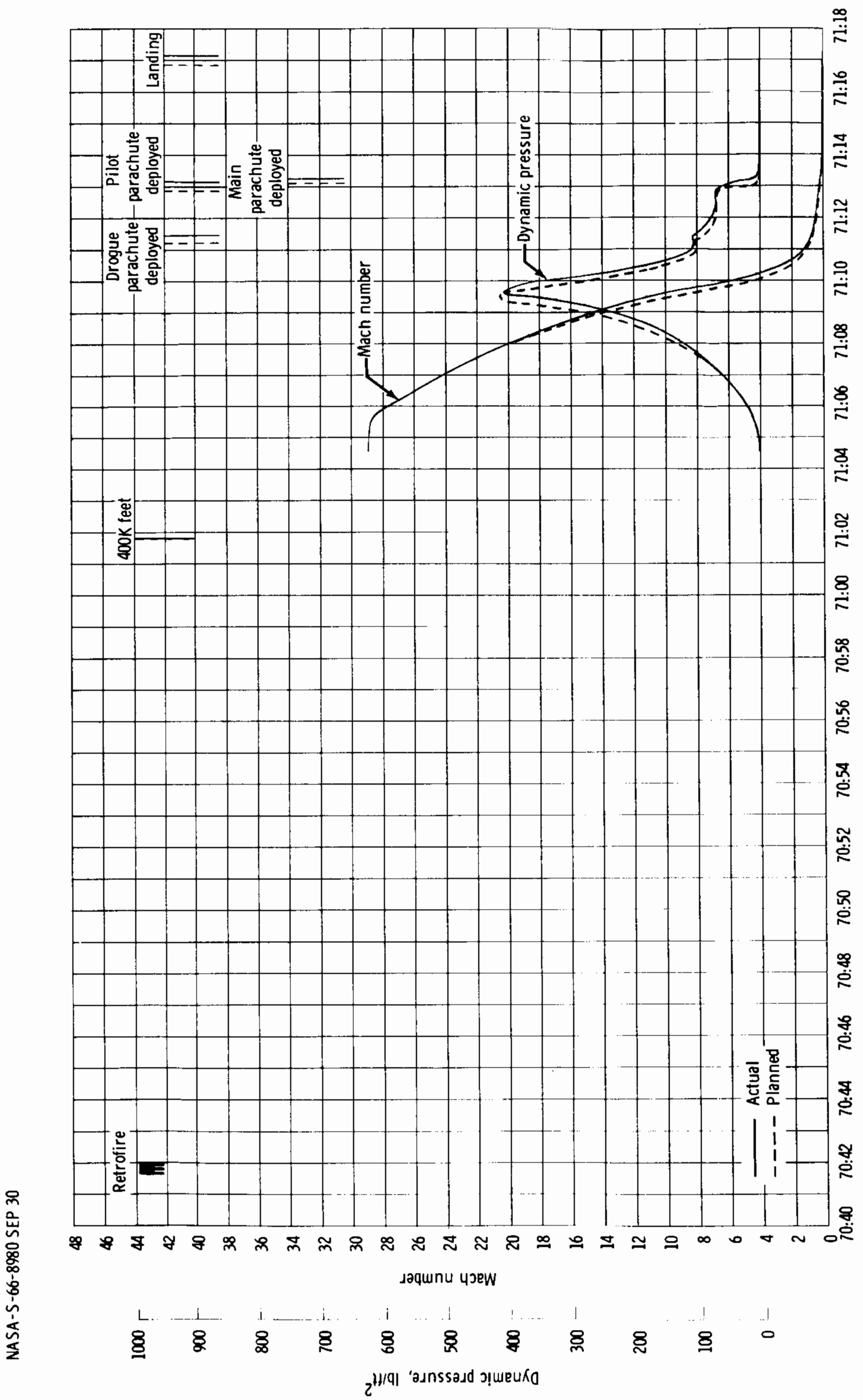
(b) Space-fixed velocity and flight-path angle.

Figure 4.3-5.- Continued.



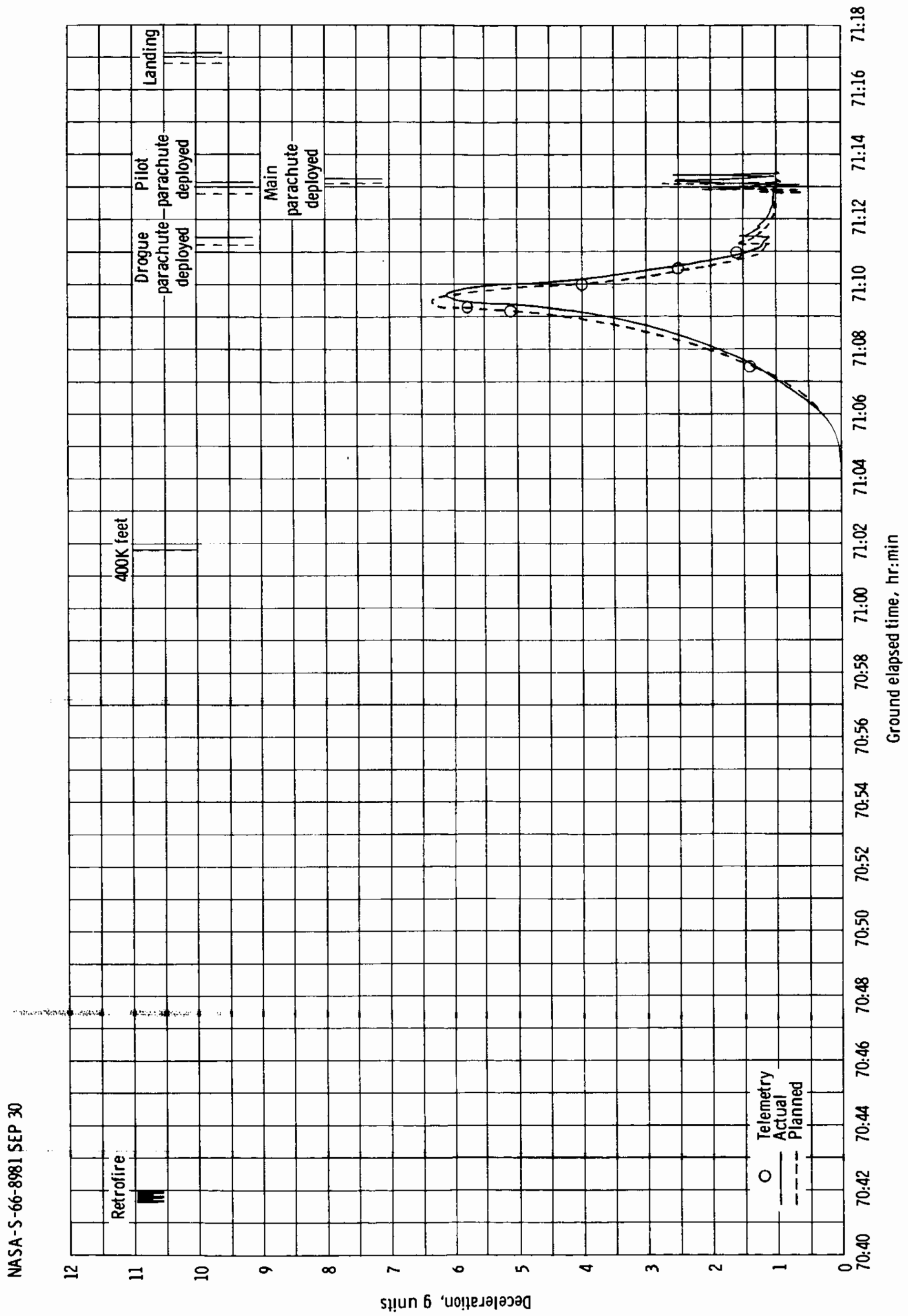
(c) Earth-fixed velocity and flight-path angle.

Figure 4.3-5. - Continued.



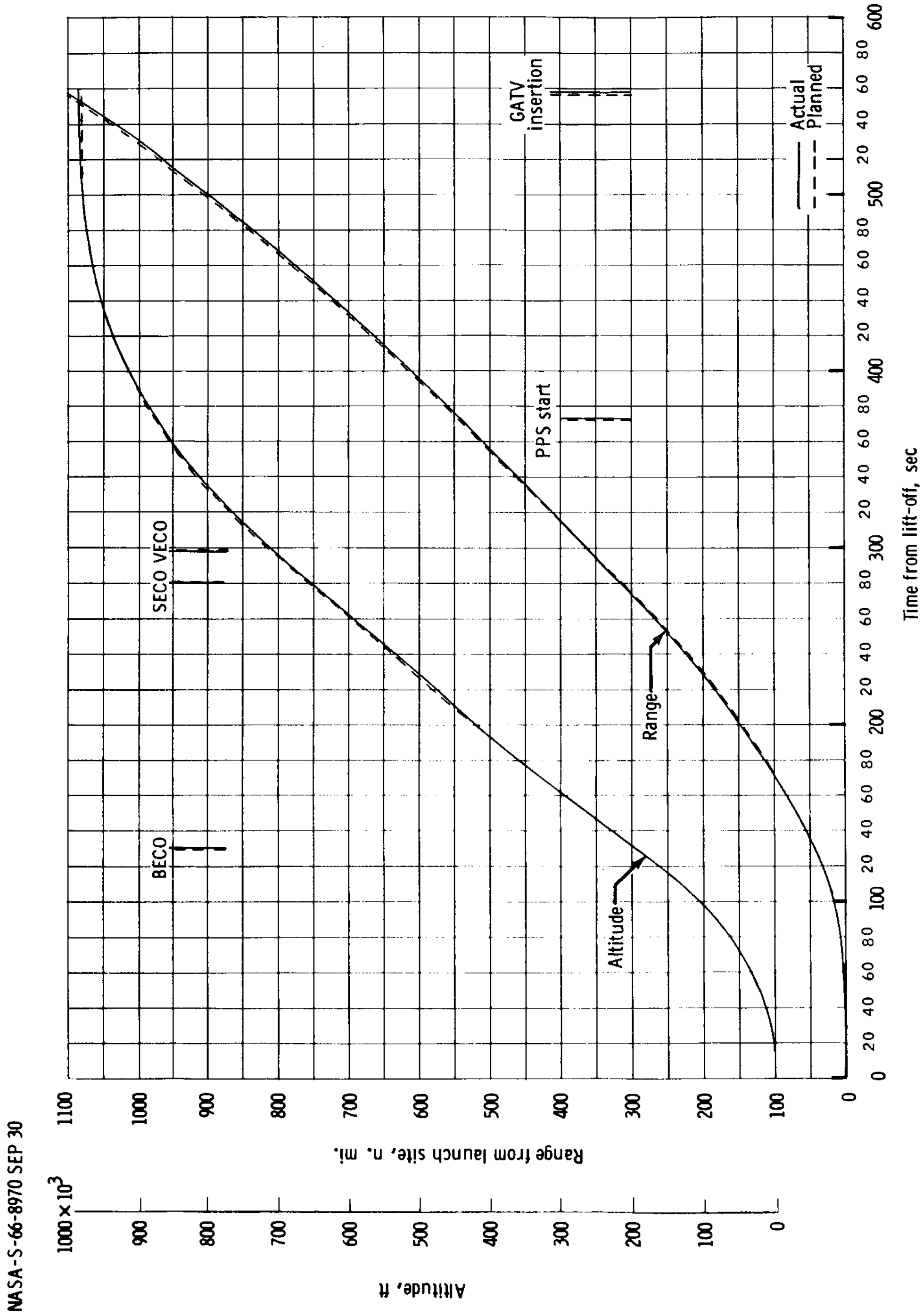
(d) Dynamic pressure and Mach number.

Figure 4.3-5. - Continued.



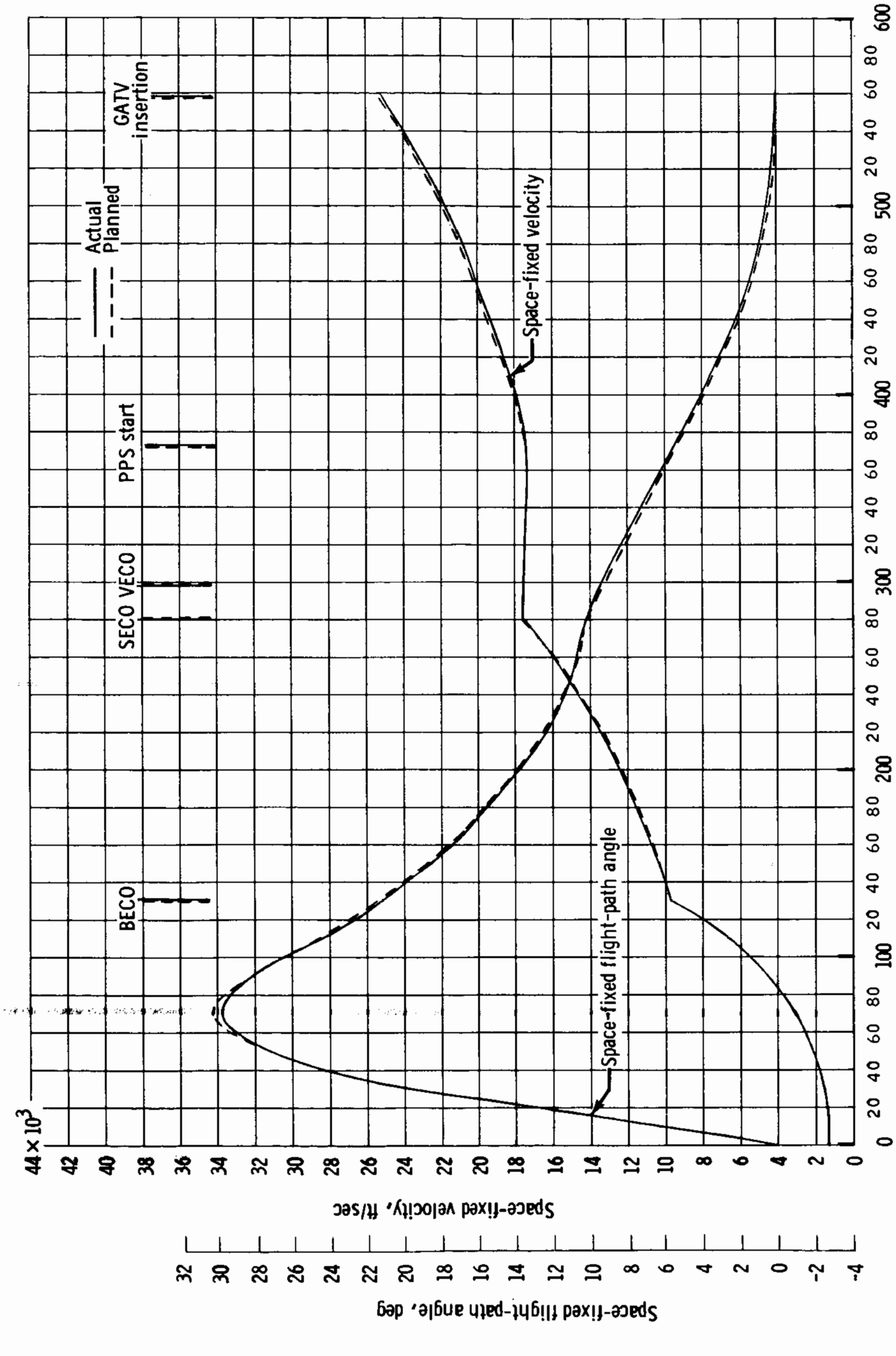
(e) Longitudinal deceleration.

Figure 4.3-5.- Concluded.



(a) Altitude and range.

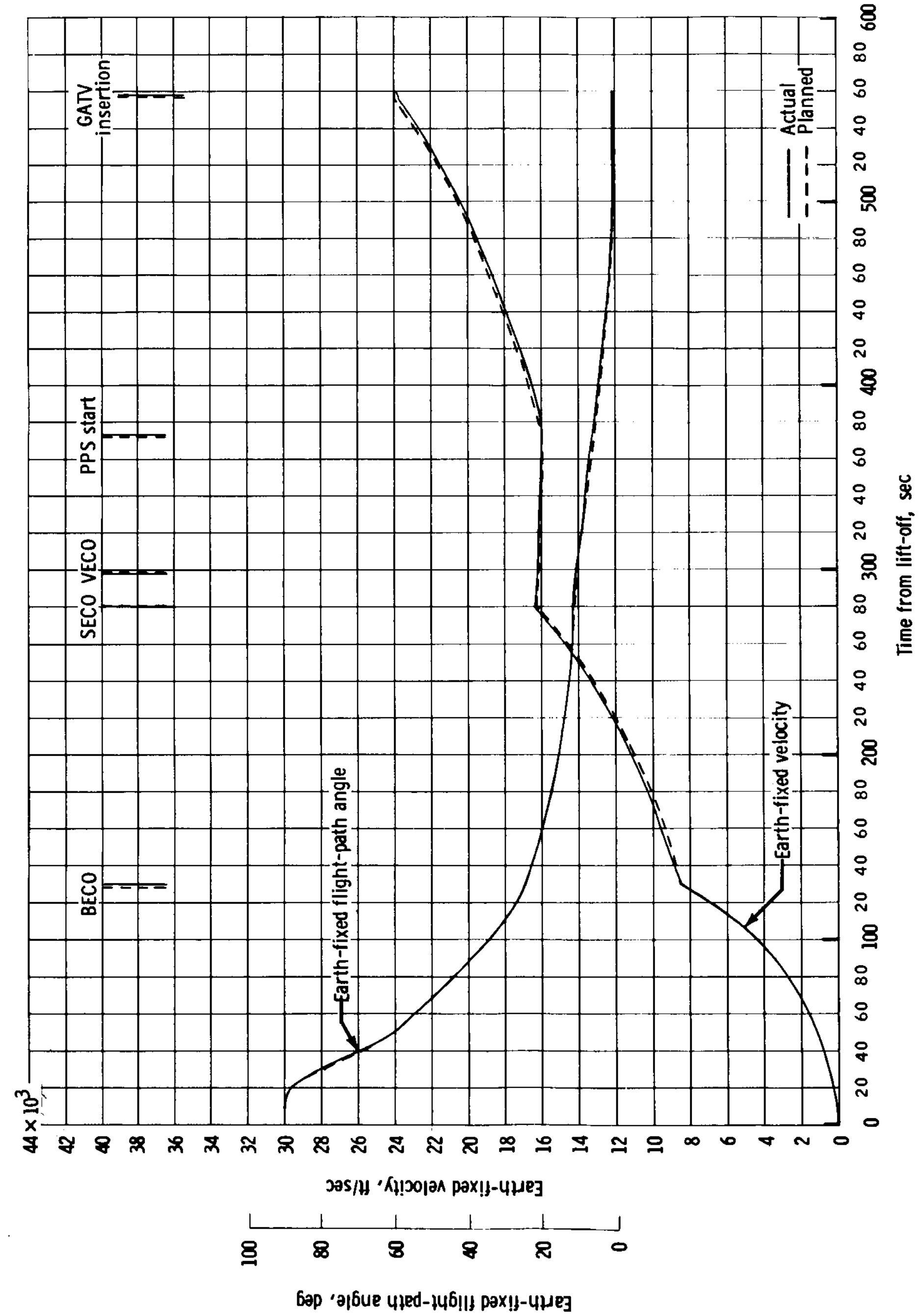
Figure 4.3-6.- Trajectory parameters for the GAATV launch phase.



NASA-S-66-8971 SEP 30

(b) Space-fixed velocity and flight-path angle.

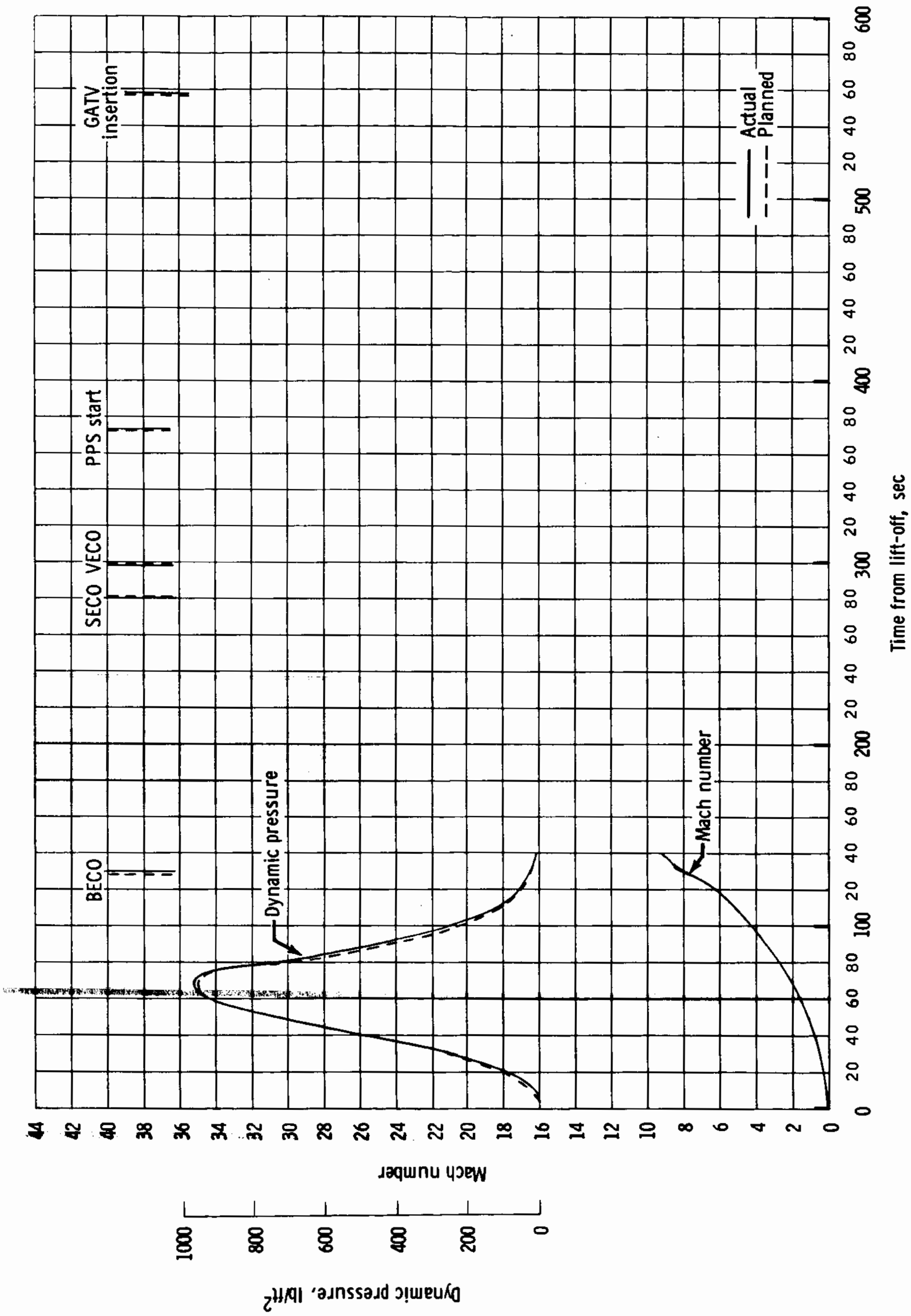
Figure 4.3-6. - Continued.



NASA-S-66-8972 SEP 30

(c) Earth-fixed velocity and flight-path angle.

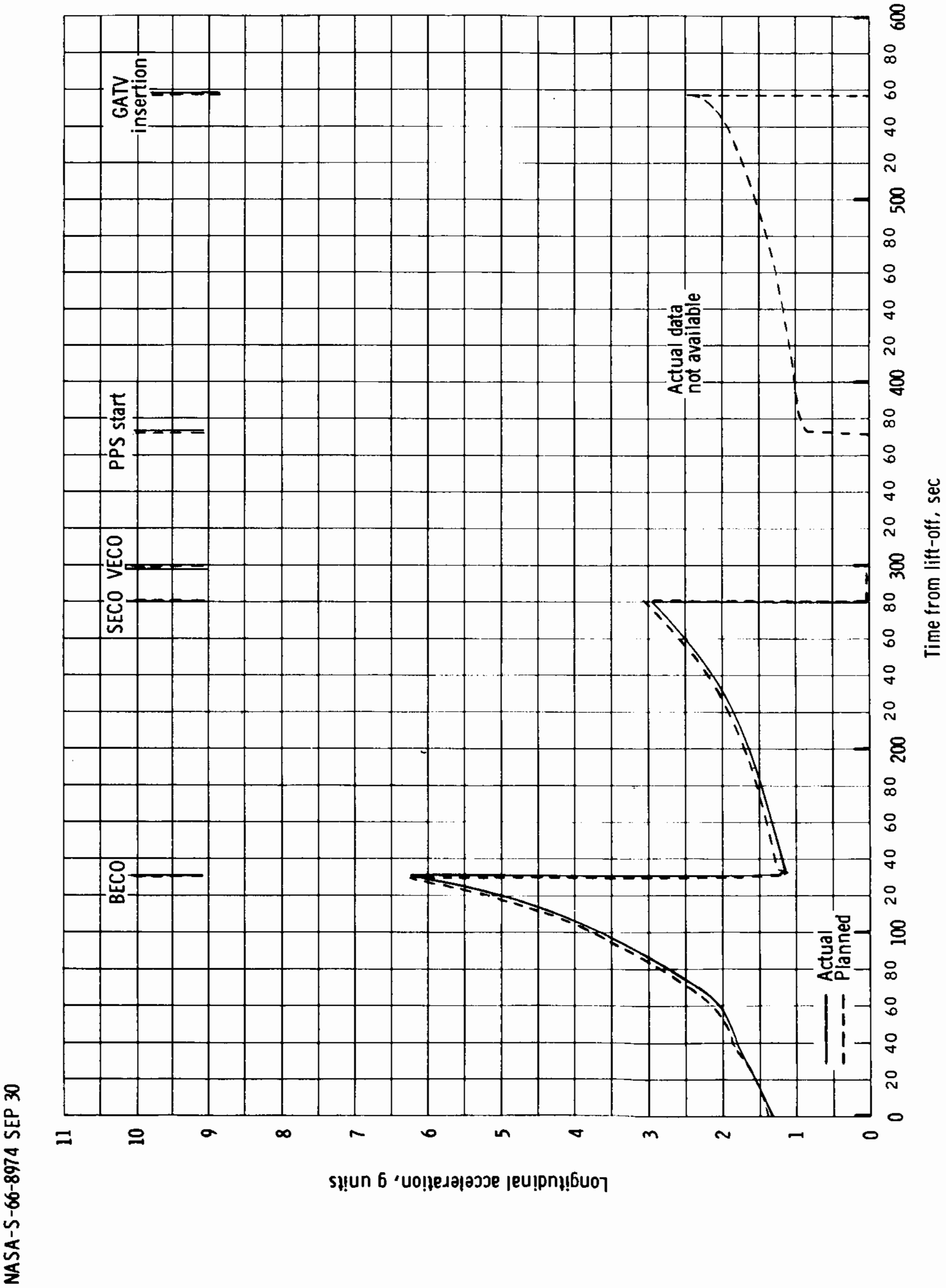
Figure 4.3-6. - Continued.



NASA-S-66-8973 SEP 30

(d) Dynamic pressure and Mach number.

Figure 4.3-6. - Continued.



(e) Longitudinal acceleration.

Figure 4.3-6. - Concluded.

5.0 VEHICLE PERFORMANCE

5.1 SPACECRAFT PERFORMANCE

5.1.1 Spacecraft Structure

The structure satisfactorily sustained the loading and environment of the mission. The crew reported contaminated windows and, based on photographs taken in flight, the command pilot's visibility was reduced more than on previous Gemini missions. Foreign material was noted on the outside surfaces of both windows; however, the major concentration appeared to be between the windows on the left side. This window condition was also noted during the postflight inspection. At the time of this writing, it was considered that the contamination was due to a combination of manufacturing and/or processing and outgassing of nonmetallic materials in the local window area. This contamination is to be tested and, if the origin and the process of deposition can be established, corrective action will be taken on Spacecraft 12.

Two other anomalies were investigated during the postflight inspection. One horizon sensor door failed to close prior to reentry. An examination of the component parts indicated that the fiber glass door apparently jammed in the frame, preventing closure; however, several attempts to repeat the condition were unsuccessful. Examination of the cavity showed no damage resulting from reentry heating. The other anomaly concerned a damaged area on the top (leeward) side of the heat shield near the fiberite ring. A depression, 8 inches long, 0.4 of an inch wide, and approximately 1/8 inch deep, was noted during the postflight inspection. The exact time that the damage occurred is not known. It has been impossible to determine whether the damage occurred prior to reentry or as a result of a disturbance during reentry, since the char depth is the same under the depression as it is under the surrounding area. An investigation revealed 0.6 of an inch of virgin material beneath the deepest part of the depression, compared with 0.7 of an inch in the adjacent area. This indicates a substantial factor of safety, as the remaining virgin material could withstand up to 10 000 Btu/ft^2 before exceeding the bondline design limit. The spacecraft reentry aerodynamics and heating were nominal, with a maximum stagnation heating rate of 45.5 Btu/ft^2/sec and a total heat of 9900 Btu/ft^2. The apparent stagnation point, as measured on the heat shield, was 11.5 inches below center. This was within the range of the measurements made on previous reentries. The stagnation point indicated an angle of attack between five and ten degrees.

5.1.2 Communications Systems

All spacecraft communications equipment performed in a satisfactory manner and without any real-time evidence of malfunction. During the postmission debriefings and data analyses, a few minor areas of concern were noted and investigated.

A crew report of intermittent operation of the voice tape recorder was verified when the tape cartridges were examined during the data analysis period. Some of the tapes were blank after only a few seconds of tape and were even interrupted in the middle of a word, all of which is indicative of intermittent recorder operation. Also, at least one tape cartridge malfunctioned as the tape was found to be off the roller. The tape recorder system was tested in the spacecraft during postflight inspection and continued to operate intermittently with power definitely supplied to the recorder. It was returned to the manufacturer for a failure analysis.

The crew also reported a low hum in the earphones when the cryogenic quantity switch was turned to either the hydrogen or oxygen position. This condition started about halfway through the mission and was described as being noticeable but low enough in volume to cause no interference with communications. This condition could not be repeated during postflight testing in the spacecraft; however, this mode of operation will be thoroughly checked on Spacecraft 12 before launch.

Voice communications blackout during reentry occurred from 71:04:00 to 71:10:23 ground elapsed time (g.e.t.). These times were determined from the real-time telemetry signal-strength charts recorded at the Texas and the Grand Turk stations, respectively.

As in previous missions, there were several instances of poor intelligibility during air-to-ground voice communications. The usual causes are microphone positioning, low audio level, and interference caused by high breath noise. Because of automatic-gain-control action in the microphone amplifiers, lower than normal or momentary decreases in the voice level of a crewmember is transmitted to the ground with a substantial increase in background noise level. During several such instances, the crew were requested by the capsule communicator to check the microphone positioning, and, in at least one instance, the repositioning resulted in a very noticeable improvement in signal-to-noise quality. These minor abnormalities caused insignificant interference with mission operations and usually required only a single repeat of the information.

5.1.2.1 Ultrahigh frequency voice communications.- UHF voice communications were satisfactory for mission support during launch and the orbital phase of the mission up to the beginning of communications blackout. Voice communications were excellent between the spacecraft and the recovery forces from the end of blackout until after landing. The voice operated relay (VOX) mode of transmitter keying was used satisfactorily during the initial portion of the umbilical extravehicular activity (EVA). The pilot's breathing became very heavy during the latter portion of EVA and the capsule communicator requested a push-to-talk keying mode to prevent continuous spacecraft VOX keying from blocking ground transmissions to the spacecraft.

5.1.2.2 High frequency voice communications.- The HF voice communications equipment is included in the Gemini spacecraft for emergency purposes during orbital flight and to aid in locating the spacecraft after landing. The HF equipment was not used during the orbital mission phase. Because of landing within sight of the recovery ship and subsequent rapid deployment of pararescue personnel, no attempt was made to use the HF equipment for either direction-finding or voice communications during the postlanding phase.

5.1.2.3 Radar transponder.- The operation of both C-band radar transponders was very satisfactory, as evidenced by the excellent tracking information supplied by the network stations. Beacon-sharing operations by ground radars were satisfactory; and C-band tracking during reentry was also satisfactory.

5.1.2.4 Digital Command System.- The performance of the Digital Command System (DCS) was satisfactory throughout the mission. Flight control personnel reported that all commands sent to the spacecraft were validated.

5.1.2.5 Telemetry transmitters.- Satisfactory operation of all telemetry transmitters was indicated by the quantity and quality of data received. Several network signal-strength charts were reviewed, and the signal levels were found to be more than adequate for good telemetry reception and tracking. It is significant that the data were generally superior to that received during any previous mission, although signal levels were approximately the same.

5.1.2.6 Antenna systems.- All antennas which were deployed operated properly during the mission, as evidenced by the satisfactory performance of the communications system. The HF whip antenna installed on the adapter assembly was not extended in orbit, and the HF whip antenna installed on the reentry assembly was not deployed for the postlanding phase of the mission.

Both the UHF descent antenna and the UHF recovery beacon antenna were correctly deployed at main parachute two-point suspension.

5.1.2.7 Recovery aids.- UHF voice communications between the spacecraft and the recovery forces were excellent. The flashing light extended normally but was not required and was not turned on by the crew. During the recovery phase of the mission and prior to the hatches being opened, communications between the swimmers and the flight crew were also excellent. The operation of spacecraft recovery aids is further discussed in section 6.3.3. The UHF recovery beacon operated normally, and signals were received at a distance of approximately 195 nautical miles.

5.1.3 Instrumentation and Recording System

The Instrumentation and Recording System performed very well throughout the mission. The PCM tape recorder was used continuously from prior to lift-off until two minutes after landing. The overall data quality was better than for any previous Gemini mission.

5.1.3.1 System performance.- Satisfactory performance was obtained from each of the 217 channels used during this mission.

5.1.3.2 Real-time data quality.- Proper operation of the delayed-time PCM tape recorder during this mission resulted in a minimum requirement for computer processing of the real-time telemetry data. From the real-time computer-processed time edits, the following usable data percentages were obtained:

Station	Phase or revolution	Usable data, percent
Cape Kennedy	Launch	99.91
Cape Kennedy	1/2	99.86
Texas	17	99.75
Hawaii	34	96.12

The usable data obtained represent nominal operation of the real-time data link.

5.1.3.3 Delayed-time data quality.- The delayed-time data reception at the Cape Kennedy, Hawaii, Antigua, and Texas ground stations, as well as the last revolution and reentry data recovered from the onboard PCM tape recorder, are summarized in table 5.1.3-I. This table represents data from 28 of the 42 delayed-time data dumps, and, based on the computer-processed edits of all recovered data, an average of 99.785 percent usable data was obtained. The worldwide ground network and flight controllers reported that the quality of the real-time and delayed-time data received during this mission was better than on any previous Gemini flight, and this report was verified by the high percentage of usable data obtained from the computer-processed time edits.

TABLE 5.1.3-I.- DELAYED-TIME DATA FROM SELECTED STATIONS

Station	Revolution	Total data received		Total data lost		Usable data, percent
		Duration, hr:min:sec	Prime subframes	Prime subframes	Percent	
Cape Kennedy	1, 2, 12, 13, 14, 15, 16, 26, 28, 29, 30, 41, 42, and 43	21:06:05	759 645	727	0.096	99.904
Hawaii	3, 4, 5, 18, 19, 32, 33, and 34	10:47:53	338 734	2086	0.537	99.463
Antigua	11, 12, 25, and 26	04:25:44	159 439	102	0.064	99.936
Texas	17 and 31	02:48:51	101 309	169	0.167	99.833
Onboard recorder	44 and reentry	01:43:50	62 298	83	0.133	99.867
Summation		40:52:23	1 421 425	3167	0.215	99.785

5.1.4 Environmental Control System

The performance of the Environmental Control System (ECS) was satisfactory throughout the mission, with no known anomalies. The crew reported that they were comfortably warm throughout the mission with one exception—the command pilot was cool during the first sleep period. He reported he was able to adjust his suit flow control valve and restore comfortable conditions. At 54 hours 31 minutes g.e.t., the inlet temperature of fuel-cell section 2 increased slightly, indicating an increase in the heat that was being added to the coolant fluid. An analysis has indicated that this increase resulted from the failure of fuel-cell stack 2C. See section 5.1.7 for a complete discussion.

At approximately 25 hours 30 minutes g.e.t., fluctuations were noted in the telemetered value of carbon-dioxide partial pressure. Partial pressure readings of up to 3.53 mm Hg were recorded. Examination of the data shows that two spikes occurred, one at 25:30:04 g.e.t. and one at 25:32:26 g.e.t. The crew reported that they did not observe any fluctuations at any time during the mission. A close examination of the data showed that these spikes were caused by resets in the telemetry system.

5.1.5 Guidance and Control

5.1.5.1 Summary.- The performance of the Guidance and Control System was nominal throughout the mission with the exception of a rendezvous-radar transponder failure sometime after the first midcourse correction of the first rendezvous. Ascent backup guidance was excellent with small navigation errors after second stage engine cutoff (SECO). The Insertion Velocity Adjust Routine (IVAR) solution was applied by the crew to place the spacecraft on a nominal trajectory for a first-orbit rendezvous. This rendezvous was successfully completed and was accomplished by using the onboard-generated maneuvers. The system provided adequate monitoring of the docked Gemini Agena Target Vehicle (GATV) firings used to transfer the vehicle to and from the 741.5 nautical mile altitude apogee. The crew demonstrated the ability to establish and control a tether rotation operation using the spacecraft control system. The Auxiliary Tape Memory Unit (ATMU) provided the ~~same 53 795~~ thirteen-bit equivalent instruction words for the onboard computer as were used on the previous spacecraft, and the operation was satisfactory throughout the mission. An automatic reentry was conducted which resulted in a miss from the target of approximately three nautical miles. The automatic portion was accomplished with low propellant consumption. Main parachute deployment and spacecraft landing were observed from the recovery ship. The control system performance was adequate to achieve mission objectives. An intermittent low thrust level was experienced with thrust chamber assembly (TCA) no. 8, and no. 15 was reported by the crew as having questionable thrust levels during both rendezvous braking operations, although proper signals were generated and supplied to both TCA's. Table 5.1.5-I contains a summary of significant guidance and control events for this mission.

5.1.5.2 <u>Guidance system performance evaluation</u>.-

5.1.5.2.1 Ascent phase: The Inertial Guidance System (IGS) roll, pitch, and yaw steering-command deviations are represented in figure 5.1.5-1. Superimposed on the IGS steering quantities are the steering signals of the Radio Guidance System (RGS) along with the upper and lower (no wind) IGS attitude error limit lines for the nominal steering signals. Analog time histories of predicted pitch and yaw attitude errors for lift-off winds, predicted at T minus two hours, are shown for the first 90 seconds of flight. The IGS attitude error time histories remained essentially within the preflight predicted boundaries. The IGS indicated agreement with the RGS, except for minor deviations due to known programmer and timing differences, initial engine misalignment, and drifts in the primary Three Axis Reference System (TARS).

If guidance switchover had occurred early in second stage flight, the vehicle would have achieved an insertion vector with a flight path angle of less than 0.010 of a degree from nominal, an in-plane and out-of-plane velocity error, both of approximately 2.0 ft/sec, and an altitude error of approximately 1200 feet. The IGS SECO discrete was delivered about 15 milliseconds after the primary SECO signal indicating that, had switchover occurred, the resulting insertion velocity error would have been about one half of the error actually obtained. Following the IVAR maneuver, the resultant orbit would have been the same as that actually achieved.

The IVAR correction was applied during this mission and a successful first-orbit rendezvous was completed with near-nominal maneuvers, indicating that the IVAR solution and application were accurate. The Incremental Velocity Indicator (IVI) display, as computed by the onboard IVAR, was reconstructed using the IGS navigational and gimbal-angle data. At spacecraft separation, the reconstructed IVI display read 39 ft/sec forward, 11 ft/sec right, and 4 ft/sec up displaying a 41 ft/sec in plane and 0.2 ft/sec out-of-plane velocity correction in component form. About 30 seconds later, following the roll and yaw to zero degrees and the nulling of the pitch attitude error needles, the reconstructed IVI read 39 ft/sec forward and 1 ft/sec left, confirming the reported crew readings. During the 53-second IVAR maneuver, the crew maintained a zero-degree yaw angle and used the right-firing thruster seven times for a total of 7.7 seconds, to maintain zero on the out-of-plane (L-R) IVI window. Following the IVAR maneuver, the reconstructed IVI window displayed 1 ft/sec aft, 0 rt/lt, and 0 up/dn. The perigee correction to be applied at apogee, as computed by IVAR, was 0.4 ft/sec, reflecting the small altitude error at insertion. The value of the reconstructed IVAR parameters in the final computation cycle, as compared with the actual values obtained from telemetry, verify that the orbit insertion equations and computer/IVI interface operated properly.

In order to achieve a more accurate insertion, a radial velocity correction was made following the IVAR maneuver. At 380 seconds after lift-off, 19 seconds after separation, the crew read the central angle travelled, using the Manual Data Readout Unit (MDRU), to be 11.63 degrees. This was compared with the desired value, at 380 seconds, of 11.76 degrees obtained from the onboard flight charts, and yielded a minus 0.13 of a degree error. Twenty seconds later, the radial velocity, as determined by the IGS computer, was read on the MDRU as 0 ft/sec. The onboard charts were again used to determine that a radial firing of 15 seconds down was required to achieve a minus 5 ft/sec change in radial velocity to compensate for the minus 0.13 of a degree central angle error. The crew applied forward-firing thrusts of 4.6-second total duration to compensate for the forward velocity component obtained from the radial thrusters. The results of the firing were 5.5 ft/sec radially down and 0.35 ft/sec tangentially forward. The maneuver shifted the central angle of apogee 0.045 of a degree for a downrange displacement of 2.8 nautical miles and caused a 0.67-second delay in the time of apogee. This was the first time that this technique was used to correct the insertion error.

An estimate of orbital injection parameters at SECO + 20 seconds, as determined from the IGS and the various tracking systems, is given in table 5.1.5-II. The differences between the real-time MISTRAM and GE MOD III data and the postflight MISTRAM and GE MOD III data indicate the extent of postflight corrections to the data.

The velocity residuals obtained with GE MOD III, GE/Burroughs, and MISTRAM 100K tracking data were used to determine a set of Inertial Measurement Unit (IMU) component errors which would induce velocity error propagations as shown in figure 5.1.5-2.

The data acquired from the various trackers agree relatively well along the X and Z axes from lift-off to SECO. The velocity residuals do not agree along the vertical (Y) axis. There were large position discontinuities in the MISTRAM 100K-foot data during the time interval from lift-off to BECO. The GE/Burroughs data have a refraction error. The GE MOD III final data are the GE/Burroughs data smoothed and corrected for the refraction error, but it appears that some refraction error remained. The GE MOD III and GE/Burroughs radar data were corrected for refraction by 8 ft/sec at 200 seconds and 70 ft/sec at 340 seconds. At spacecraft separation, approximately 361 seconds after lift-off, a shift of the velocity residuals, approximately 5 ft/sec, is indicated along the X-axis. The guidance data do not show any shift in velocity greater than 2 ft/sec during this time period, and a radar tracking problem may also have existed along this axis. Data from 120 to 280 seconds after lift-off were assumed to be the most reliable and were used to determine a set of IMU error coefficients.

On this flight, the gyro drift rates were successfully compensated for in the computer. The compensations reduced the velocity error by 7.1 ft/sec and 24.5 ft/sec along the Y and Z axes, respectively. The ability to compensate for errors allows some relaxation in the allowable preflight component performance in that the effect of gyro characteristics can be offset. On this mission, if no compensation had been possible, a gyro remelt would probably have been necessary and would have increased the prelaunch operation activity. A plot of the preflight error coefficient history, used to predict the compensation in the computer, is shown in figure 5.1.5-3.

The indicated vertical velocity error could be induced by a Zp-accelerometer scale-factor shift of approximately minus 100 ppm, and a Zp-accelerometer input-axis misalignment toward Xp of 35 arc seconds. A platform drift about the pitch axis propagates similarly to a misalignment, but was excluded from the analysis because the X-axis residuals do not indicate the coupling effects of the vertical velocity.

An Xp-accelerometer scale factor of approximately minus 90 ppm could have been the primary contributor to the indicated error along the X axis. Timing errors, which were smaller than on the three previous flights, were also used to fit the trend of the data.

The Z-axis error was caused primarily by an azimuth misalignment of about 30 arc seconds. This error was not an IMU error, but occurred because the RGS is limited and cannot make an exact azimuth update. The differences between gyro data acquired during precount and the compensation values were also used to fit the Z-axis residuals.

A summary of preliminary estimates of IMU component errors and total velocity errors induced by each error source during powered flight is given in table 5.1.5-III. In addition, sensor and tracking errors are presented which were obtained from a preliminary Error Coefficient Recovery Program (ECRP) computer run. This program assumes that the prelaunch sea-level refraction characteristics are representative of the actual flight refraction characteristics.

The present best estimates of the position and velocity errors of the guidance at SECO + 20 seconds are given in table 5.1.5-IV. These quantities were obtained from position and velocity comparisons using preliminary best estimates of the tracker reference trajectory. In this table, the IMU error consists of sensor errors, while navigation errors result from various approximations within the airborne computer.

5.1.5.2.2 Orbital phase: Table 5.1.5-V summarizes the translation maneuvers performed during the mission. The crew reported no difficulty with zeroing the residuals in order to perform a precise translation maneuver, and the ease of this operation is reflected in the accuracy shown in the table.

The postflight platform alignment checks indicated that all alignments, both BEF and SEF, were accomplished with the expected accuracy. Because of their significance, three alignments—one prior to each rendezvous and one prior to retrofire—were examined in detail. Following the scanner lock after insertion, the platform was switched from FREE to SEF and the platform was aligned using the platform mode. At 22 minutes 7 seconds g.e.t., the crew switched from PLAT to PULSE mode and reduced the sensor output oscillations from 1.5 degrees to 0.8 of a degree in both pitch and roll, and reported that they were extremely careful in maintaining null attitudes and that the task required complete concentration. (For further discussion of this alignment, refer to section 7.1.2.) Two minutes and fifty-five seconds later, the alignment was ended and the platform was switched to ORB RATE. The difference between the sensor outputs and the platform pitch and roll outputs indicates that the alignment was within 0.35 of a degree in pitch and 0.2 of a degree in roll. The platform was in alignment for about three revolutions prior to retrofire in the BEF mode and attitude control in PLAT. Alignment was terminated approximately 6 minutes 18 seconds prior to retrofire, with the alignment accuracy estimated to be 0.3 of a degree in pitch and 0.2 of a degree in roll.

The Auxiliary Tape Memory Unit operated satisfactorily for this mission. Module III (Catch-up and Rendezvous) was loaded at 8 minutes 29.9 seconds g.e.t. and remained in the computer throughout the orbital phase. Module IV (Touchdown Predict and Reentry) was loaded starting at 66:56:07.3 g.e.t. Both loading operations were performed using the automatic procedure.

The initial rendezvous on this mission was accomplished during the first revolution, with terminal phase initiation occurring near relative spacecraft apogee. Figure 4.3-4 shows the relative trajectory of the spacecraft with respect to the GATV from insertion through the rendezvous.

The close agreement of the actual trajectory with the preflight planned trajectory indicates close to nominal performance throughout.

Figure 5.1.5-4 shows time histories of the gimbal angles and radar parameters taken from computer telemetry words during the initial rendezvous sequence. The figure also contains a history of the values of total velocity change required to achieve rendezvous $\left(\Delta V_T\right)$, computed (1) inflight and (2) in a postflight simulation using Best Estimated Trajectory (BET) target and spacecraft state vectors. As shown in the figure, the pitch-up maneuver to acquire the GATV was conducted at approximately 26 minutes g.e.t. The values of ΔV_T calculated onboard agreed closely with those produced by the simulation, and exhibited none of the variations caused by alignment or off-boresight errors experienced in previous flights.

The spacecraft was reoriented off boresight for the terminal phase initiate (TPI) maneuver so that the aft-firing thrusters could be used. Table 5.1.5-VI lists TPI and other rendezvous maneuvers calculated by the onboard computer, by the ground, and by the onboard backup procedures.

The onboard computer solutions were used for TPI and the first midcourse correction, but apparent erratic radar behavior (fig. 5.1.5-4 and paragraph 5.1.5.4) prior to the second midcourse correction invalidated the computer solution for that maneuver. The crew realized that the radar data would cause the computer solution to be erroneous; therefore, they used the backup solution, calculated onboard, for the second midcourse correction. After the second midcourse correction, inertial line-of-sight rates were small, and braking was accomplished with little difficulty. Fuel consumption throughout the rendezvous sequence was within acceptable bounds. The GATV was first seen by the crew in reflected sunlight at a range of 73 nautical miles (29 minutes g.e.t.). The crew reported that the GATV acquisition lights were first observed at 31 nautical miles at dusk (40 minutes g.e.t.).

The BET target and spacecraft state vectors were used in conjunction with the rendezvous equation simulator to produce a number of different postflight simulations. These simulations provided a basis for comparing the ground-computed, onboard-computer-computed, and simulator-computed results of the rendezvous maneuvers with the results of the maneuvers actually applied in flight.

Tables 5.1.5-VII and 5.1.5-VIII show the maneuvers applied in these simulations in spacecraft and navigational coordinates, respectively, and the resulting relative trajectories are shown in figure 5.1.5-5.

The run designations used in the tables and in the figure refer to the solutions used for each of the three rendezvous maneuvers (see key in figure 5.1.5-5).

For the in-plane components, figure 5.1.5-5 shows that the flight values, onboard-computer values, and simulation values produced essentially the same trajectory. The close agreement between the run using the simulator values for the TPI and first midcourse maneuvers and those using the flight and computer values for these maneuvers indicates that the in-plane components of the state vectors used closely represented the actual flight situation.

The trajectory obtained from the simulation using the ground-computed solution for TPI differed from the trajectories obtained from the other runs in both the in-plane and out-of-plane components. The radial component ($\Delta\dot{Y}$) of the ground TPI solution was 11 ft/sec less than that of the computer solution. The resulting trajectory rose too fast and required a 19 ft/sec component radially downward to depress the trajectory and achieve a rendezvous.

For the out-of-plane components of the simulated trajectories, the figure shows that the runs using the flight and onboard-computer maneuver values had almost the same trajectory. The GSS trajectory is nearly a mirror image of the flight trajectory. This is as expected, because the out-of-plane component of the ground TPI solution was of the same order of magnitude as the computer solution but of opposite sign. However, the SSS trajectory falls approximately midway between the FSS and GSS trajectories. This shows that, so far as the out-of-plane components are concerned, the problem defined by the state vectors used in these simulations was slightly different from either the problem solved by the onboard computer or the one solved by the ground complex. The out-of-plane components of state vectors derived from ground tracking before TPI may have been less accurate than normal because a plane change maneuver was executed only 20 minutes prior to TPI.

The reasons for the differences between the onboard-computer and simulator solutions for the out-of-plane components were somewhat harder to assess. Figure 5.1.5-6 shows a relative trajectory reconstructed from the gimbal angles and radar parameters taken from computer telemetry data. This trajectory shows the spacecraft to be north of the target moving southward toward a nodal crossing which would have occurred after TPI but before the desired time of rendezvous. The out-of-plane component of the computer TPI solution was intended to move this nodal crossing downrange to the desired rendezvous point. Because the backup TPI solution calculated by the crew agreed with the computer solution, it was apparent from the radar and platform outputs that the spacecraft was following such a trajectory. On the other hand, the BET state vectors placed the spacecraft north of the target and moving northward at TPI, having passed through a nodal crossing shortly prior to TPI. The out-of-plane component of the simulator TPI solution was calculated to move the next nodal crossing uprange to occur at the proper time for a 120-degree rendezvous. No evidence of platform yaw misalignment or radar azimuth bias was noted; therefore, the most likely cause of these differences was an error in the BET state vector. The FFC simulation shows the effect of applying the onboard closed-loop solution and indicates acceptable performance of the system.

Figures 5.1.5-7 and 5.1.5-8 are time histories of gimbal angles, translation thruster firings, and resultant ΔV's for the first and second rendezvous. Figure 4.3-4 shows spacecraft relative motion with respect to the GATV during the final phases of the second rendezvous. The braking maneuver was initiated at 66:34:43.3 g.e.t. with minimum spacecraft maneuvering, resulting in a very low ΔV required to rendezvous. Total ΔV expenditure for the second rendezvous (TPI, midcourse corrections, and braking) was 33 ft/sec.

5.1.5.2.3 High-altitude translation maneuvers: Figures 5.1.5-9 and 5.1.5-10 show the accelerations, body rates, and attitude excursions during the second and third GATV primary propulsion system (PPS) translations. The maximum attitude excursion in each case occurred in yaw, reaching five degrees in the second maneuver and 3.8 degrees in the third. The excursions were damped to within two degrees in less than ten seconds and to within one degree by just before the end of the maneuver. The maximum rates noted were less than 4 deg/sec. The maneuvers were monitored on the IVI's using the logic choice which causes the fore/aft window to display velocity in units of 10 ft/sec. This window was serviced approximately every 1.4 seconds and would have been changing in steps of approximately 50 ft/sec at the acceleration achieved. This value would be the order of the accuracy obtainable with a manually actuated cutoff.

5.1.5.2.4 Retrofire-reentry phase: The IGS operated properly throughout the retrofire and reentry phases of the mission. The total velocity change as a result of firing the retrorockets was 0.56 ft/sec less than predicted (as measured by the IGS). A comparison of the actual and planned velocity components is contained in table 5.1.5-V. The pitch and yaw attitudes were held within 1.5 degrees and roll was held within 1.0 degree. According to ground tracking at the White Sands station, the total footprint shift due to the entire retrofire maneuver was approximately 22 nautical miles, as shown in figure 5.1.5-11. The IVI readings called out by the crew, however, indicated a shift of approximately seven nautical miles in the opposite direction, excluding the small ΔV's realized from sources other than the retrorockets. The IVI's are zeroed at retrofire and do not take into account adapter equipment section separation. The IVI readings after adapter retrograde section jettison do include the retrograde section jettison impulse but the values used were read by the crew and transmitted to the ground prior to adapter retrograde section jettison. The adapter equipment section separation impulse, as measured by the IGS accelerometer, had a ΔV of less than 0.7 ft/sec.

From retrofire to an altitude of 400K feet, a 10-degree bank angle toward the south was flown as planned. At 71:01:51.713 g.e.t., the computer commanded a zero-degree bank angle, indicating proper spacecraft navigation to the 400K-foot level when compared with the time of arrival at 400K feet, as computed on the ground using IVI data acquired after retrofire. From the 400K-foot level to guidance initiate, the backup bank angle (based on the footprint shift of 22 nautical miles) of 44 degrees toward the south was flown as planned. At 71:04:48.703 g.e.t., the spacecraft passed an acceleration level of 1.0 ft/sec^2 (density altitude factor of 8.76594) and the computer began to calculate the bank commands necessary to guide the spacecraft to the planned target, indicating normal operation.

Approximately 51 seconds after guidance initiate, the flight crew selected an automatic reentry by changing the control mode to reentry, and, from this point on, the computer-calculated commands controlled the spacecraft attitude directly. The control system held the bank angles to within one degree of those commanded by the computer. The roll maneuvers were initiated by a continuous bank-angle error. At guidance initiation, 27.3 pounds of propellant remained in the A-ring tanks and 27.8 pounds in the B-ring tanks. At guidance termination, 17.0 and 27.0 pounds remained in the A-ring and B-ring tanks, respectively. Therefore, 10.3 pounds were used from the A-ring tanks and 0.8 of a pound was used from the B-ring tanks. This low propellant consumption left adequate propellants for spacecraft control and damping below 80K feet. Time histories of bank-angle command, actual bank angle, downrange error, and crossrange error are presented in figure 5.1.5-12. This figure shows the downrange and crossrange errors converging. At guidance initiate, the errors were 0.11 of a nautical mile uprange and 0.95 of a nautical mile left, for a guidance error of 0.96 of a nautical mile. The IGS initial-condition, platform, and computational errors propagated into a navigational error at guidance termination of 2.9 nautical miles (0.3 of a nautical mile east and 2.9 nautical miles north of the target). Table 5.1.5-IX shows the initial-condition errors in the ground update quantities prior to retrofire. The initial misalignment errors at retrofire (0.44, 0.42, and 0.17 of a degree in X, Y, Z, respectively) shown in the table could have been major contributors to the navigation error. Table 5.1.5-IX also shows the total controlled reentry miss distance at drogue deploy to be 3.1 nautical miles (1.6 nautical miles west and 2.7 nautical miles south of the target) as obtained from ground tracking radar.

Table 5.1.5-X contains a comparison of the reentry parameters obtained from telemetry data with the same parameters reconstructed after the flight using the Digital Command System update, gimbal angles, spacecraft body rates, and platform accelerometer outputs. This verifies that the computer operations were correct during reentry.

5.1.5.3 Control system performance evaluation.-

5.1.5.3.1 Attitude control and maneuvering system: Performance was excellent throughout the mission. Two discrepancies were reported, neither of which was caused by the attitude control and maneuvering system signals.

The crew noted a discrepancy in attitude control during the Apollo sump tank test and correctly diagnosed the problem as a degradation of TCA no. 8. The spacecraft responded to a yaw-left command with a combined yaw left and roll right. A test was subsequently performed over Texas during revolution 17 to obtain real-time data for analysis. The direct mode was used and the redundant valve-driver channels were exercised. By opening the proper circuit breakers, TCA no. 7 and no. 8 were commanded on individually. Rate gyro data show that, although the correct electrical firing commands were present, the resulting thrusts were lower than nominal, indicating that the problem was in the propulsion system. See section 5.1.8 for further discussion.

The command pilot reported that the down-firing thruster was "soft or intermittent" during the late stages of both rendezvous. An examination of spacecraft accelerations, measured by the IGS, and rates, measured by the rate gyros, indicated that the correct disturbance torque was generated when the thrusters indicated "on" and revealed no evidence of low thrust level from either the up-firing or down-firing thrusters. The absence of telemetry on the maneuver hand controller prevents an analysis to determine whether or not the thruster was firing correctly in response to commands. Investigation of postflight operation of the maneuver controller is underway and a comparison of preflight simulator runs and flight data will be made to verify hand-controller operation. Neither of these apparent or reported failures had any effect on the ability of the crew to complete the mission objectives.

The first automatic reentry of the Gemini Program used the reentry control mode with the resultant miss distance verifying the control system performance. Following retrofire, the control mode was switched from rate command to pulse. The reentry rate-command mode was selected 22 minutes 15 seconds later, and the spacecraft was rolled to the backup bank angle in preparation for IGS computer guidance initiation. Fifty-one seconds after guidance initiation, the control mode was switched to reentry (automatic control) and remained in this mode until drogue parachute deploy. From drogue parachute deploy until the spacecraft was powered down, the rate command mode was used. The crew reported that single-ring Reentry Control System (RCS) operation was used until 90K feet, after which both rings were used. The maximum rates experienced by the spacecraft prior to drogue parachute deployment were approximately 4 deg/sec in pitch and 6 deg/sec in yaw which is comparable to the rates observed in previous missions and indicates normal operation of the RCS in the reentry and reentry rate-command modes. Figure 5.1.5-13 is a complete time history of control system parameters during the reentry phase.

5.1.5.3.2 Spacecraft/GATV tethered operations: At 50:12:48 g.e.t., the crew imparted a rotational rate to the tethered spacecraft/GATV combination. Minor difficulties were encountered in initiating the rotation, due in part to the unanticipated behavior of the tether under tension— a "skip-rope" motion (see section 7.1.2). Figure 5.1.5-14 shows selected samples of the spacecraft attitudes, rates, and control system usage during the tether evaluation. The intervals shown are from 50:12:00 to 50:22:00 g.e.t. (showing the initiation of the rotational rate and about nine minutes thereafter); 50:52:30 to 50:57:30 g.e.t. (a sample of rates and attitudes after about 40 minutes of rotation); and 51:40:30 to 51:50:30 g.e.t. (showing an increase in the rotational rate through use of the spacecraft thrusters, and an attempt by the crew to damp the spacecraft rates). Figure 5.1.5-15 is a low-speed record of the spacecraft attitudes, rates, and control system usage for the entire tether evaluation.

The inertial rotational rate following the initiation was about 38 deg/min. The plane of rotation was inclined to the orbit plane by about 40 degrees, as evidenced by the yaw gimbal readings in figure 5.1.5-15. At 51:35:43 g.e.t., the crew used the spacecraft control system to modify the spacecraft rates, which established conditions leading to a satisfactory attitude for increasing the rotational rate.

Figures 5.1.5-14 and 5.1.5-15 show that the spacecraft pitch, yaw, and roll attitudes at the time the rotational rate was increased were 145, 17, and 180 degrees, respectively. TCA nos. 11 and 12 (aft) and TCA no. 16 (down) were fired, producing an in-plane tangential component, a radial component, and a small out-of-plane component of thrust. The presence of an out-of-plane thrust component is indicated by the attitude disturbances shown at and immediately following 51:42:05 g.e.t., and in particular at 51:42:45 g.e.t. All three attitudes and rates remained fairly stable for about 35 seconds following the thruster firings but then began to deviate. This indicates that the tether was under low tension for the 35 seconds, and then it rather abruptly became taut. The fairly rapid transients in rates attributable to "jerking" the tether were present for only about 60 seconds, although oscillations remained. The crew noted that the GATV was also oscillating, but less than the spacecraft. The crew indicated that this was the case throughout the tether evaluation.

At 51:46:00 g.e.t., the crew used the spacecraft control system to assist in damping the spacecraft oscillation, and indicated that this action tended to stabilize the entire tethered system. Figures 5.1.5-14 and 5.1.5-15 show the control system activity and the effect on the spacecraft oscillations. The crew was successful in reducing the amplitude of the roll and yaw oscillations, but the pitch oscillations were larger after the control system activity than they were before; however, the pitch rate had been increasing in magnitude prior to the control system activity and may have been even larger without the efforts of the crew.

The data shown in figure 5.1.5-15 show no obvious indication of a cyclic transfer of rotational energy from one vehicle to the other. Following the initial transients, the spacecraft rates exhibited a slowly decaying amplitude and a slowly increasing period. The disturbances in spacecraft rates were damped more quickly and more completely following the increase to a higher rotation rate than after the initial rotation. The higher damping is probably attributable to the higher tension in the tether. No GATV rate data were available for the periods of interest. However, comments by the crew indicated that both vehicles were stabilizing, substantiating the hypothesis that the rotational energy of both vehicles was being absorbed by the damping of the tether.

At 52:58:36 g.e.t., the crew damped the spacecraft rates using the spacecraft control system, translated forward to remove tension from the tether, and jettisoned the docking bar, ending the tether evaluation.

5.1.5.3.3 Horizon sensors: The horizon sensors performed satisfactorily during the flight. The primary sensor was used for the first 37 minutes following orbital insertion, including the platform alignment prior to the rendezvous maneuver. The secondary scanner was then used for the remaining 50 minutes before docking. Both scanners were used during subsequent alignments and displayed good agreement. No difficulties were reported by the crew.

5.1.5.4 Radar anomaly.- The L-band transponder was turned on 48 minutes prior to Gemini Space Vehicle lift-off, and the rendezvous radar was placed in the standby mode at approximately 14 minutes g.e.t. The crew initiated the radar search mode at 23 minutes 30 seconds g.e.t. and immediately had radar lock-on. The lock-on range was approximately 103 nautical miles. Subsequently, radar lock-on was lost but was re-acquired at 26 minutes 30 seconds g.e.t. at a range of 88 nautical miles. This loss of lock was caused by a large off-boresight angle in pitch, and the signal was reacquired when the crew pitched up to the target.

As figure 5.1.5-4 indicates, radar tracking continued through 47 minutes 30 seconds g.e.t. with smooth tracking in angle and in range. The crew reported steady FDI readings and that the indicators were in agreement with the optical boresight within 1/2 of a degree in both azimuth and elevation. At approximately 55 minutes g.e.t., the radar was interrogated for data for the first midcourse correction. These data were obtained and the closed-loop solution was used for the correction. After the first midcourse correction, at 1 hour 7 minutes g.e.t., the crew reported that the indicators went off boresight approximately three degrees in both azimuth and elevation, while maintaining optical boresight on the target. The motion can be observed in figure 5.1.5-4. No GATV data exist for this period; however, data available prior to and after this time indicate that the spiral antenna was in use. The crew reported an increase in analog range-rate noise but both digital and analog range continued to read correctly. The crew also reported that the angle excursions increased at about 1 hour 15 minutes g.e.t. and that this condition remained until the radar was placed in standby at 1:32:04 g.e.t., just prior to docking. The transponder power monitor showed variations during the periods of erratic radar angle data. The crew did not receive message acceptance pulses (MAP's) from the RF link which indicated that the transponder was not transmitting the required pulse characteristics. All of the symptoms indicated that the transponder receiver was functioning normally and that a problem had developed with the transponder transmitter. Commands were successfully transmitted (acquisition lights on-off and antenna select) using the radar command link. The radar-transponder loop was again exercised during an experiment, and, after undocking, the radar was placed in the search mode. Radar lock-on was observed for less than one minute. At 2:36:17 g.e.t., radar lock-on was lost and the transponder power monitor signal dropped to zero where it remained for the duration of the mission; however, after this time, commands (acquisition lights on-off and antenna select) were successfully transmitted using the radar RF link, indicating that the transponder receiver was functioning properly. This was subsequently confirmed over Hawaii at 49 hours 50 minutes g.e.t. when the radar was tested at a range of approximately 20 feet. The coder lock-up parameter indicated that the transponder receiver was locked-on to the radar interrogation; however, the transponder power monitor again read zero. The digital data from the spacecraft read the same value as it did at

2:36:17 g.e.t. This indicates that this failed condition had existed from 2:36:17 g.e.t. to the end of the mission.

Preliminary evaluation of the problem in the transponder indicates that the transmitter section of the transponder failed. The failure most likely occurred in either the modulator, the high-voltage power circuit, or the transmitter tube. An investigation of the failure was being conducted at the time of this writing.

TABLE 5.1.5-I.- SPACECRAFT GUIDANCE AND CONTROL SUMMARY CHART

Ground elapsed time, hr:min:sec	Event	Component status					Remarks
		ACME	Computer	IMU	Horizon sensor	Radar	
	Lift-off	Rate command, OAMS off	Ascent	Free	Off	Off	14:42:27 G.m.t.
0:05:40.3	SECO	Rate command, OAMS off	Ascent	Free	Off	Off	
0:06:01.0	Separation (spacecraft/GLV)	Direct	Ascent	Free	Off	Off	Thrusters 9 and 10 on at 6 minutes 0.3 second g.e.t.
0:06:30.7	IVAR maneuver	Rate command	Ascent	Free	Off	Off	Horizon sensor covers blown 7 minutes 59 seconds g.e.t.
0:07:30.1	Radial correction	Rate command	Ascent	Free	Off	Off	
0:08:29.9	Load Module III	Pulse and platform	Prelaunch	Free, SEF, and orbit rate	Primary	Off	
0:29:40.0	Out-of-plane correction	Rate command	Catch-up	Orbit rate	Primary	On	
0:49:58.1	Terminal phase initiate	Rate command	Rendezvous	Orbit rate	Secondary	On	Closed-loop computer solution
1:03:40.9	First midcourse correction	Rate command	Rendezvous	Orbit rate	Secondary	On	Closed-loop computer solution
1:07:00	Radar problem	Rate command	Rendezvous	Orbit rate	Secondary	On	Radar indicators drift 3 deg; no MAP's; no antenna switching
1:15:43.0	Second midcourse correction	Rate command	Rendezvous and catch-up	Orbit rate	Secondary	On	Crew backup charts
1:17:41.2	Terminal phase finalize	Rate command	Catch-up	Orbit rate	Secondary	On	
1:34:07.3	Docking	Rate command	Catch-up	Orbit rate	Secondary	On	

TABLE 5.1.5-I.- SPACECRAFT GUIDANCE AND CONTROL SUMMARY CHART - Continued

Ground elapsed time, hr:min:sec	Event	Component status					Remarks
		ACME	Computer	IMU	Horizon sensor	Radar	
1:55:29.3	Mass determination	Rate command	Catch-up	Orbit rate	Off	Off	
3:15	Docking practice	Rate command	Catch-up	Orbit rate	Primary	Off	
4:28:48	PPS calibration maneuver	Rate command	Catch-up	On	Off	Off	
7:29:38	Power down	Off	Off	Off	Off	Off	Voice tapes
16:11:30	Power up				Off	Off	Crew report
19:15:00	Thruster no. 8 problem	Rate command	Off	On	Off	Off	Voice tapes
24:02:00	EVA	Rate command	Off	On	Off	Off	
27:12:14	Thruster no. 8 test	Direct	Off	Off	Off	Off	
27:19:58	Power down	Off	Off	Off	Off	Off	G and C summary TWX
	Power up				Off	Off	Voice tapes
40:30:15	PPS posigrade maneuver	Pulse	Catch-up	On	Off	Off	
43:52:55	PPS retrograde maneuver	Rate command	Catch-up	On	Off	Off	
49:51:39.4	Undocking and radar test	Rate command	Catch-up	On	Off	Standby, then on	RF power = 0.02
50:12:48	Tether evaluation						
53:24:57.5	Prephasing maneuver	Rate command	Catch-up	Orbit rate	Primary	Off	
54:37:28.1	Stand-off maneuver	Rate command	Catch-up	Orbit rate	Primary	Off	
54:46:14	Power down	Off	Off	Off	Off	Off	
64:50:24	Power up					Off	
65:27:22.3	TPI	Rate command	Catch-up	Orbit rate	Primary	Off	
66:30:35.8	Intercept first midcourse correction	Rate command	Catch-up	Orbit rate	Primary	Off	

TABLE 5.1.5-I.- SPACECRAFT GUIDANCE AND CONTROL SUMMARY CHART - Concluded

Ground elapsed time, hr:min:sec	Event	Component status					Remarks
		ACME	Computer	IMU	Horizon sensor	Radar	
66:34:43.3	TPF	Rate command	Catch-up	Orbit rate	Primary	Off	
66:52:31.3	Separation maneuver	Rate command	Catch-up	Orbit rate	Primary	Off	
66:56:07.3	Load Module IV	Platform	Prelaunch	Orbit rate	Primary	Off	
70:41:36.5	Retrofire	Rate command	Reentry	Free	Primary	Off	

TABLE 5.1.5-II.- ORBIT INJECTION PARAMETERS AT SECO + 20 SECONDS

Data source	Inertial velocity, ft/sec	Inertial flight path angle, deg	Inertial velocity components (computer coordinates), ft/sec		
			X	Y	Z
Flight plan	25 714	0.000			
IGS	25 705	-0.018	25 286	4621	-84
Preliminary best estimate trajectory	25 706	-0.004	25 289	4616	-86
MISTRAM 100K	25 708	-0.008	25 290	4617	-86
GE MOD III (final)	25 705	+0.001	25 288	4613	-86
GE/Burroughs	25 706	-0.030	25 289	4628	-86
GE MOD III (real time)	25 706	-0.040			
MISTRAM IP	25 711	-0.080			

TABLE 5.1.5-III.- ASCENT IGS AND TRACKING SYSTEM ERRORS

Error source	Specification value	Engineering estimates: Error	Engineering estimates: Velocity error, ft/sec X	Y	Z	Error coefficient Recovery Program estimates: Error	Recovery Program estimates: Velocity error, ft/sec X	Y	Z
Constant drift	0.3 deg/hr	deg/hr				deg/hr			
X_p-gyro		-0.05			0.5				
Y_p-gyro		N				0.05 ±0.02	N	1.3	
Z_p-gyro		-0.05			-0.6				
g-sensitive drift	0.5 deg/hr/g					deg/hr/g			
X_p-gyro spin-axis unbalance	N								
Y_p-gyro spin-axis unbalance	N								
Z_p-gyro spin-axis unbalance	N								
X_p-gyro input-axis unbalance	0.04				-0.5				
Y_p-gyro input-axis unbalance	N								
Z_p-gyro input-axis unbalance	-0.03				-1.0	-0.125 ±0.004			-4.4
Acceleration bias	300 ppm	ppm				ppm			
X_p		N							
Y_p		N							
Z_p		N							

N = negligible

TABLE 5.1.5-III.- ASCENT IGS AND TRACKING SYSTEM ERRORS - Concluded

Error source	Specification value	Engineering estimates				Error coefficient Recovery Program estimates			
		Error	Velocity error, ft/sec			Error	Velocity error, ft/sec		
			X	Y	Z		X	Y	Z
Accelerometer scale factor	360 ppm	ppm				ppm			
X_p		-90	-2.2			-106 ±3.3	-2.6		
Y_p		N							
Z_p		-100		0.7		45 ±37		0.3	
Misalignments		Arc seconds				Arc seconds			
Azimuth misalignment	60 arc seconds	30			3.6	56 ±1.8			6.7
Pitch misalignment	100 arc seconds	35		4.2		42 ±3.2		5.0	
Initialization error (data processing error)		0.5 ft/sec		0.5		0.5 ft/sec		0.5	
Time bias		-0.006 sec	-1.2	-0.3		-0.006 ±0.4	-1.2	-0.3	
IGS time scale factor	50 ppm	15 ppm	1.0	.3		11.1 ±0.4	0.8	0.2	

External tracker errors

System	Range bias, ft	P-bias, ft	Q-bias, ft	Azimuth, radians	Elevation, radians	Refraction, n units
GE MOD III (final)	8.3 ± 4	N/A	N/A	31×10^{-6} $\pm 10 \times 10^{-6}$	31×10^{-6} $\pm 53 \times 10^{-6}$	.5 ±2.0
MISTRAM 100K						

N = negligible
N/A = Not applicable

TABLE 5.1.5-IV.- GUIDANCE ERRORS AT SECO + 20 SECONDS

Error	Position, ft			Velocity, ft/sec		
	X	Y	Z	X	Y	Z
IMU	-400 ±150	800 ±200	400 ±100	-2.2 ±1.0	4.9	2.0 ±1.0
Navigation	340	250	50	-0.3	0.5	0.0
Total guidance	-60 ±150	1050 ±200	450 ±100	-2.5 ±1.0	5.4 ±3.0	2.0 ±1.0

TABLE 5.1.5-V.- TRANSLATION MANEUVERS

Maneuver	Ground elapsed time, hr:min:sec	ΔV_X, ft/sec	ΔV_Y, ft/sec	ΔV_Z, ft/sec	ΔV total, ft/sec	ΔV real-time planned, ft/sec
Tail-off	0:05:40.3	81.6	17.2	-4.6	83.6	81 (ΔV_X)
Separation	0:06:00.3	2.4	-0.4	-0.0	2.4	[a]2.0
IVAR	0:06:30.7	38.6	9.0	3.5	39.8	[a]28.0
M=1 rendezvous						
Radial correction	0:07:30.1	-1.0	5.5	0.0	5.6	
Out-of-plane correction	0:29:40.0	0.3	0.1	2.9	[b]3.0	3.0
Terminal phase initiate	0:49:58.1	141.0	28.3	4.8	143.9	140.8
First vernier	1:03:40.9	-2.0	-3.4	-3.9	6.2	
Second vernier	1:15:43.0	-0.9	-1.8	-0.5	2.1	
Terminal phase finalize	1:17:41.2	18.6	35.2	-2.7	39.8	
Mass determination maneuver	1:55:29.3	0.9	-0.2	10.8	10.8	(c)
PPS calibration	4:28:48	2.4	1.1	109.7	109.8	110.0
PPS posigrade	40:30:15.0	917.4	1.3	-34.6	918.0	920.0
PPS retrograde	43:52:55.0	-917.3	-9.2	20.8	917.6	920.0

[a]Preflight planned.

[b]Crew reported.

[c]Total thruster firing time was 25.4 seconds; time used for experiment was only seven seconds.

TABLE 5.1.5-V.- TRANSLATION MANEUVERS - Concluded

Maneuver	Ground elapsed time, hr:min:sec	ΔV_X, ft/sec	ΔV_Y, ft/sec	ΔV_Z, ft/sec	ΔV total, ft/sec	ΔV real-time planned, ft/sec
Separation	53:24:57.5	+5.4	+7.6	+0.2	9.3	8.8
Stand-off	54:37:28.1	-5.4	+8.1	0.2	9.7	[d] 8.9
Coincident-orbit rendezvous						
Terminal phase initiate	65:27:22.3	-8.8	11.9	-0.1	14.7	14.2
Vernier correction	66:30:35.8	1.2	+5.8	0.1	5.9	6.0
Terminal phase finalize	66:34:43.3	+3.1	+11.8	-0.0	12.2	
Separation	66:52:31.3	-2.9	0.2	0.2	2.9	3.0
Retrofire	70:41:36.5	-302.8	117.9	-1.6	325.0	325.6

[d] Total thruster firing time was 11.2 seconds; time used for experiment was 8.9 seconds.

TABLE 5.1.5-VI.- FIRST RENDEZVOUS MANEUVERS

[All values in ft/sec]

Maneuver	Ground backup	Computer closed loop	Onboard backup	Polar plot	Intended to apply	Actually applied
Terminal phase initiate (TPI)	139.6 fwd	140 fwd	140 fwd	Near nominal (140 fwd)	140 fwd	141.0 fwd
	17.0 dn	27 dn	22 dn	Small down	27 dn	28.3 dn
	6.6 rt	5 lt	4 lt	(a)	5 lt	4.8 lt
First midcourse correction (72 deg)	--	1 fwd	3 aft	Indicated nearly on course	1 fwd	1 fwd
	--	4 up	6 up		4 up	4 up
	--	4 rt	--	(a)	4 rt	4 rt
Second midcourse correction (24 deg)	--	1 fwd	2 fwd	Indicated nearly on course	2 fwd	2 fwd
	--	3 up	[b]1 up		1 up	2 up
	--	11 rt	--	(a)	0	0

[a]No out-of-plane indication from polar plot.

[b]Postflight analysis indicates 3 down for this value.

TABLE 5.1.5-VII.- THRUST HISTORY - SPACECRAFT COORDINATES

[All values in ft/sec]

		FFF	FFS	FFC	FCS	FSS	GSS	CSS	SSS
TPI	ΔV_{X_b}	143.91	143.91	143.91	143.91	143.91	140.83	142.96	142.07
	ΔV_{Y_b}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ΔV_{Z_b}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
First mid-course correction	ΔV_{X_b}	1.34	1.34	1.34	1.02	1.83	-3.27	3.53	4.61
	ΔV_{Y_b}	3.79	3.79	3.79	3.90	5.46	-4.10	5.46	0.15
	ΔV_{Z_b}	-3.83	-3.83	-3.83	-3.51	-5.46	21.06	-6.81	-7.32
Second mid-course correction	ΔV_{X_b}	1.72	4.40	1.05	6.66	2.96	3.93	3.91	3.65
	ΔV_{Y_b}	0.00	2.97	-10.92	2.30	0.39	0.16	-0.55	0.17
	ΔV_{Z_b}	-1.07	-4.48	-0.69	-6.24	-0.77	-0.57	-1.10	-1.10
Total ΔV applied	ΔV_{X_b}	146.97	149.65	146.30	151.59	148.70	148.03	150.40	150.33
	ΔV_{Y_b}	3.79	6.76	14.71	6.20	5.85	4.26	6.01	0.32
	ΔV_{Z_b}	4.90	8.31	4.52	9.75	6.23	21.63	7.91	8.42
	$\Sigma \Delta V_b$	155.66	164.72	165.53	167.54	160.78	173.92	164.32	159.07

TABLE 5.1.5-VIII.- THRUST HISTORY - NAVIGATIONAL COORDINATES

		FFF	FFS	FFC	FCS	FSS	GSS	CSS	SSS
TPI	$\Delta\dot{X}$	141.00	141.00	141.00	141.00	141.00	139.61	140.00	139.12
	$\Delta\dot{Y}$	28.29	28.29	28.29	28.29	28.29	16.95	28.50	28.61
	$\Delta\dot{Z}$	4.73	4.73	4.73	4.73	4.73	-6.60	4.95	-1.65
First midcourse correction	$\Delta\dot{X}$	-2.01	-2.01	-2.01	-2.02	-2.92	9.05	-2.72	-1.88
	$\Delta\dot{Y}$	-3.40	-3.40	-3.40	-2.94	-4.79	19.32	-6.92	-8.48
	$\Delta\dot{Z}$	-3.91	-3.91	-3.91	-3.98	-5.61	3.99	-5.79	-0.27
Second midcourse correction	$\Delta\dot{X}$	-0.96	-4.23	-2.77	-6.05	-0.36	1.12	-0.62	-0.67
	$\Delta\dot{Y}$	-1.74	-3.86	1.22	-6.16	-3.06	-3.81	-4.05	-3.76
	$\Delta\dot{Z}$	-0.41	-3.93	-10.88	-3.74	-0.13	0.05	-0.14	0.01
TPF (Calculated theoretical impulse)	$\Delta\dot{X}_f$	-13.02	-14.89	-10.39	-16.76	-12.08	0.07	-12.95	-13.06
	$\Delta\dot{Y}_f$	-35.36	-35.22	-31.02	-35.57	-35.95	-43.82	-36.47	-36.80
	$\Delta\dot{Z}_f$	7.18	10.35	16.64	10.19	-7.41	-2.50	7.58	1.84
Miss distance, ft		1626.8	72.5	3293.0	34.2	96.7	78.0	127.4	82.7

TABLE 5.1.5-IX.- COMPARISON OF IGS AND RADAR DATA

(a) Spacecraft position data during reentry

Event	Planned		Actual (radar BET)		Miss distance (planned minus actual), n. mi.	IGS		Navigation error (IGS minus actual), n. mi.
	Longitude, deg	Latitude, deg	Longitude, deg	Latitude, deg		Longitude, deg	Latitude, deg	
Retrofire	-179.825	4.562	-179.882	4.592	0.2	-179.825	4.591	0.2
Guidance initiation	-88.160	28.040	-88.617	28.101	25.0	-88.648	28.082	2.0
Guidance termination	-70.062	24.300	-70.096	24.286	2.5	-70.090	24.334	2.9
Drogue deploy	-70.000	24.300	-70.029	24.255	3.1	-70.008	24.322	4.2

(b) State vectors used for comparison at retrofire

(Earth-centered inertial coordinates)

	BET (TRW)	IGS (RTCC)	IGS minus BET (initial-condition error)
X, ft	19 784 926	19 785 300	384
Y, ft	9 098 990	9 098 100	-890
Z, ft	1 737 911	1 737 600	-311
V_X, ft/sec	-10 231.1	-10 229.7	1.4
V_Y, ft/sec	19 870.8	19 871.4	0.6
V_Z, ft/sec	12 099.3	12 099.3	0.0

(c) Contributors to IGS/BET difference at guidance termination

	Latitude, n. mi.	Longitude, n. mi.	Total
Initial alignment error at retrofire			
X = 0.44 deg	1.80	0.90	
Y = 0.42 deg	0.20	-0.41	
Z = 0.17 deg	0.15	0.06	
Total	2.15	0.55	
Update initialization	0.76	-0.26	
Total, alignment and initialization	2.91	0.29	
Other (gyro, accelerometer, and timing)	Negligible	Negligible	0.00
Total	2.91	0.29	2.92

TABLE 5.1.5-X.- COMPARISON OF COMPUTER TELEMETRY REENTRY PARAMETERS

WITH POSTFLIGHT RECONSTRUCTION

Parameter	Time in mode = 2696.9 sec Altitude = 400K ft			Time in mode = 3226.7 sec Guidance termination		
	Telemetry	MAC	IBM	Telemetry	MAC	IBM
Radius vector, ft . . .	21 306 720	21 306 916	21 306 106	21 015 670	21 017 275	21 016 000
Velocity, ft/sec . . .	24 385.191	24 385.052	24 386.016	1764.197	1770.139	1762.527
Flight-path angle, deg	-1.3951	-1.3934	-1.394	-24.0686	-23.7622	-23.873
Spacecraft heading, deg	90.75035	90.76245	90.742	103.86906	103.89774	103.865
Longitude, deg	258.12443	258.14602	258.108	289.909	289.899	289.899
Latitude, deg	28.81729	28.81767	28.818	24.194	24.199	24.198
Crossrange error, n. mi.	-0.593	-0.479	-0.89	-0.952	-0.958	-1.02
Range to target	1728.11	1726.9	1728.95	5.427	6.009	6.08
Downrange error, n. mi.	NA	NA	NA	-0.108	0.359	0.47
Predicted zero-lift range, n. mi. . . .	NA	NA	NA	5.477	5.573	5.52
Density altitude factor	NA	NA	NA	4.656	4.656	4.654
Bank-angle command, deg	0.0	0.0	0.0	12.2108	24.4427	25.630
Integration time, sec	1215	1215	1215	1745	1745	1745

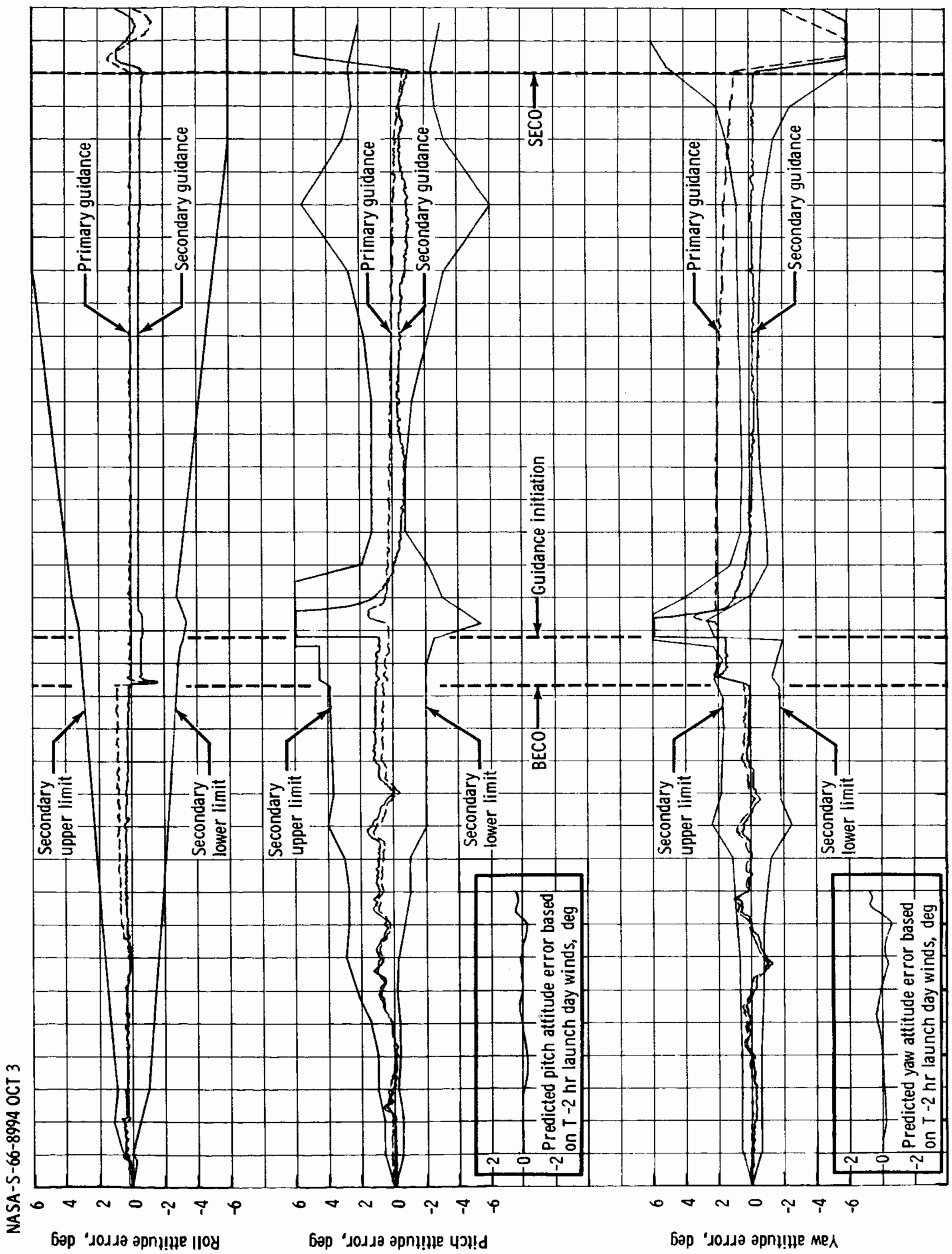


Figure 5.1.5-1. - Comparisons of launch vehicle and spacecraft steering errors.

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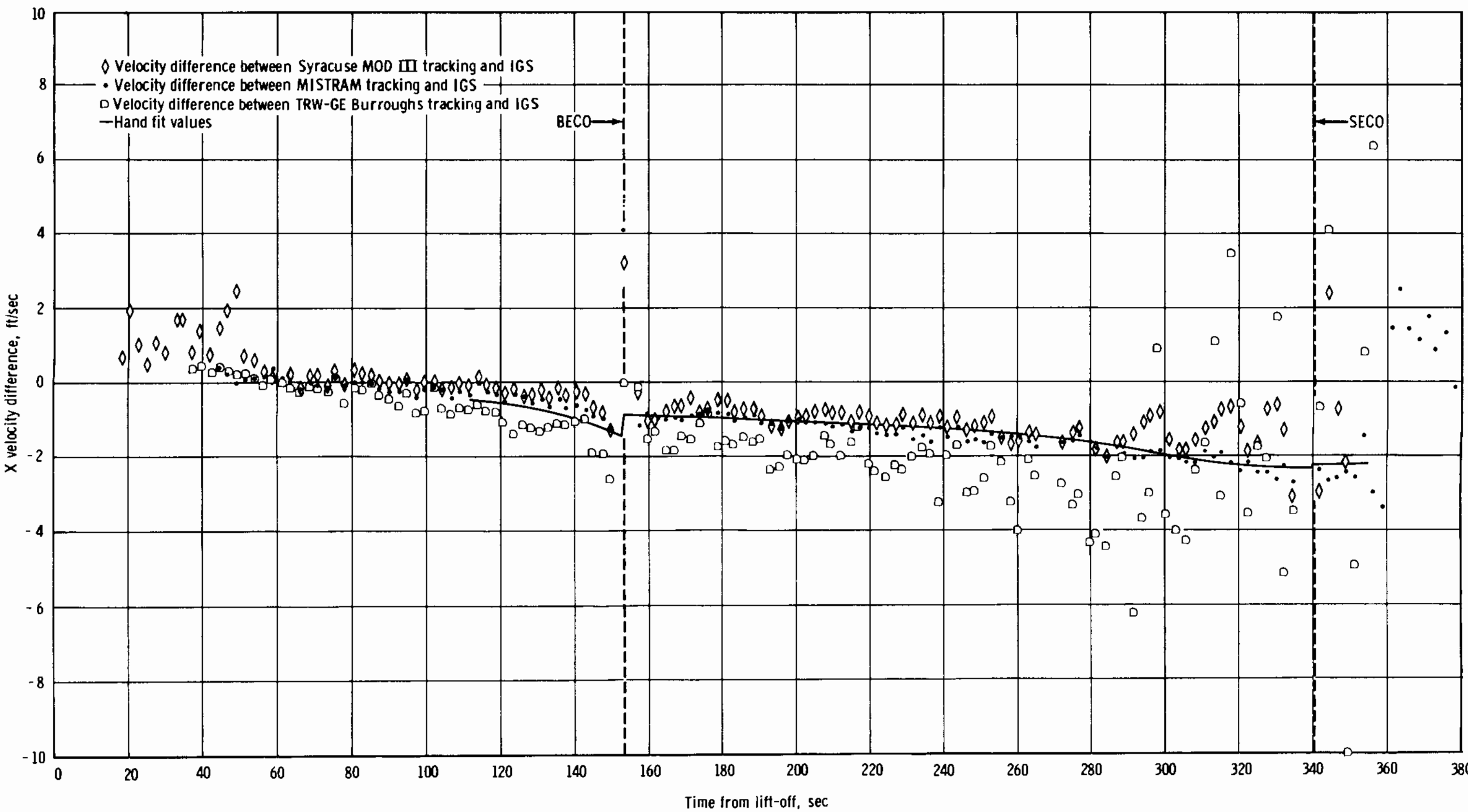

(a) Downrange velocity.

Figure 5.1.5-2. - Comparisons of spacecraft IGS and radar tracking velocities.

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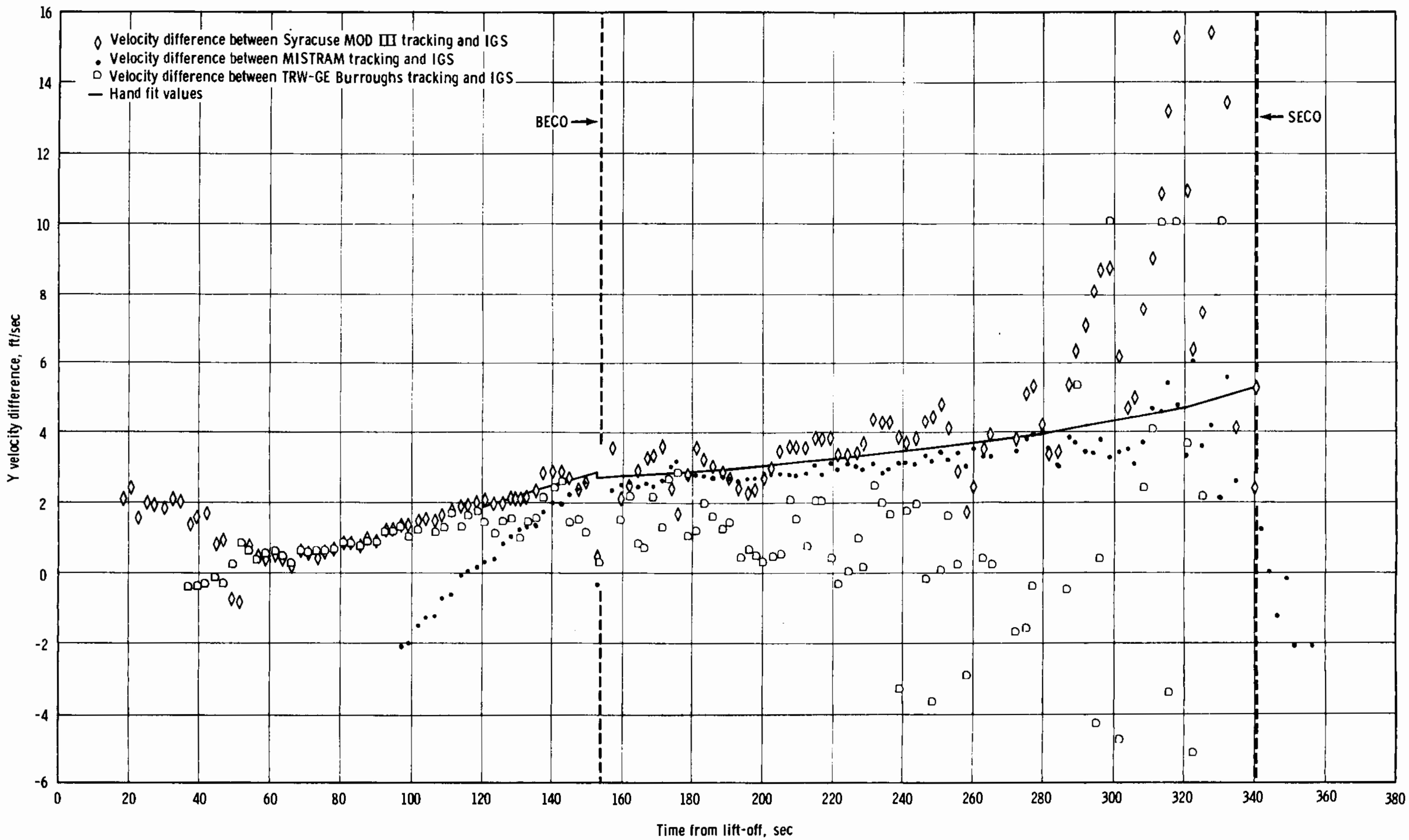

(b) Vertical velocity.

Figure 5.1.5-2. - Concluded.

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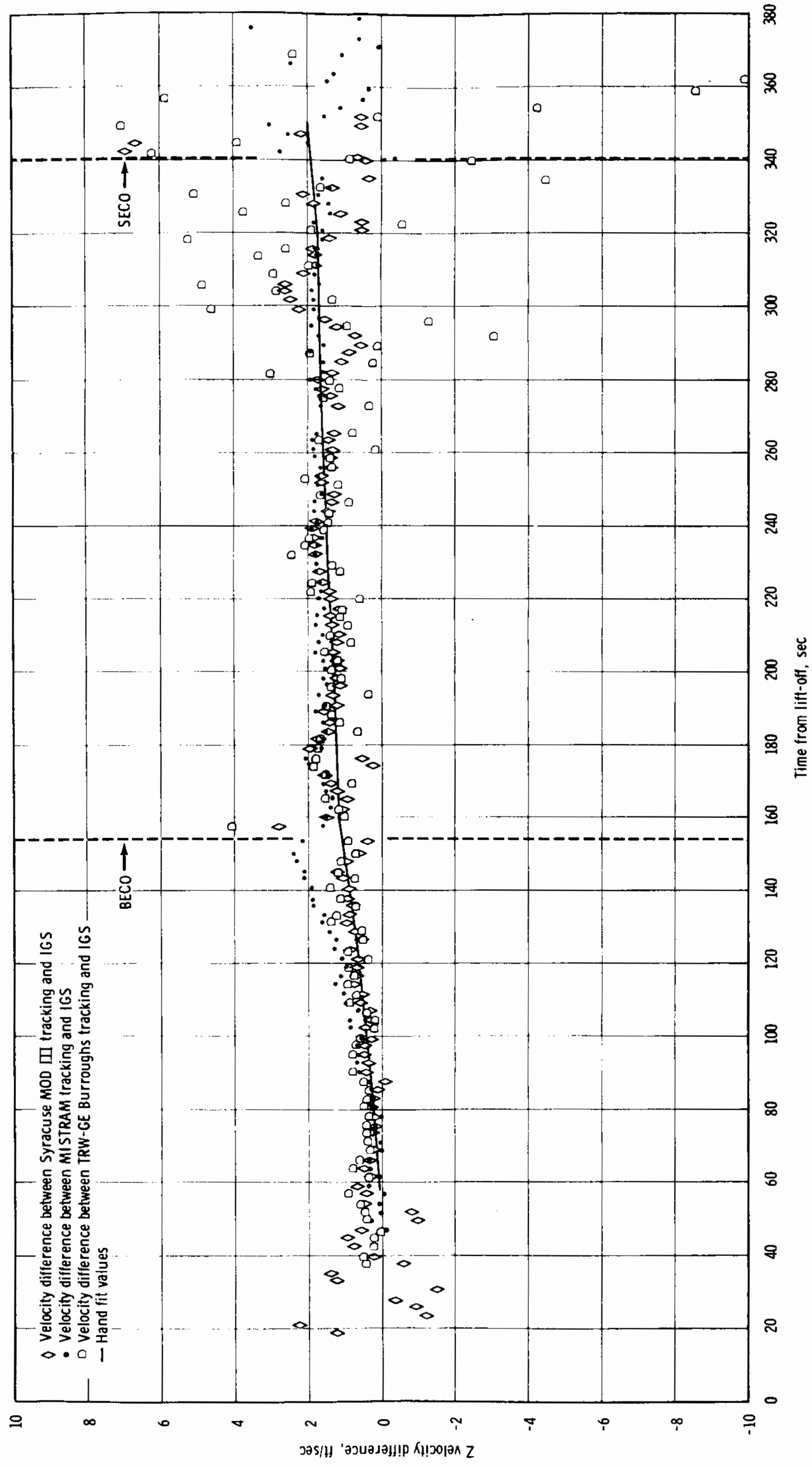

(c) Crossrange velocity.

Figure 5.1.5-2. - Continued.

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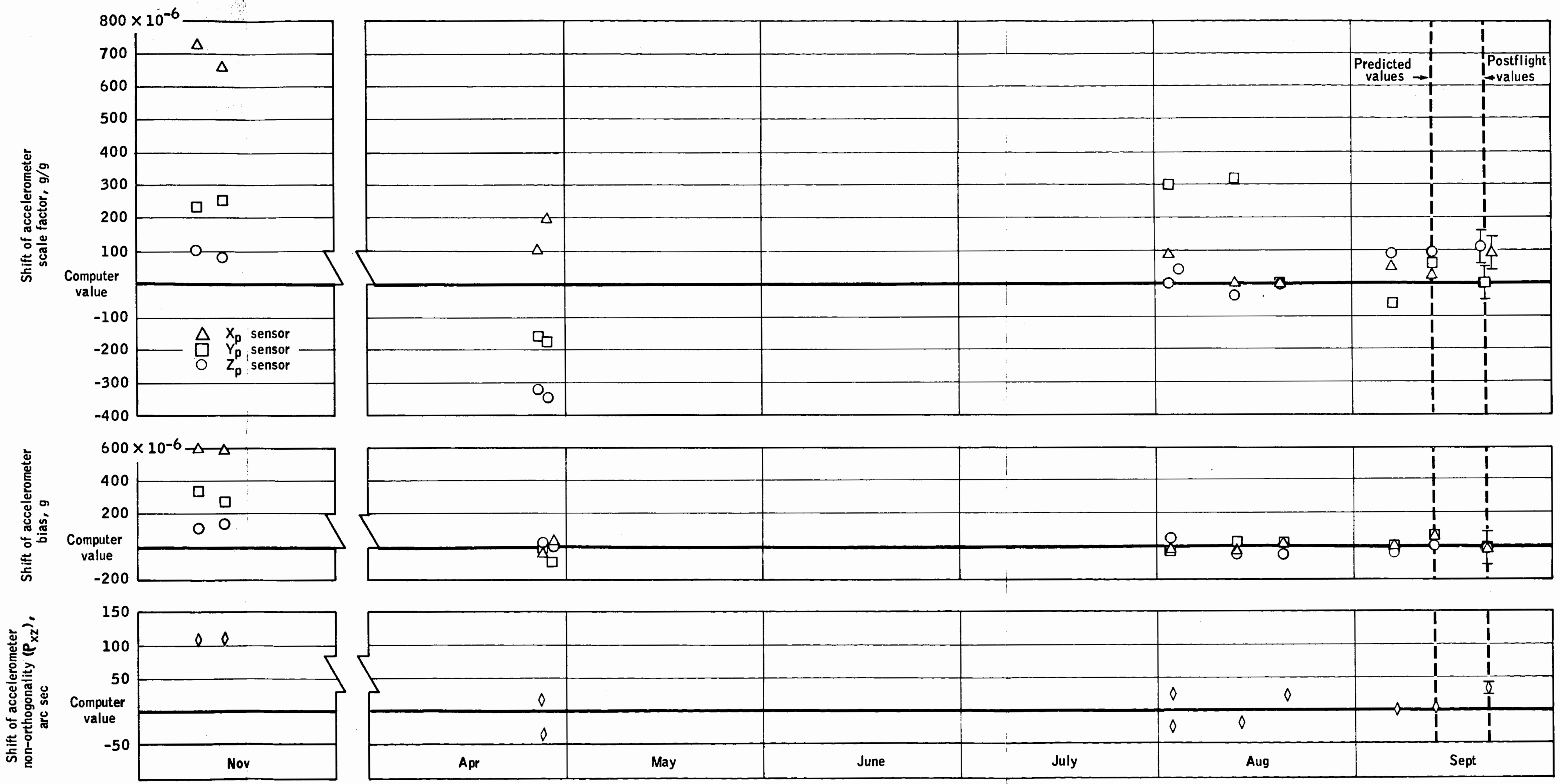

(a) Shift of accelerometer biases and scale factors.

Figure 5.1.5-3. - IMU error coefficient history.

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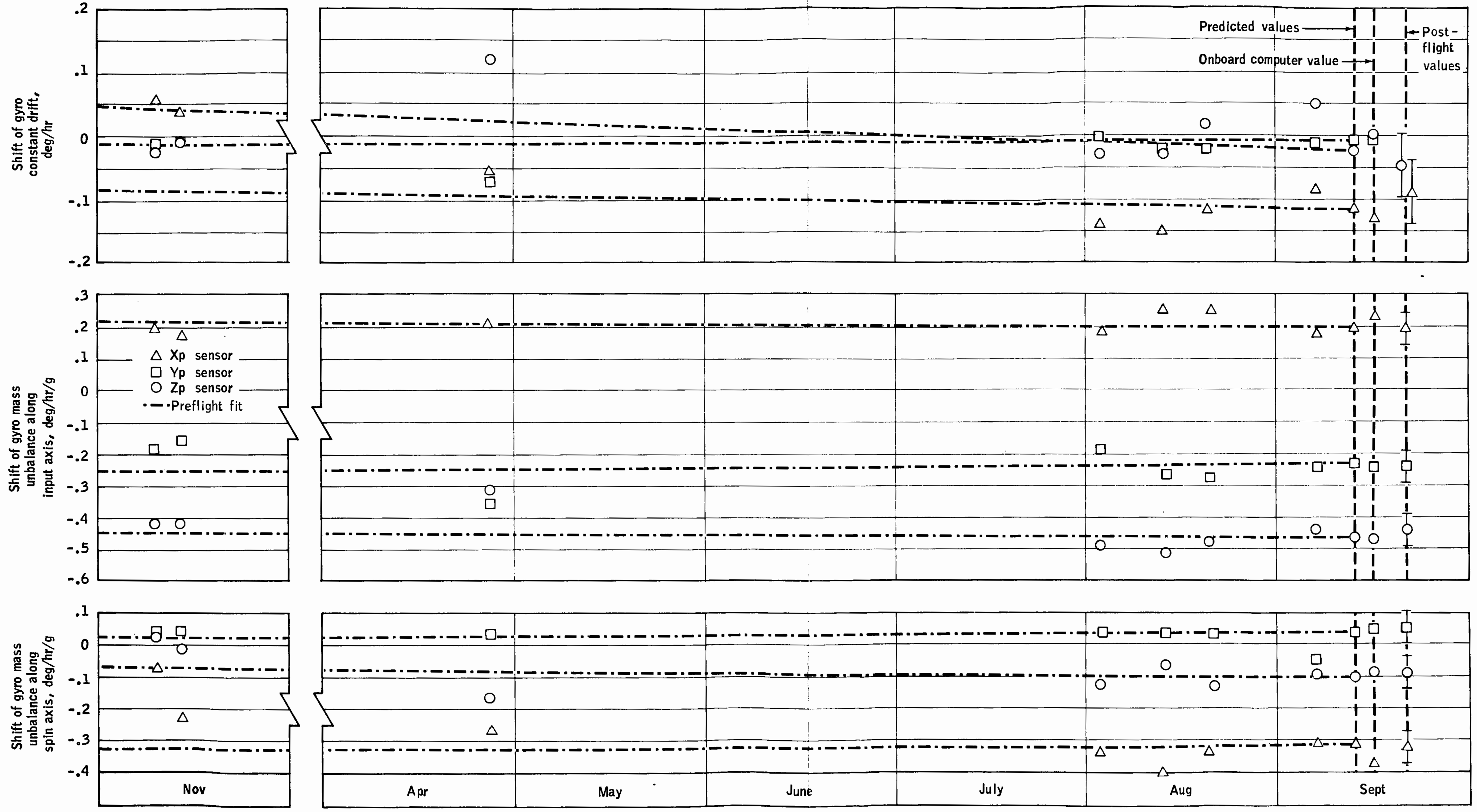


(b) Shift of gyro mass unbalances and constant drifts.
Figure 5.1.5-3. - Concluded.

NASA-S-66-9094 OCT 27

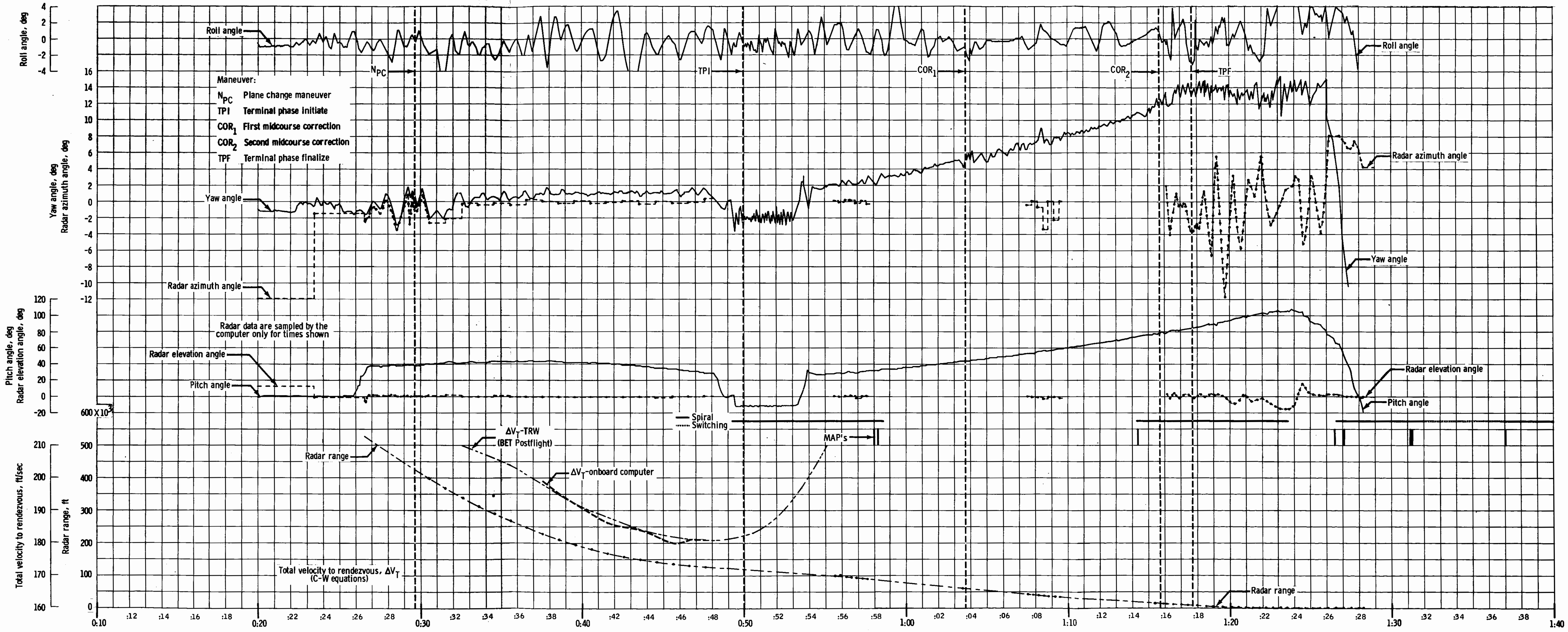


Figure 5.1.5-4.- Computer data for the closed-loop rendezvous.

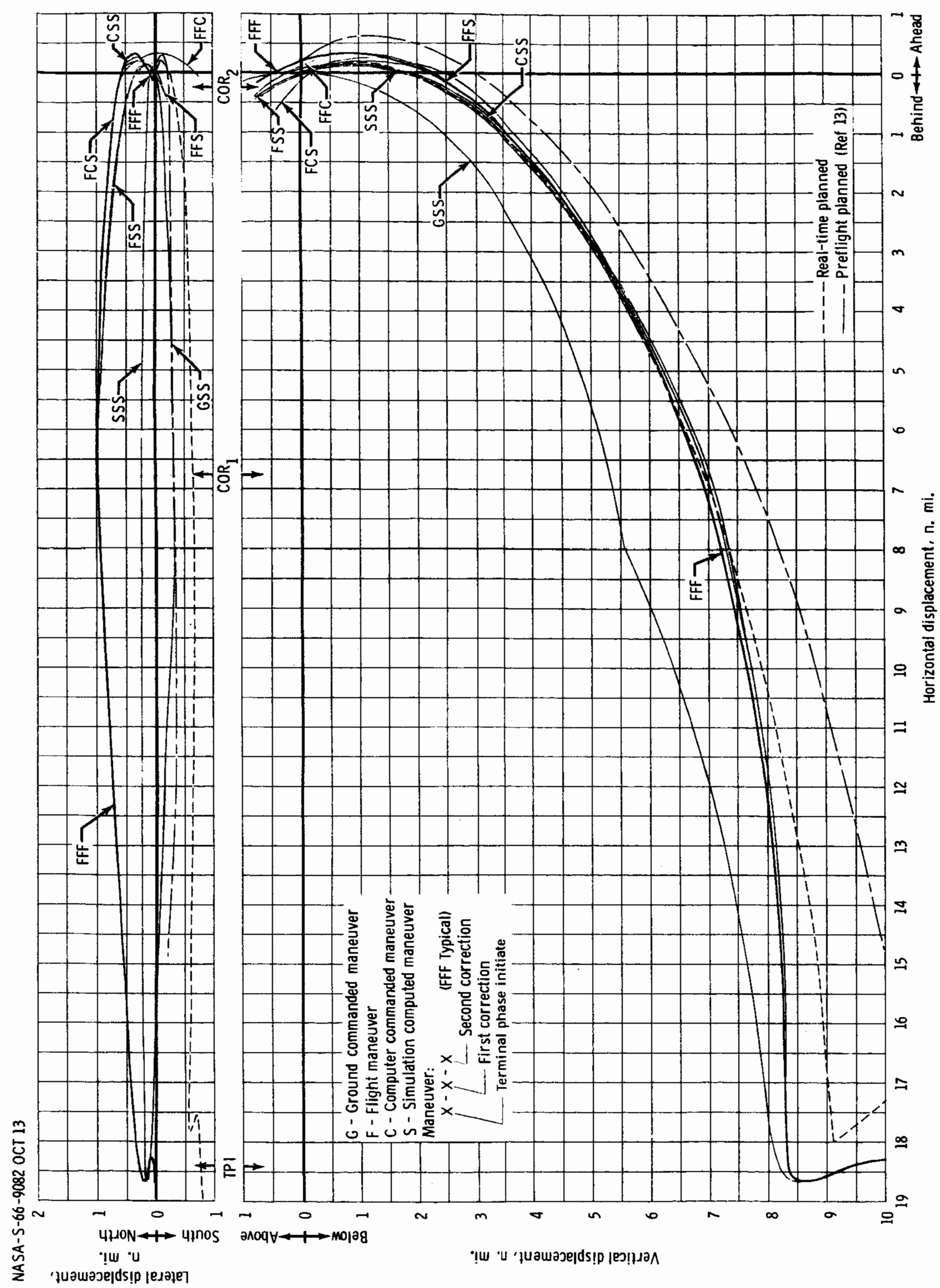
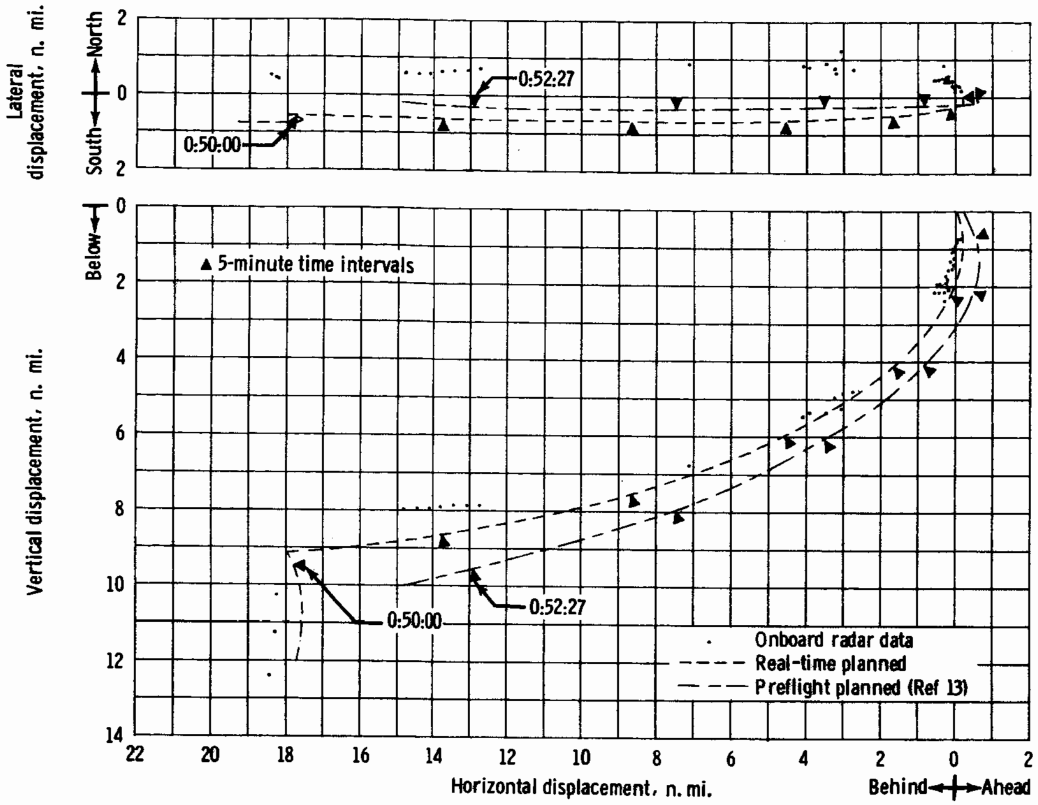
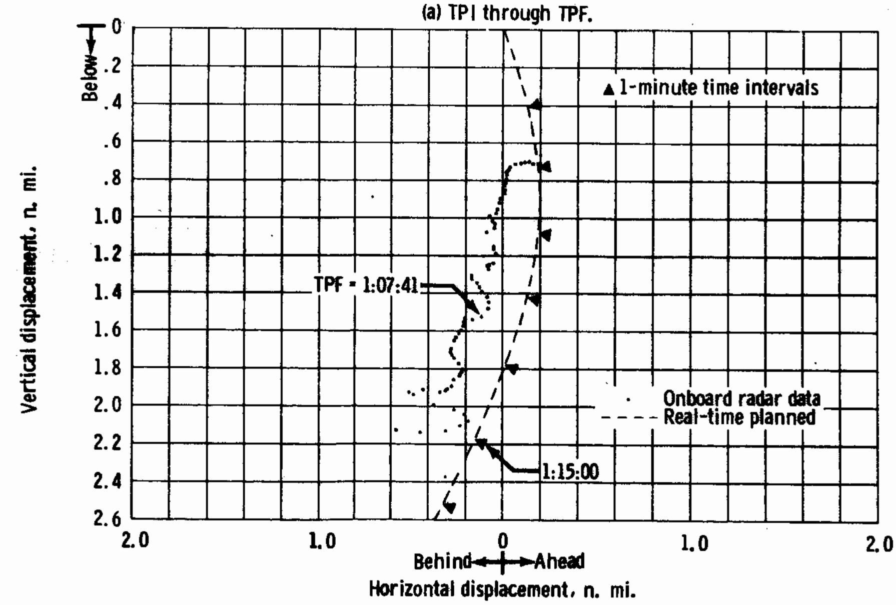


Figure 5.1.5-5. - First rendezvous simulation.

NASA-S-66-9081 OCT 13



(a) TPI through TPF.

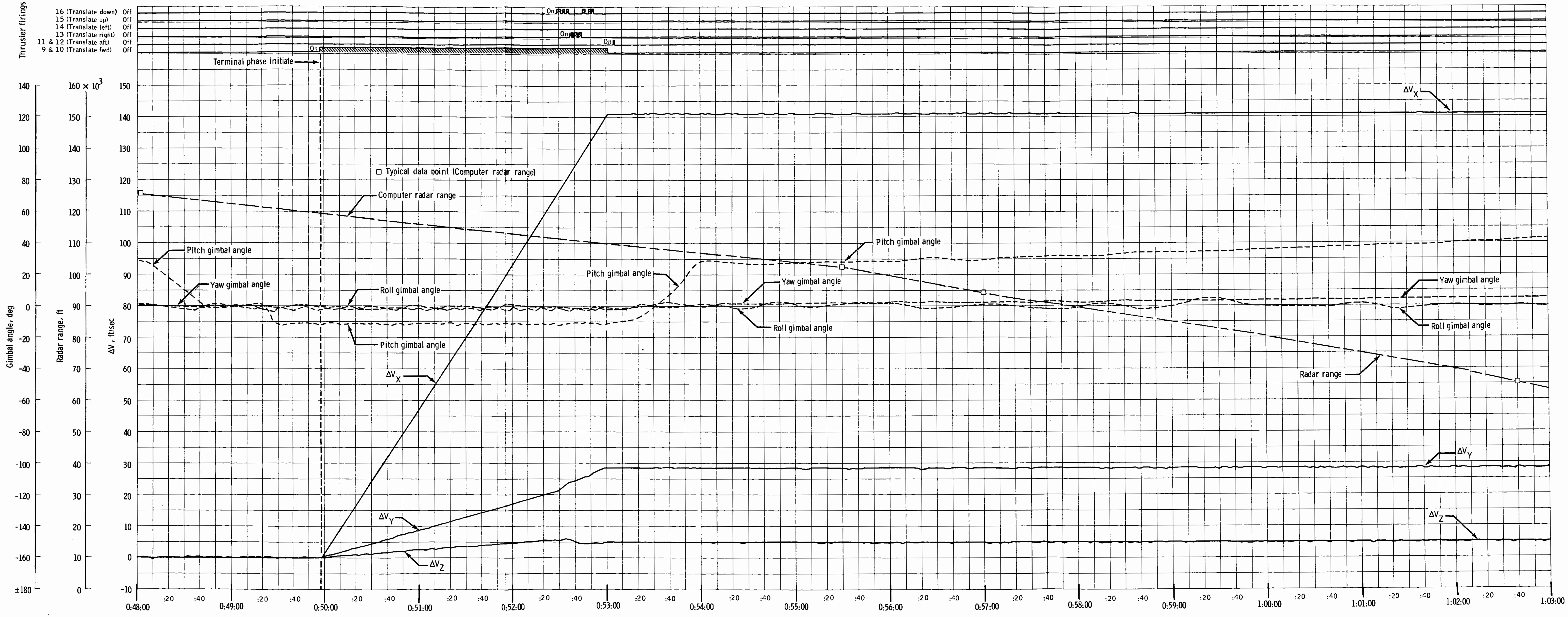


(b) COR_2 through TPF.

Figure 5.1.5-6. - First rendezvous relative motion using onboard radar data.

UNCLASSIFIED

NASA-S-66-9072 OCT 13

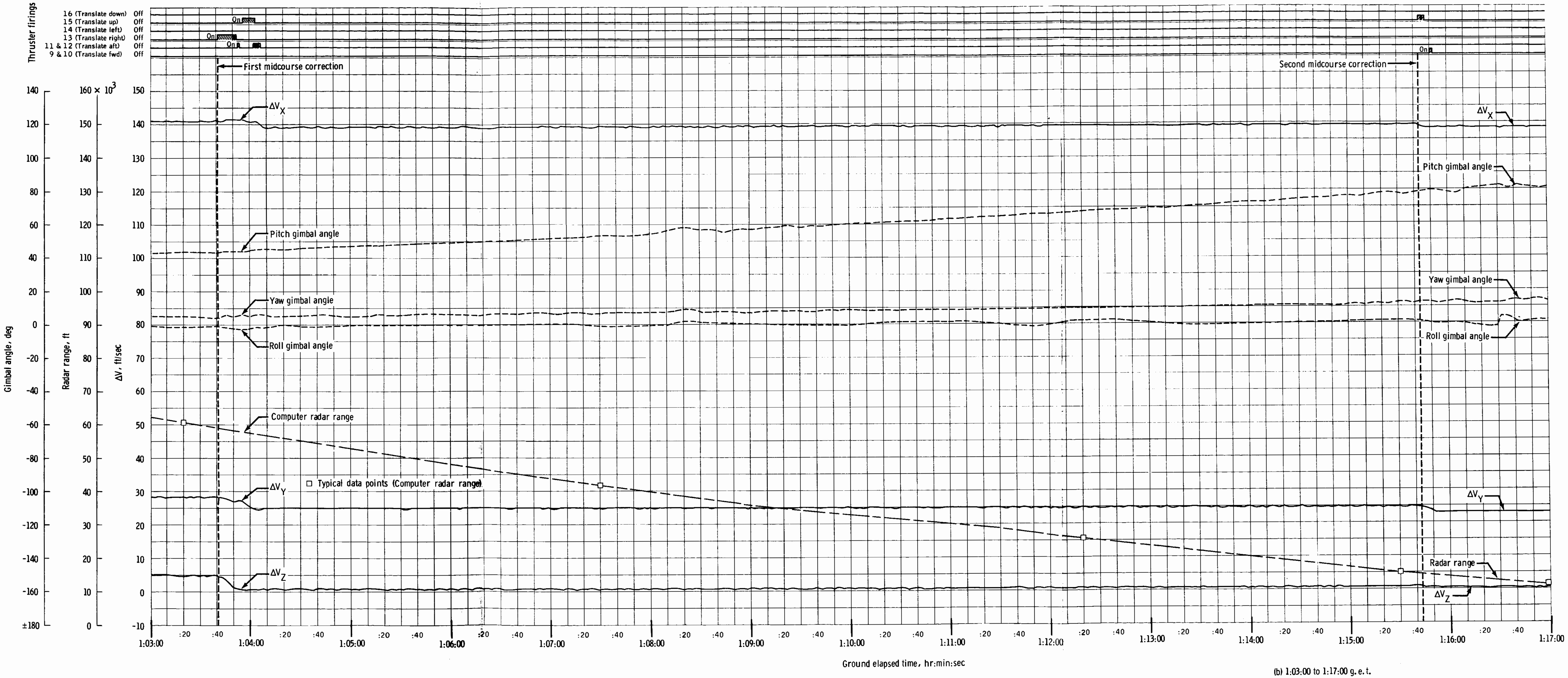


(a) 0:48:00 to 1:03:00 g.e.t.

Figure 5.1.5-7. - First rendezvous maneuvers.

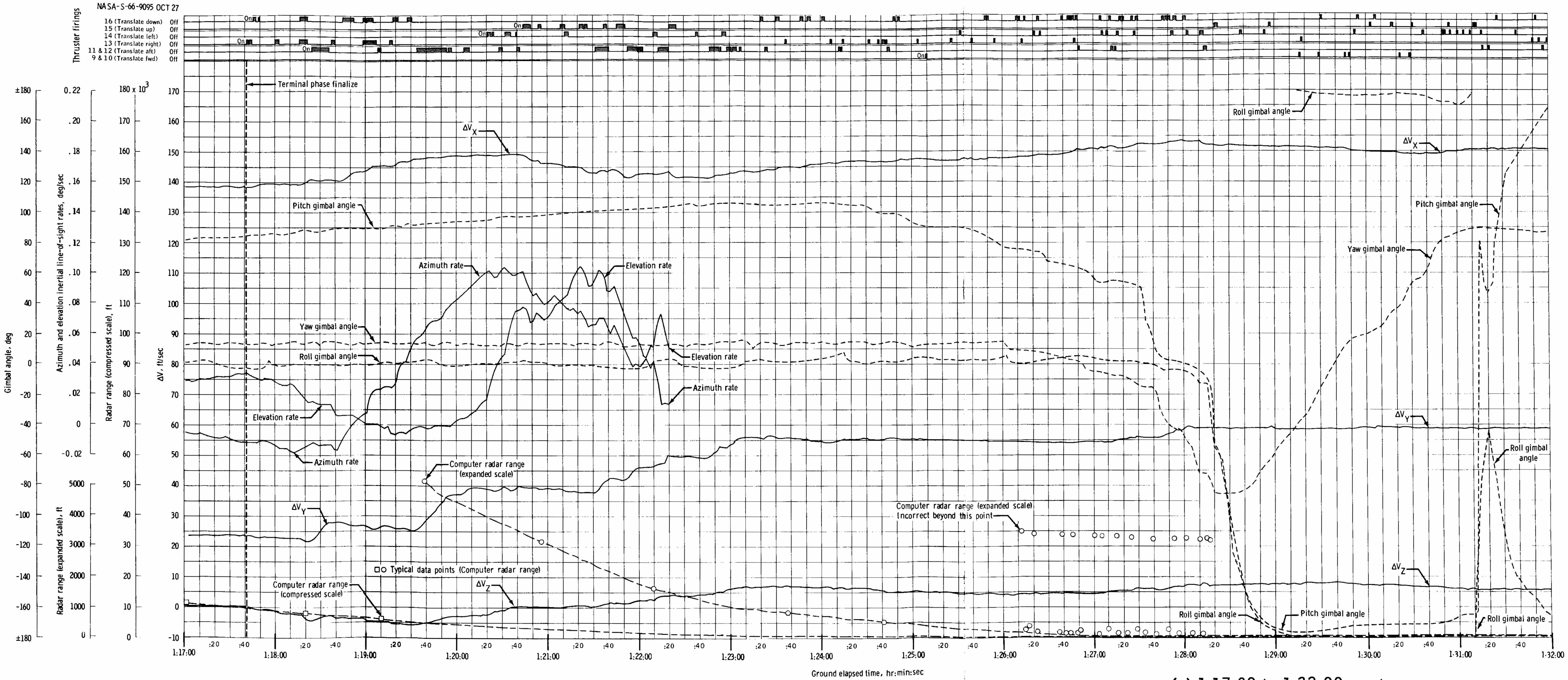
UNCLASSIFIED

NASA-S-66-9071 OCT 13



(b) 1:03:00 to 1:17:00 g. e. t.

Figure 5. 1. 5-7. - Continued.



(c) 1:17:00 to 1:32:00 g.e.t.

Figure 5.1.5-7. - Concluded.

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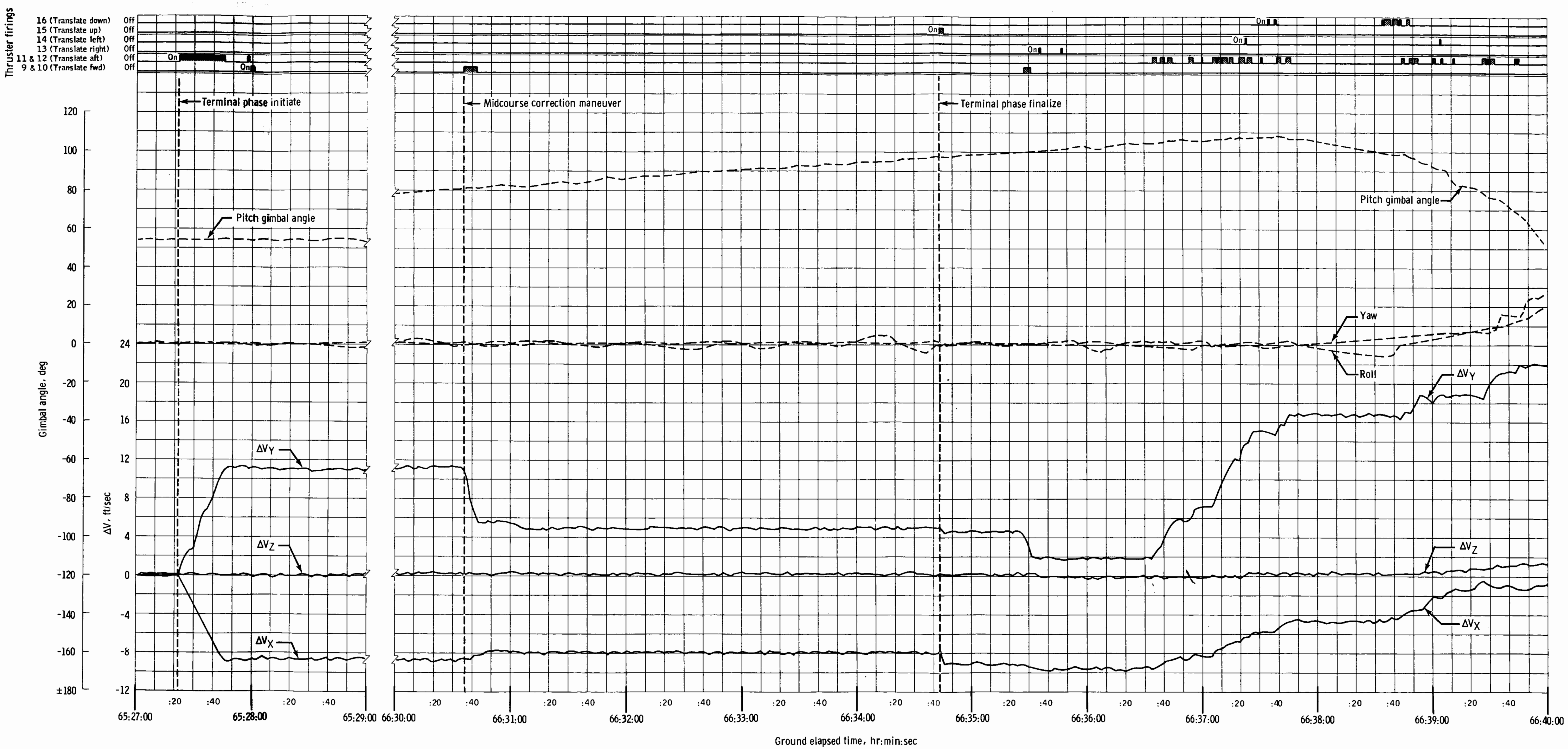


Figure 5.1.5-8. - Second rendezvous maneuvers.

NASA-S-66-9067 OCT 13

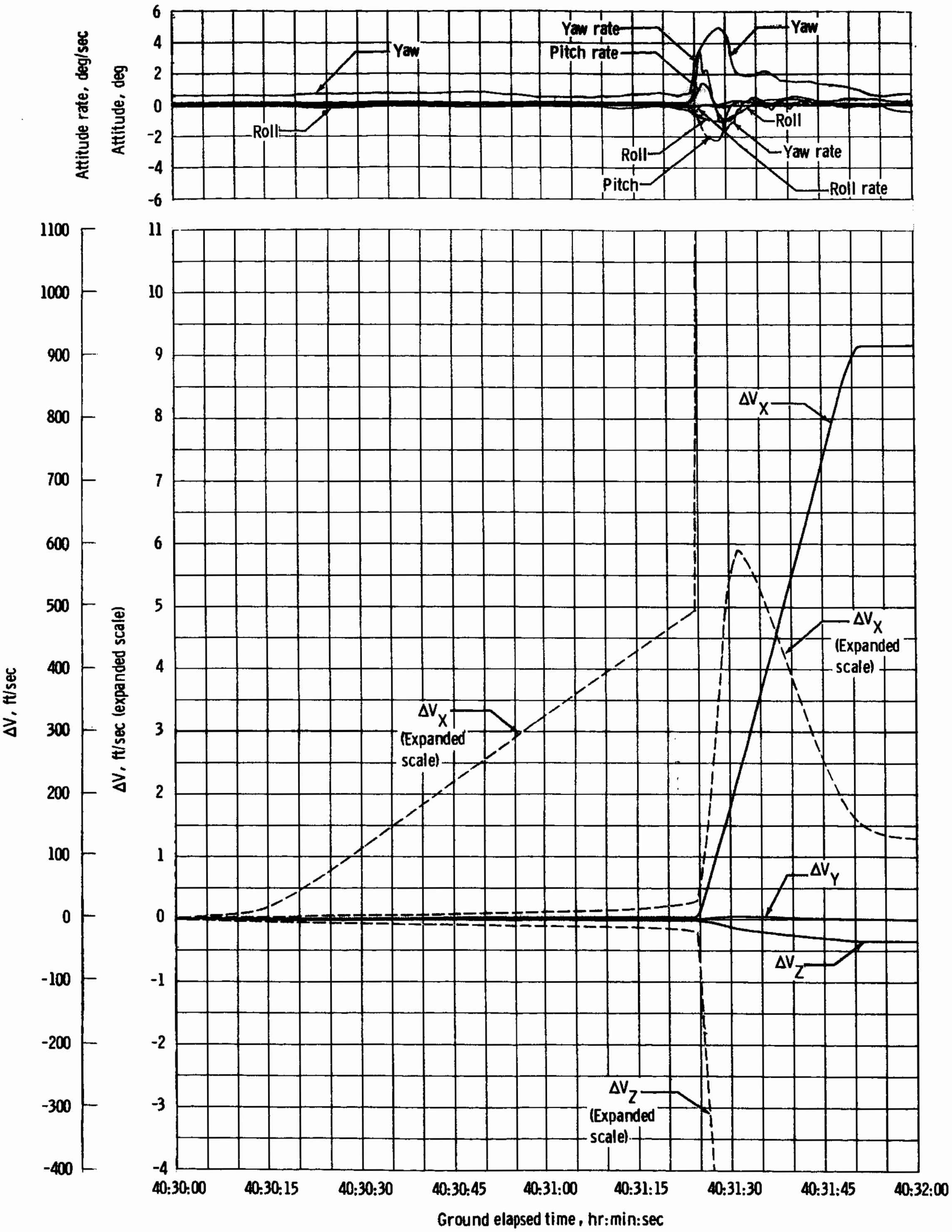


Figure 5.1.5-9. - Velocity changes during the PPS posigrade maneuver.

NASA-S-66-9061 OCT 13

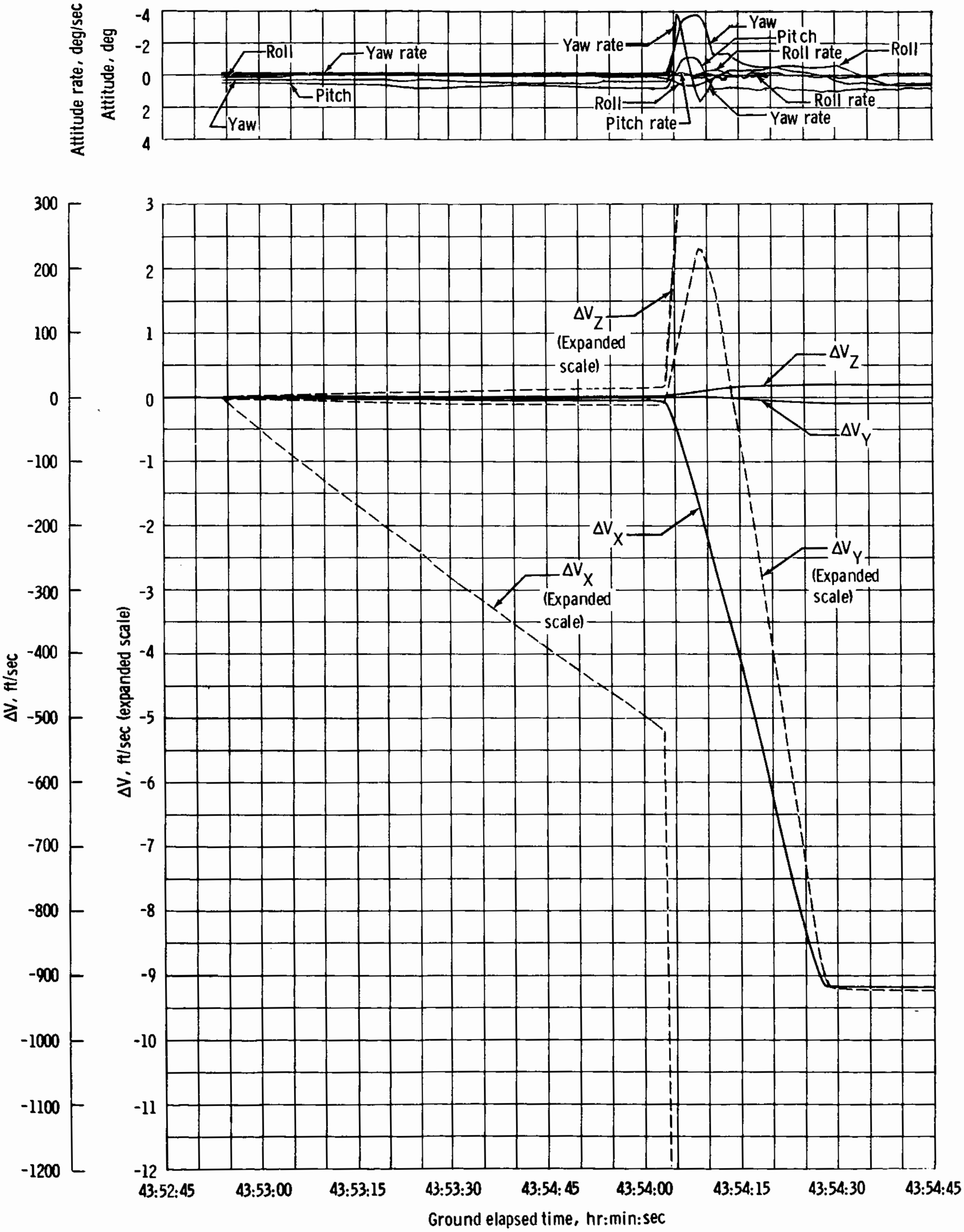


Figure 5.1.5-10. - Velocity change during the PPS retrograde maneuver.

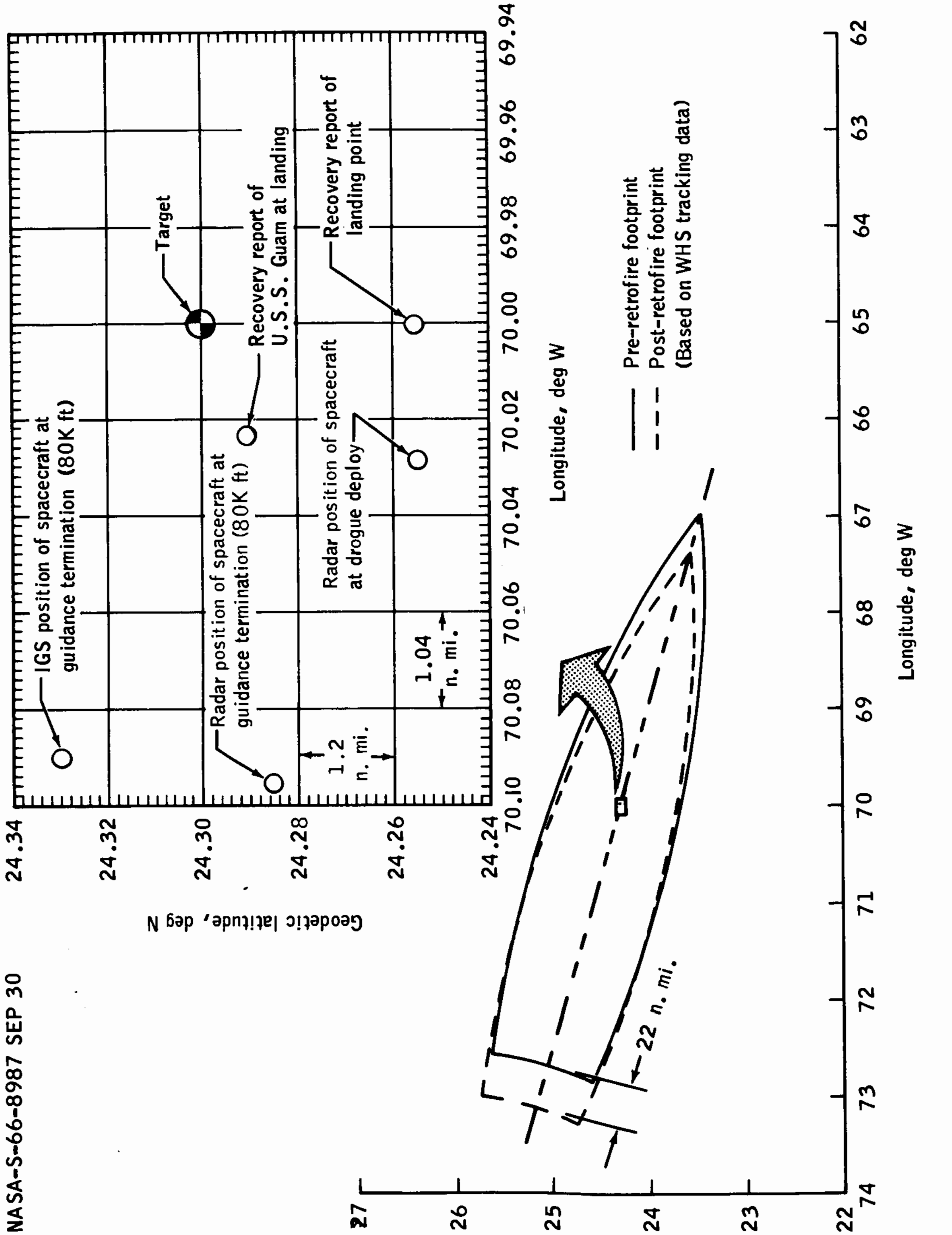


Figure 5.1.5-11. - Touchdown comparisons.

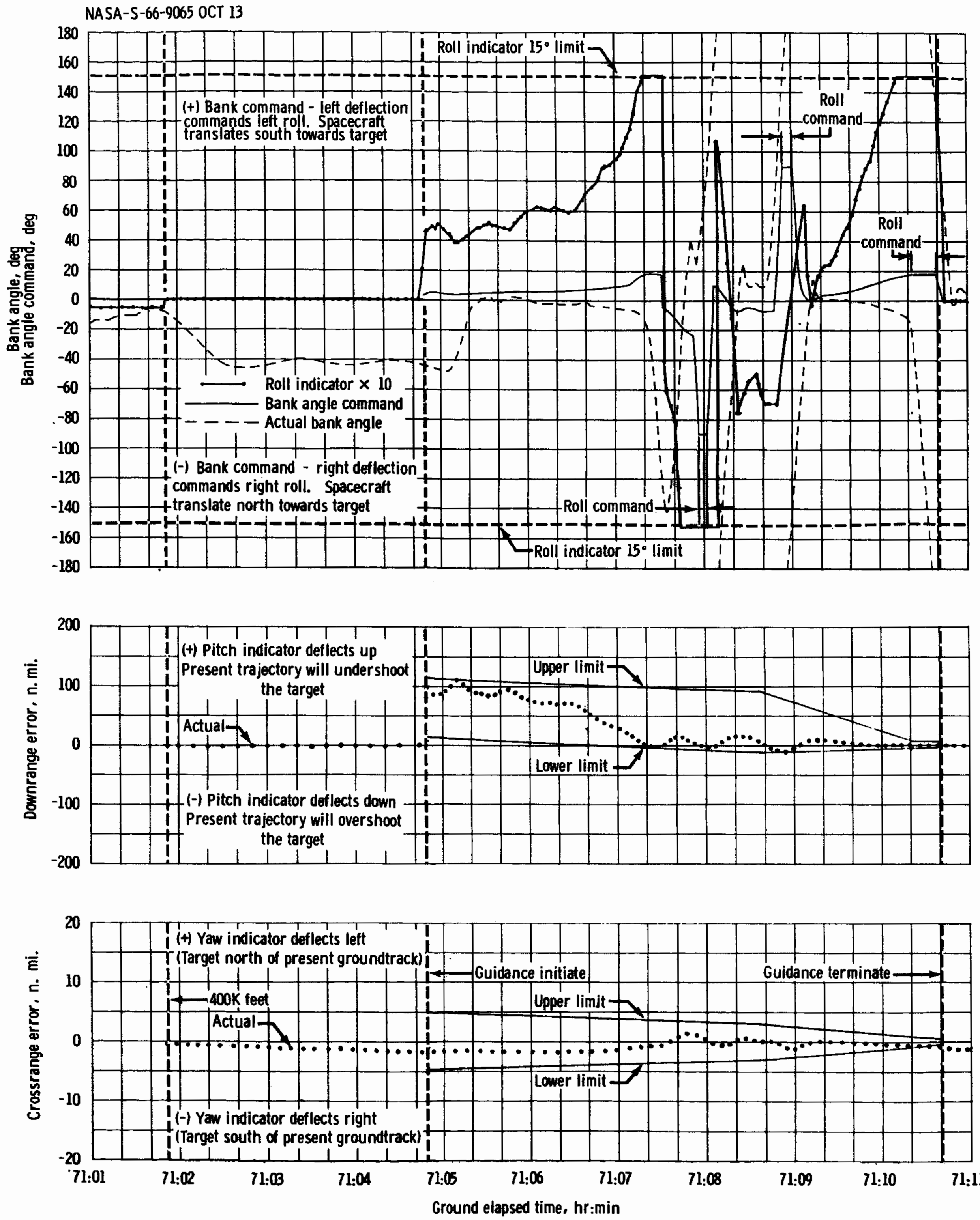
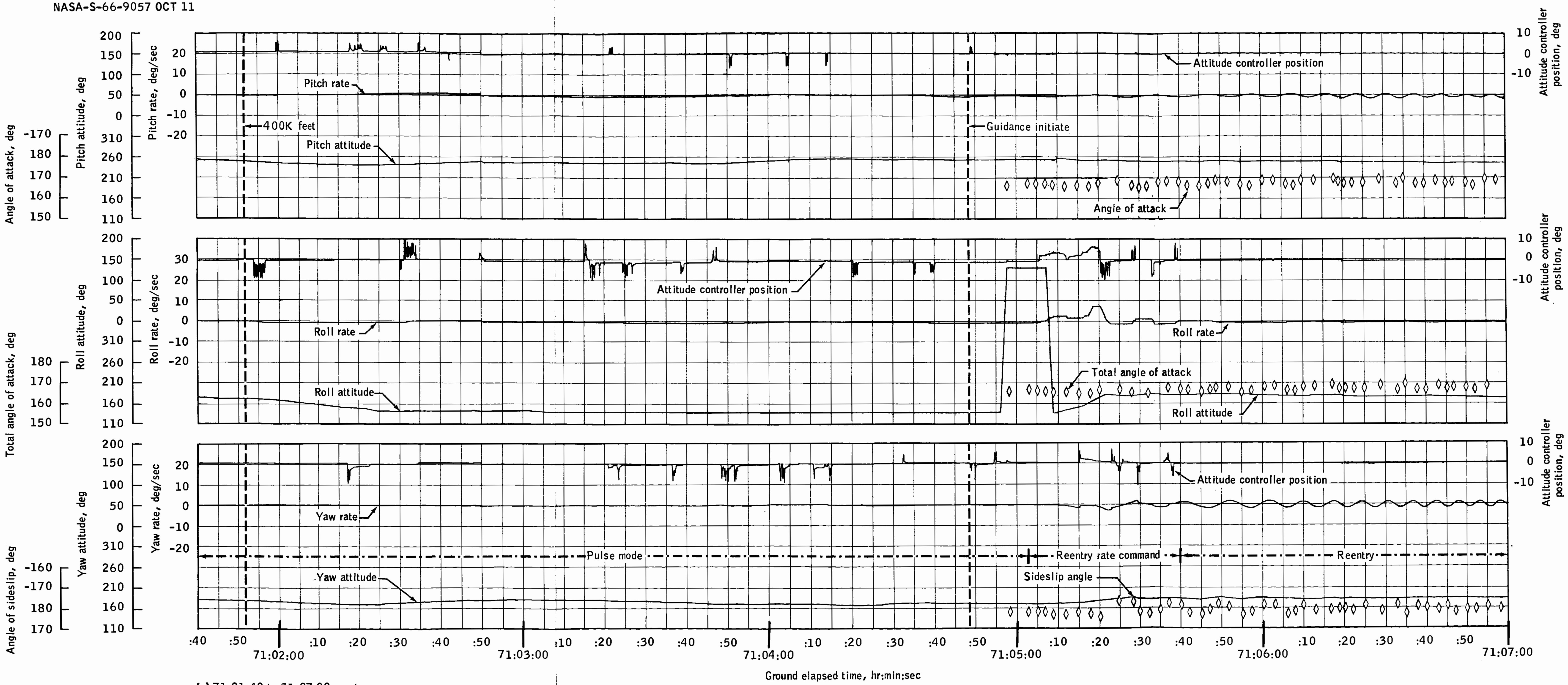


Figure 5.1.5-12. - Reentry guidance parameters.

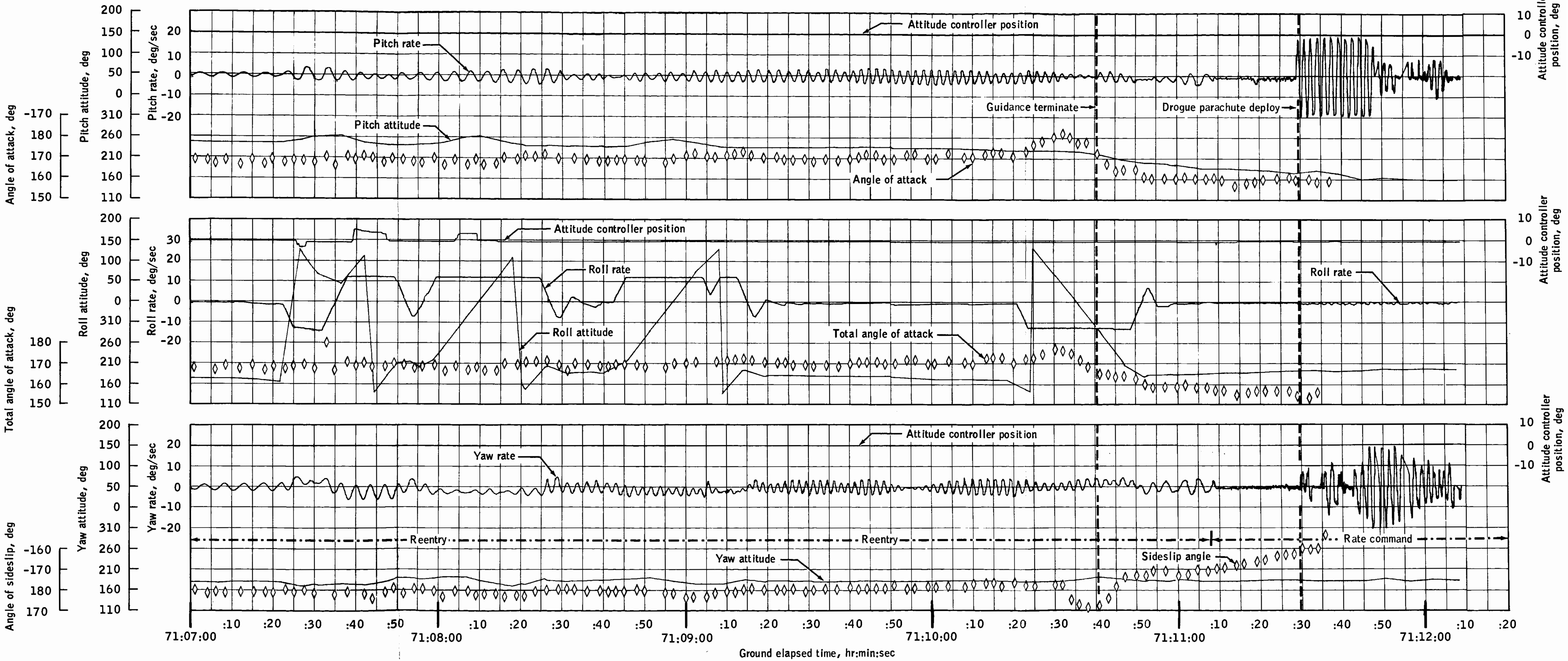
NASA-S-66-9057 OCT 11



(a) 71:01:40 to 71:07:00 g.e.t.

Figure 5.1.5-13. - Reentry Control System performance.

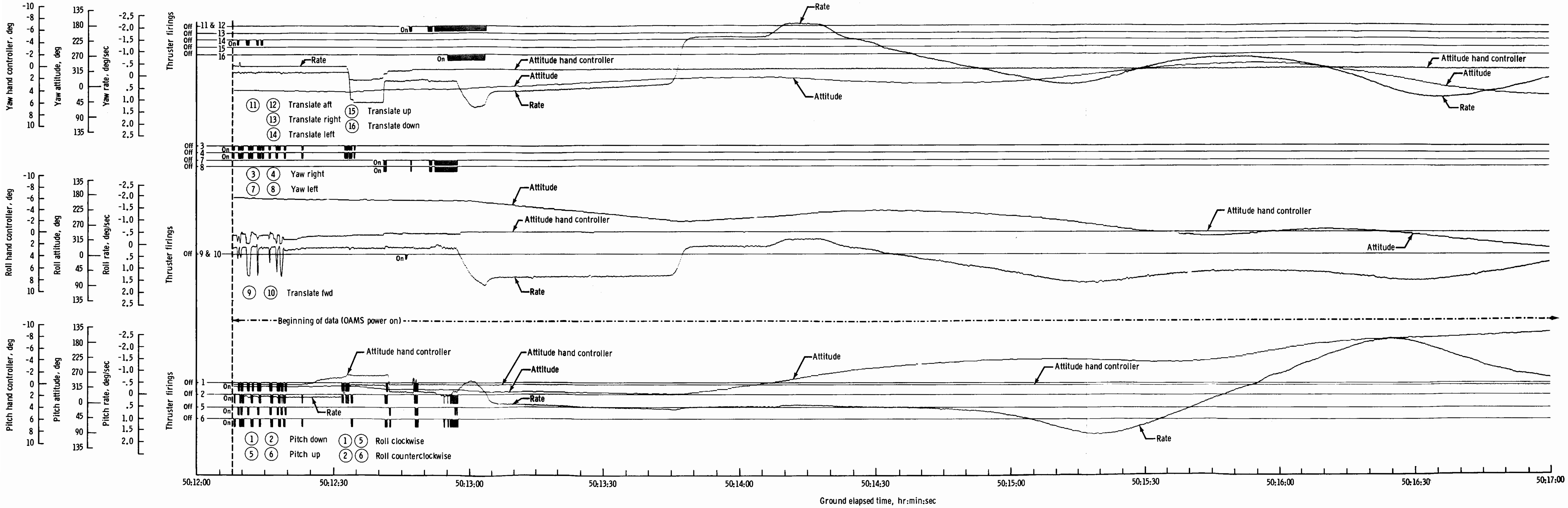
NASA-S-66-9058 OCT 11



(b) 71:07:00 to 71:12:20 g.e.t.

Figure 5.1.5-13. - Concluded.

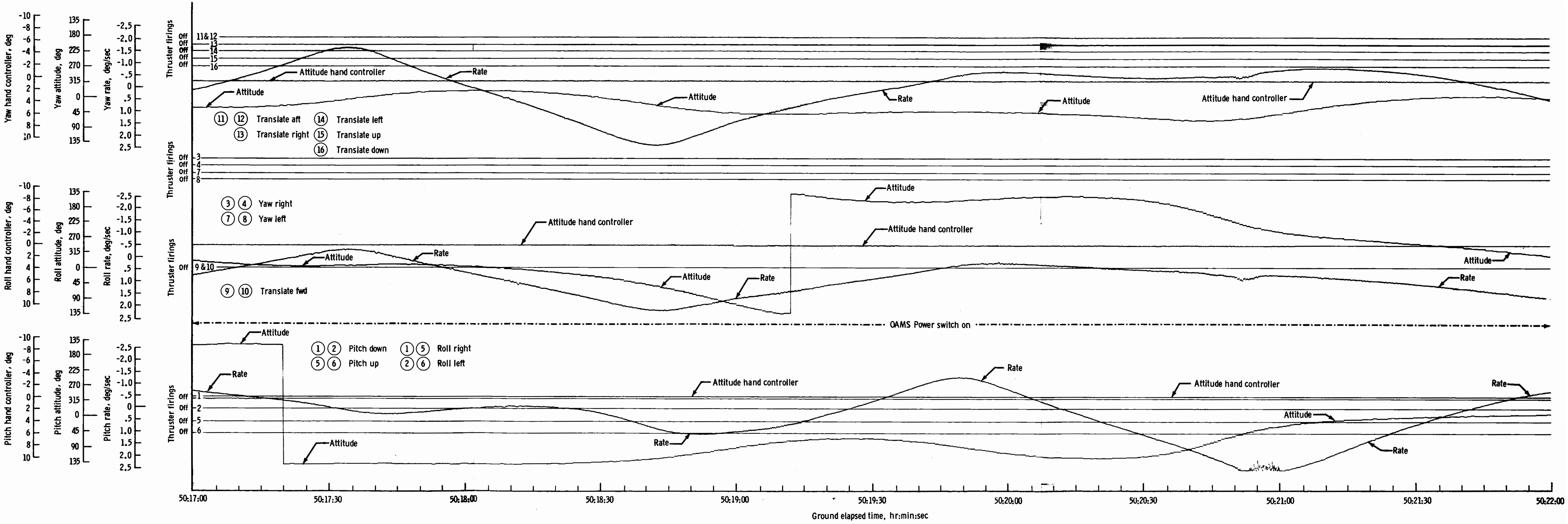
NASA-S-66-9052 OCT 12



(a) 50:12:00 to 50:17:00 g.e.t.

Figure 5.1.5-14. - Spacecraft dynamics during the tether exercise, expanded scale showing control system activity.

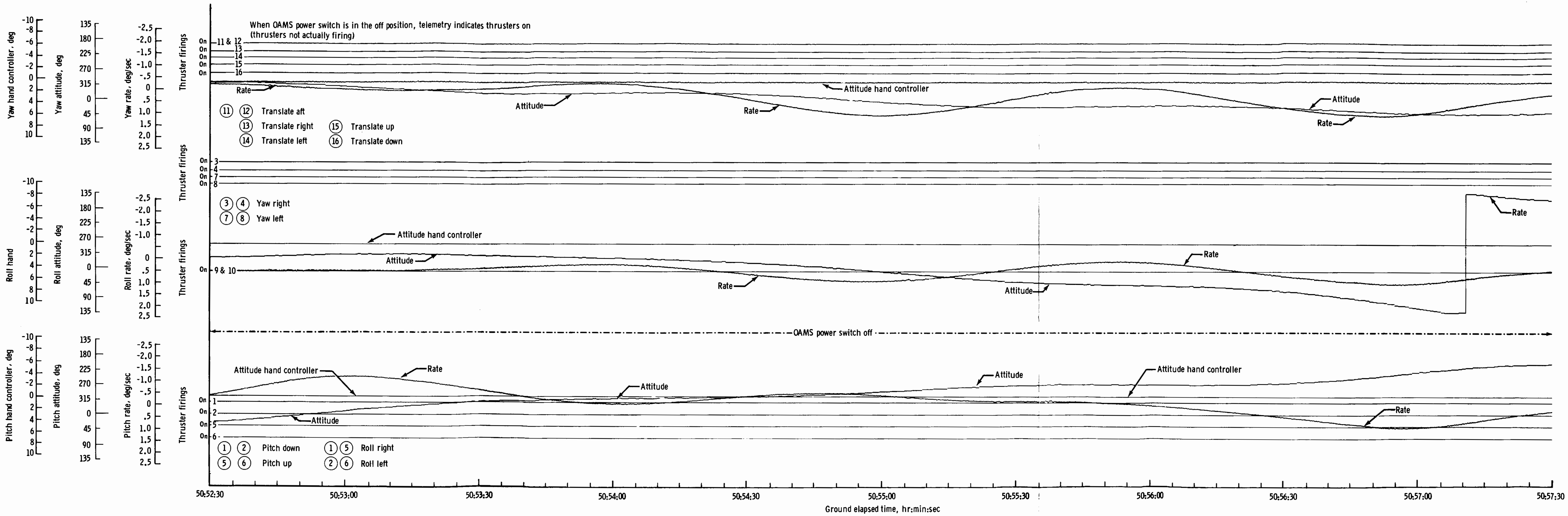
NASA-S-66-9053 OCT 12



(b) 50:17:00 to 50:22:00, g.e.t.

Figure 5.1.5-14. - Continued.

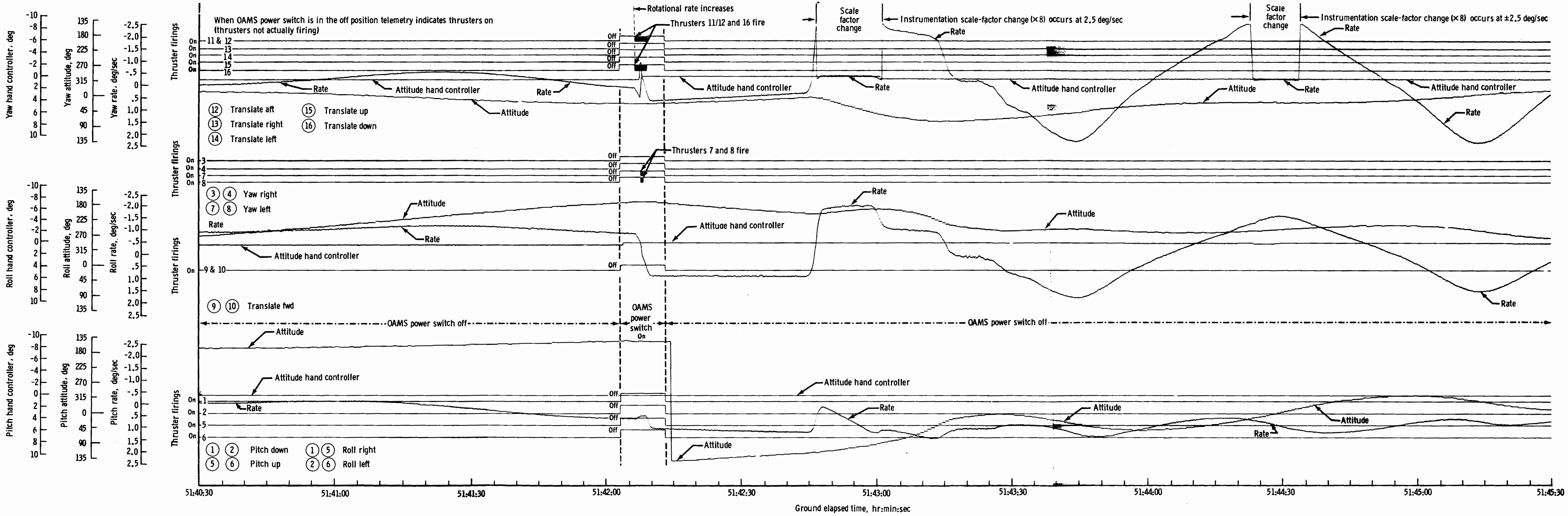
NASA-S-66-9054 OCT 12



(c) 50:52:30 to 50:57:30, g.e.t.

Figure 5.1.5-14. - Continued.

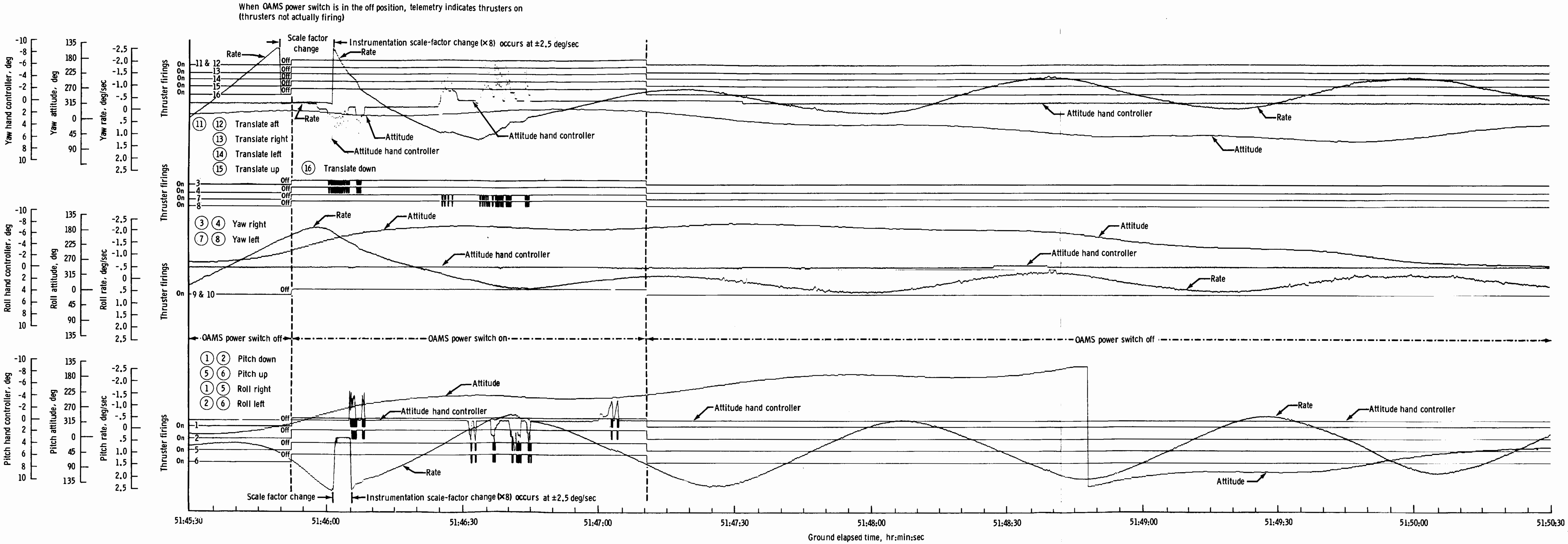
NASA-S-66-9055 OCT 12



(d) 51:40:30 to 51:45:30, g.e.t.

Figure 5.1.5-14. - Continued.

NASA-S-66-9056 OCT 12



(e) 51:45:30 to 51:50:30, g.e.t.

Figure 5.1.5-14. - Concluded.

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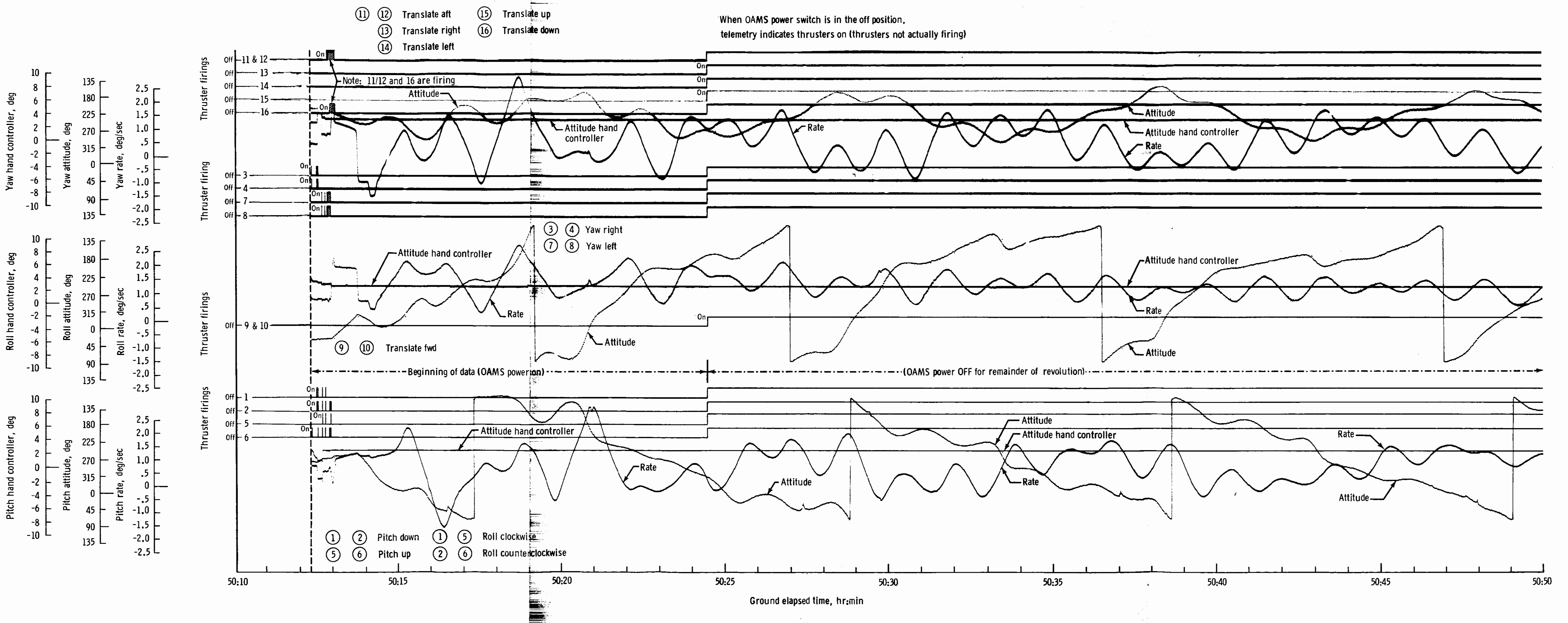
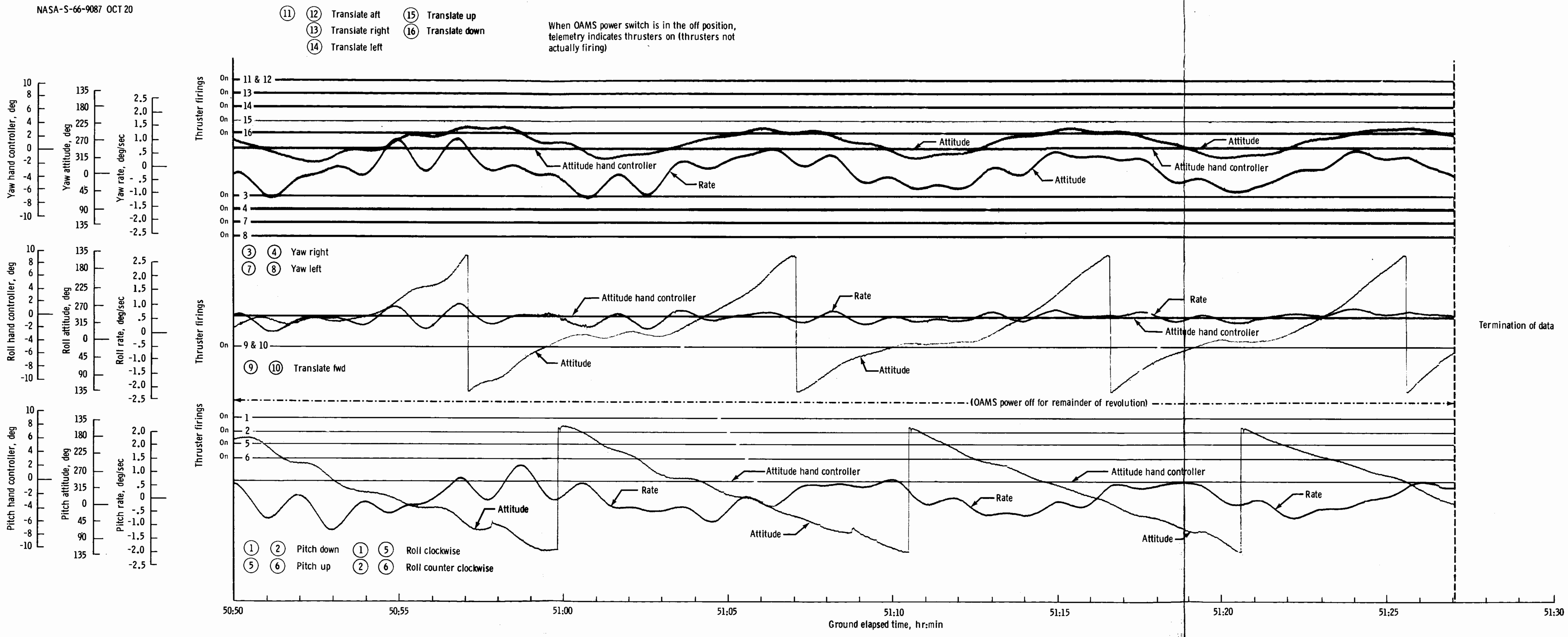


(a) 50 hr 10 min to 50 hr to 50 min g.e.t.

Figure 5.1.5-15. - Spacecraft dynamics during the tether exercise, condensed scale.

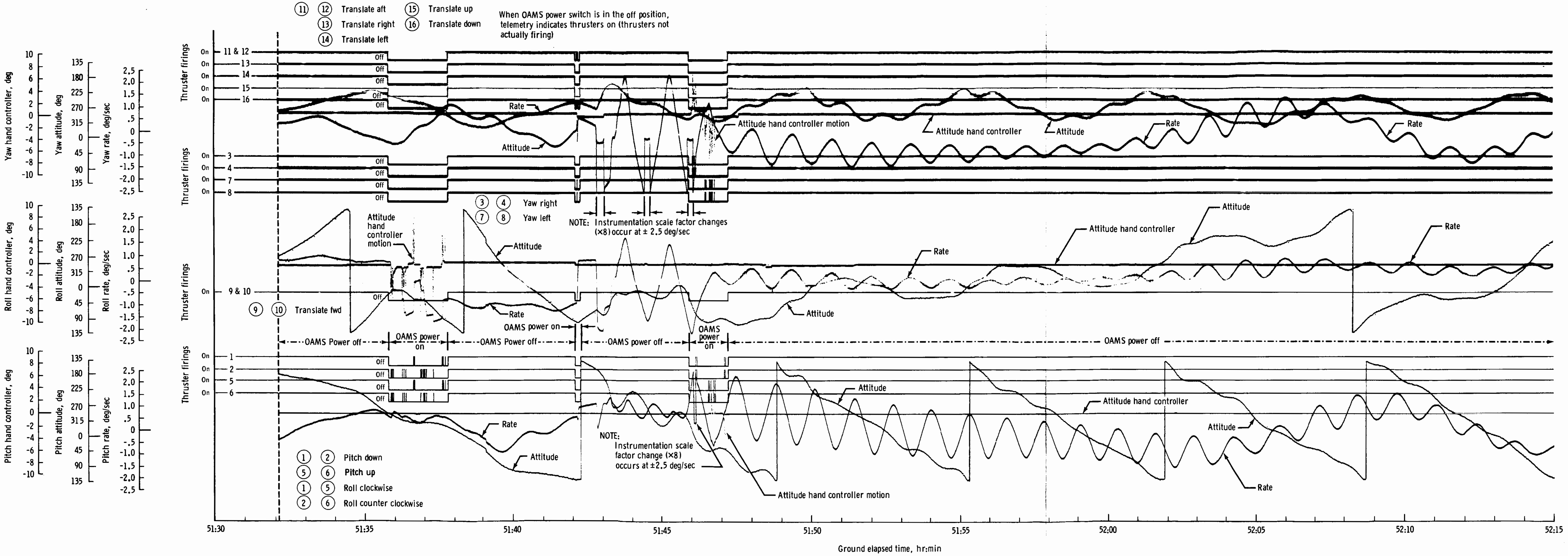
NASA-S-66-9087 OCT 20



(b) 50 hr 50 min to 51 hr 30 min g.e.t.

Figure 5.1.5-15. - Continued.

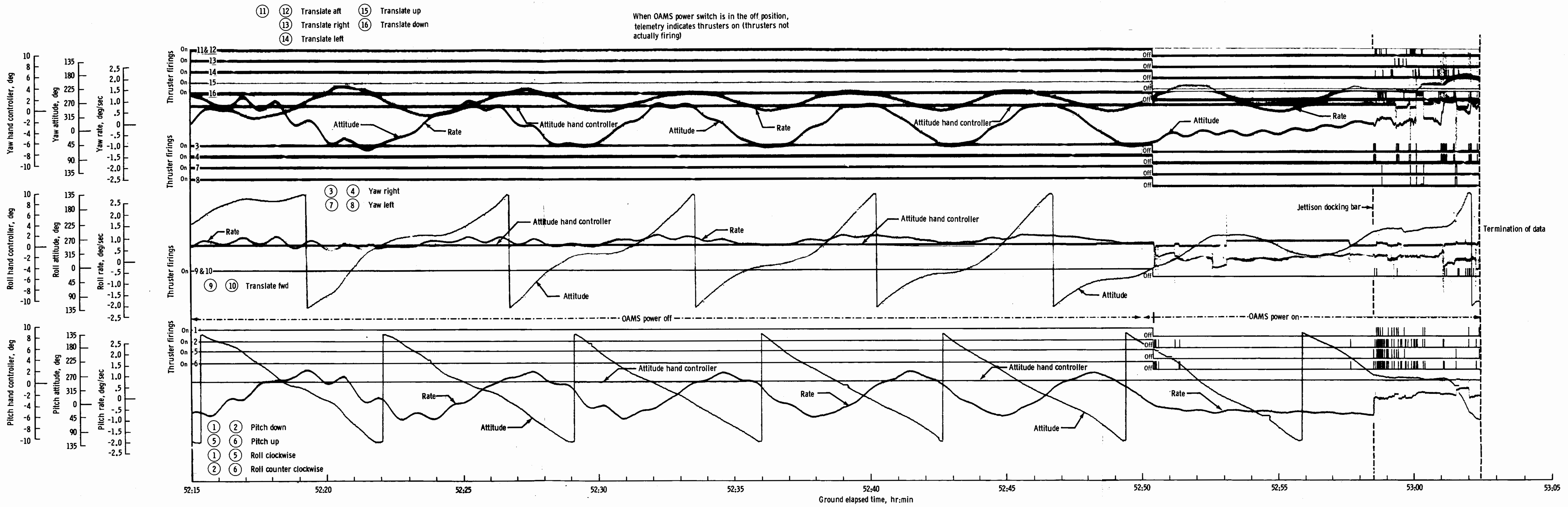
NASA-S-66-9088 OCT 20



(c) 51 hr 30 min to 52 hr 15 min g.e.t.

Figure 5.1.5-15. - Continued.

NASA-S-66-9089 OCT 20



(d) 52 hr 15 min to 53 hr 05 min g.e.t.

Figure 5.1.5-15. - Concluded.

5.1.6 Time Reference System

An analysis of available data indicates that all components of the Time Reference System (TRS) performed according to specification. The electronic timer began counting elapsed time at approximately one millisecond after lift-off. During ingress from standup EVA, the electronic timer was inadvertently turned off at 176 747.125 seconds elapsed time and remained off for approximately 3 minutes 7 seconds. During the first 174 883.312 seconds of flight (48:34:43.312 ground elapsed time), the maximum error of the electronic timer was approximately 394 milliseconds, or 2.25 parts per million, which is well within the specification requirement of 10 parts per million at 25 ±10° C. In addition, the timer successfully initiated the automatic retrofire sequence at 70:41:36.5 g.e.t. The electronic timer read 71:19:27 when it was turned off by the crew approximately 2 minutes 19 seconds after landing.

The event timer and the elapsed-time digital clock were used several times during the mission and were found to be correct when checked against other sources. The flight crew reported satisfactory operation of the G.m.t. battery-operated clock and the G.m.t. mechanical clock, but made no special accuracy checks. During the recovery sequence, when the clocks were compared with the ship's clock to the nearest minute, the battery-operated G.m.t. clock was correct and the mechanical G.m.t. clock was one minute fast. Satisfactory timing on the tapes from the onboard voice tape recorder indicated normal operation of the time correlation buffer.

5.1.7 Electrical System

The Electrical System performed in a satisfactory manner throughout the mission. The only system anomaly was a failure of stack C in fuel cell section 2. The remaining five stacks adjusted to the load and the mission continued with no further anomalies in the Electrical System.

5.1.7.1 <u>Silver-zinc batteries</u>.- The batteries performed normally throughout the mission. After adapter equipment section separation, prior to retrofire, the main bus held an expected 23.5 volts at the required 33.5 amperes.

5.1.7.2 <u>Fuel-cell power system</u>.-

5.1.7.2.1 Prelaunch history: After replacement of a failed-open water valve in section 2, membrane leak checks, and water-system leak checks, the initial activation of the fuel cells was satisfactorily performed August 5, 1966. However, while on the 1-ampere-per-stack deactivation load, failure of an Aerospace Ground Equipment valve allowed helium to be introduced into the hydrogen system. Following the discovery of this condition, when the output went to nearly zero, the oxygen and hydrogen systems were subjected to the standard helium shutdown purge, after which hydrogen was reintroduced into the system in accordance with the standard procedures. Open-circuit voltages at this time were normal for this configuration. Deactivation and depressurization of the fuel cell proceeded in what was thought to be the prescribed manner; however, it was later discovered that the coolant flow had been diverted around the fuel cells throughout the 21.5 hours of deactivation. The overall temperature rise of the fuel cells during this period was estimated to have been 17° F. The second fuel cell activation (fig. 5.1.7-1) was performed on September 8, 1966. At this time the performance of section 1 was normal, but the performance of section 2 was approximately 0.7 of a volt lower than the average second activation performance of fuel cell sections used for previous Gemini missions. Because of the launch cancellations on September 9 and 10, 1966, three unscheduled days of standby operation of the fuel cells were required. The performance decays prior to the September 12, 1966, launch were approximately 1.0 volt and 0.6 of a volt for sections 1 and 2, respectively. This compares with the 0.2 to 0.5 of a volt performance decay achieved with fuel cell sections used for previous missions. No measurable performance decay occurred during the day immediately preceding the launch, and, in addition, the system met all launch requirements.

5.1.7.2.2 Inflight performance: The fuel-cell power system performed as required in delivering electrical power to the spacecraft systems. The fuel cells supplied approximately 2300 ampere-hours during the mission. The electrical load ranged from 14.7 amperes (spacecraft powered down) to 63 amperes (full load). The EVA and rendezvous operations, in addition to the usual launch and preretrofire loads, resulted in a total time at high current loads as great as the time at high loads during any previous mission (fig. 5.1.7-2). The postflight evaluation of selective hydrogen-to-oxygen differential pressure data showed that successful purges were achieved. The unequal prelaunch performance of the individual stacks and sections continued throughout the mission (figs. 5.1.7-3 and 5.1.7-4); however, until the failure of stack 2C, only a slight performance decay had occurred in either section (fig. 5.1.7-1).

5.1.7.2.3 Stack 2C anomaly: Stack 2C began to degrade at 54:31:00 g.e.t. (fig. 5.1.7-5). Twenty-seven seconds later, this stack would not support any electrical load at the bus voltage of 23.78 volts. The stack was taken off the line at 54:42:15 g.e.t., and the open-circuit voltage was zero, whereas open-circuit voltage readings are normally greater than 33 volts. The rapid decay in performance and zero open-circuit response are characteristic of a perforation of the membrane.

Once the membrane is perforated, oxygen gas, because of its higher pressure, forces its way into the hydrogen portion of the cell. In the presence of the platinum catalyst, the gases unite and burn. The outlet coolant temperature of the fuel cell was not monitored by telemetry, but, because of the feed-back loop (fig. 5.1.7-5), changes in the outlet temperature are reflected in the inlet coolant temperatures. The inlet coolant temperatures are plotted in figure 5.1.7-5 as a function of ground elapsed time. This figure shows that the section 2 coolant inlet temperature rose to a peak, presumably due to the energy released during the oxygen-hydrogen combustion, and then dropped gradually to a point slightly lower than it had been prior to the anomaly. This type of failure mode was observed in the fuel-cell development program. As a result, the hydrogen feed line of each stack has a check valve which will close by the normal oxygen-to-hydrogen differential pressure. The closing of this check valve evidently limited the combustion period by restricting the quantity of hydrogen gas available, thereby preventing further damage. The lower temperature that followed is indicative of the lower load carried by section 2 as a result of the loss of stack C. During the same period, an increase in the coolant temperature of section 1 reflected the additional load section 1 had assumed. An examination of the analog oxygen-to-hydrogen differential-pressure data during this period also revealed evidence of the perforation and subsequent check valve closure. The data showed a very slight decrease in pressure, followed by a recovery which was presumably due to the valve closure.

Failure analysis of the hardware is not possible because it was jettisoned with the adapter equipment section prior to retrofire. Several factors may have attributed to the failure of stack 2C:

(a) The abnormal deactivation following the first activation may have resulted in 2C supporting approximately 40 percent of the section 2 load.

(b) On several occasions section 2 supported high loads with low coolant flow rates.

(c) The extended prelaunch operating periods at low loads resulted in degraded performance.

(d) Eighteen of the 32 cells in stack 2C were from an earlier, disassembled, unused stack; however, prior to use, all of these cells met all specifications required of new cells.

Evaluation of these factors has led to the conclusion that probably no single factor caused the failure of the stack, but the combination of these factors was sufficient to result in the stack failure.

5.1.7.3 Reactant supply system.- The performance of the reactant supply system was satisfactory throughout the mission. During the mission, a special test was conducted to determine the improvement, if any, of the thermal performance of the hydrogen container resulting from venting the container annulus to the hard vacuum of space. The pinch-off tube cutter was actuated at 54 hours 22 minutes g.e.t. and a comparison of data taken before and after the cutter actuation showed a 9.5-percent improvement in thermal performance of the container.

5.1.7.4 Power distribution system.- No anomalies were reported or found in the power distribution system. The postflight inspection revealed the usual number of blown fusistors in the pyrotechnic firing circuitry, a condition which is considered normal.

5.1.7.5 Sequential system.- The performance of the sequential system was nominal during the mission, as indicated in table 4.2-I.

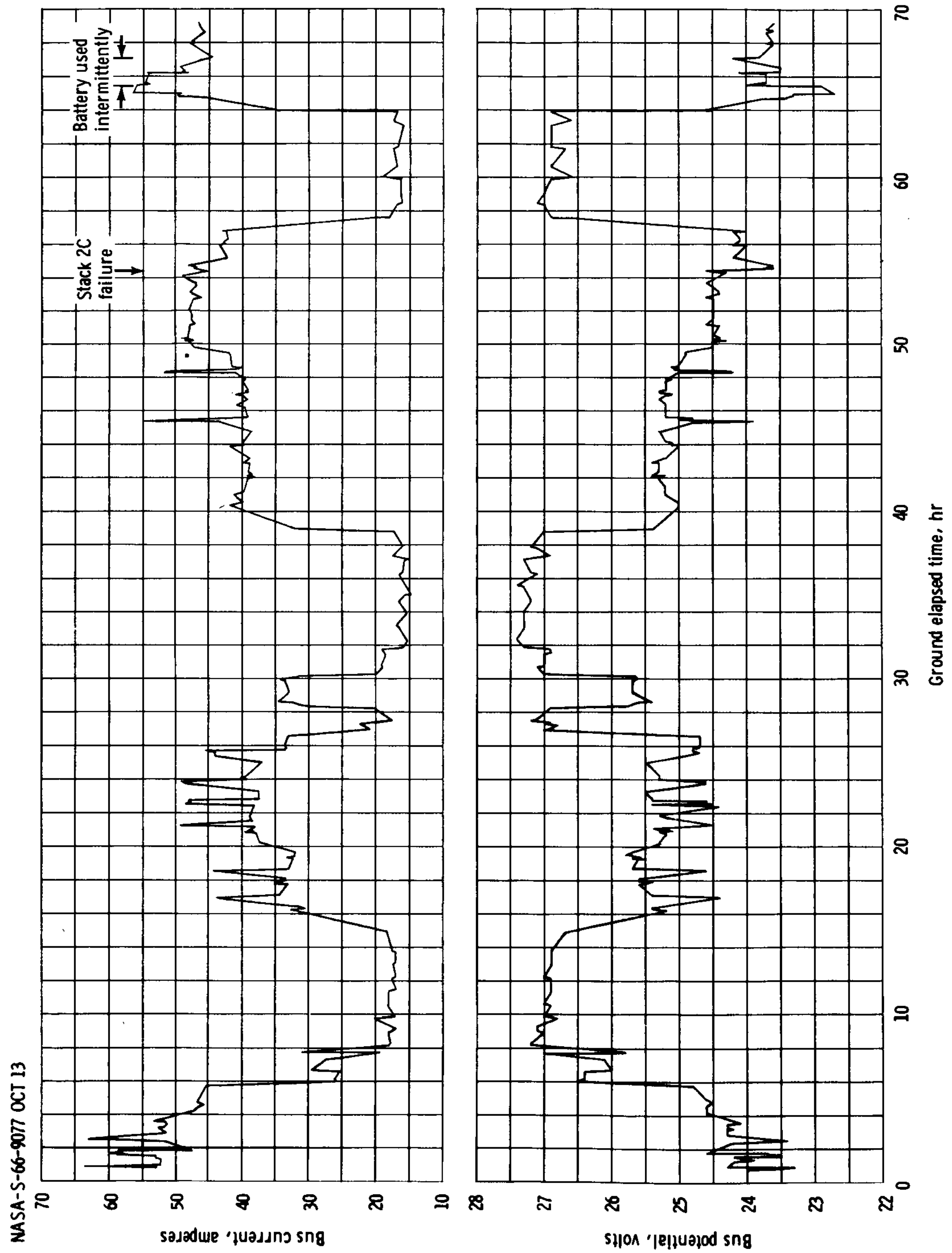


Figure 5.1.7-1.- Spacecraft 11 fuel-cell performance.

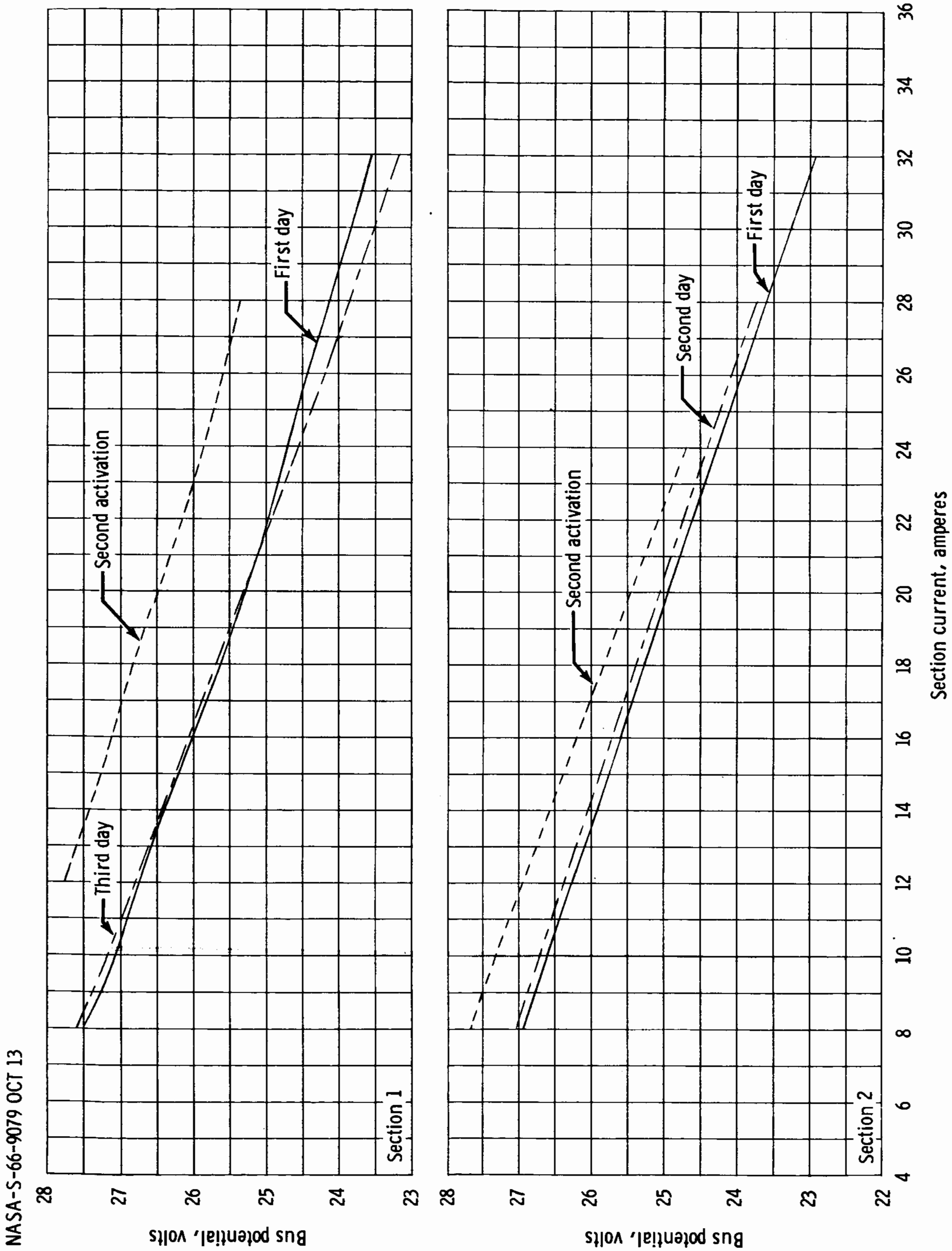


Figure 5.1.7-2. Fuel-cell section 1 and 2 performance.

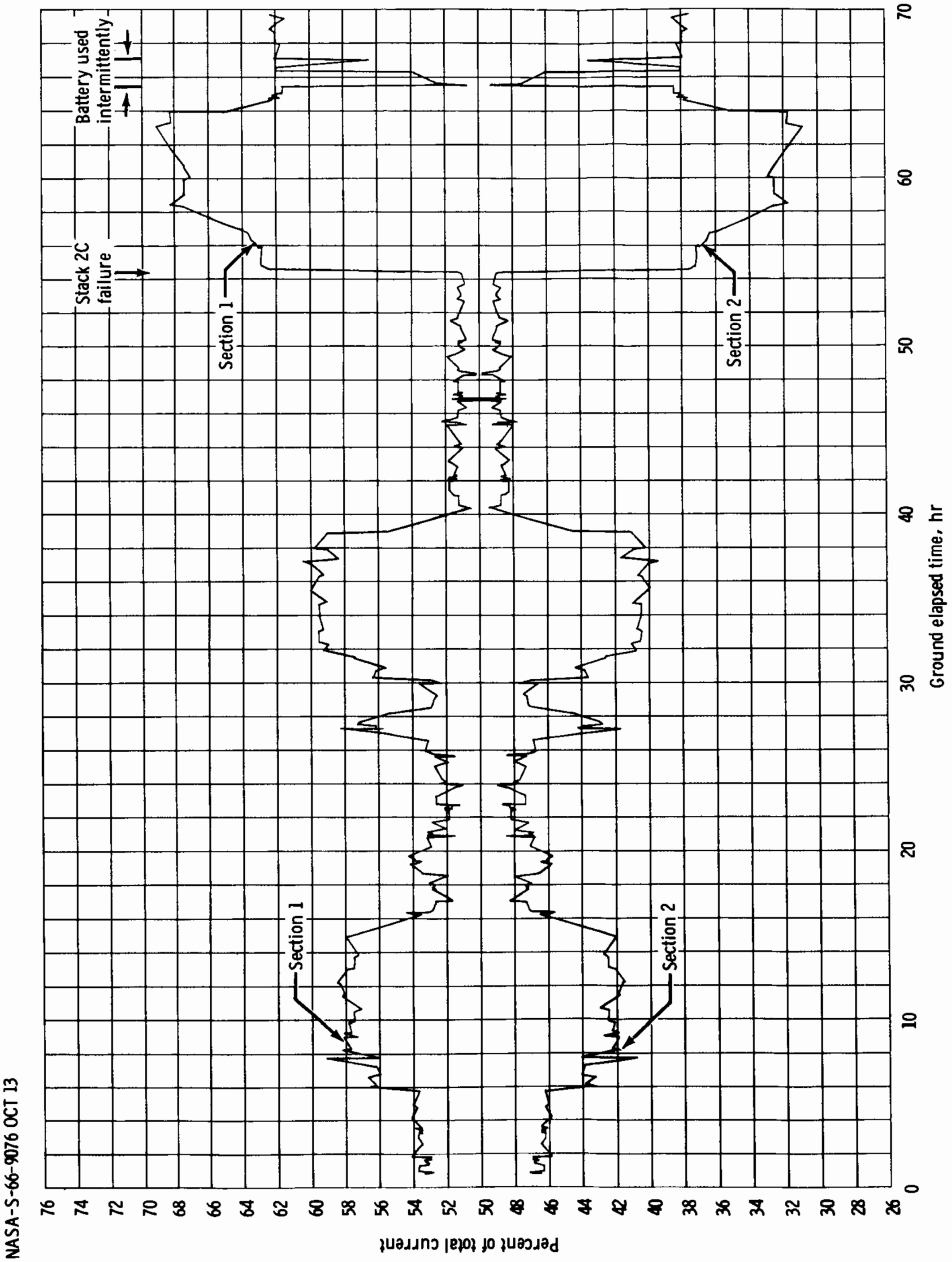


Figure 5.1.7-3. - Load sharing between fuel-cell sections.

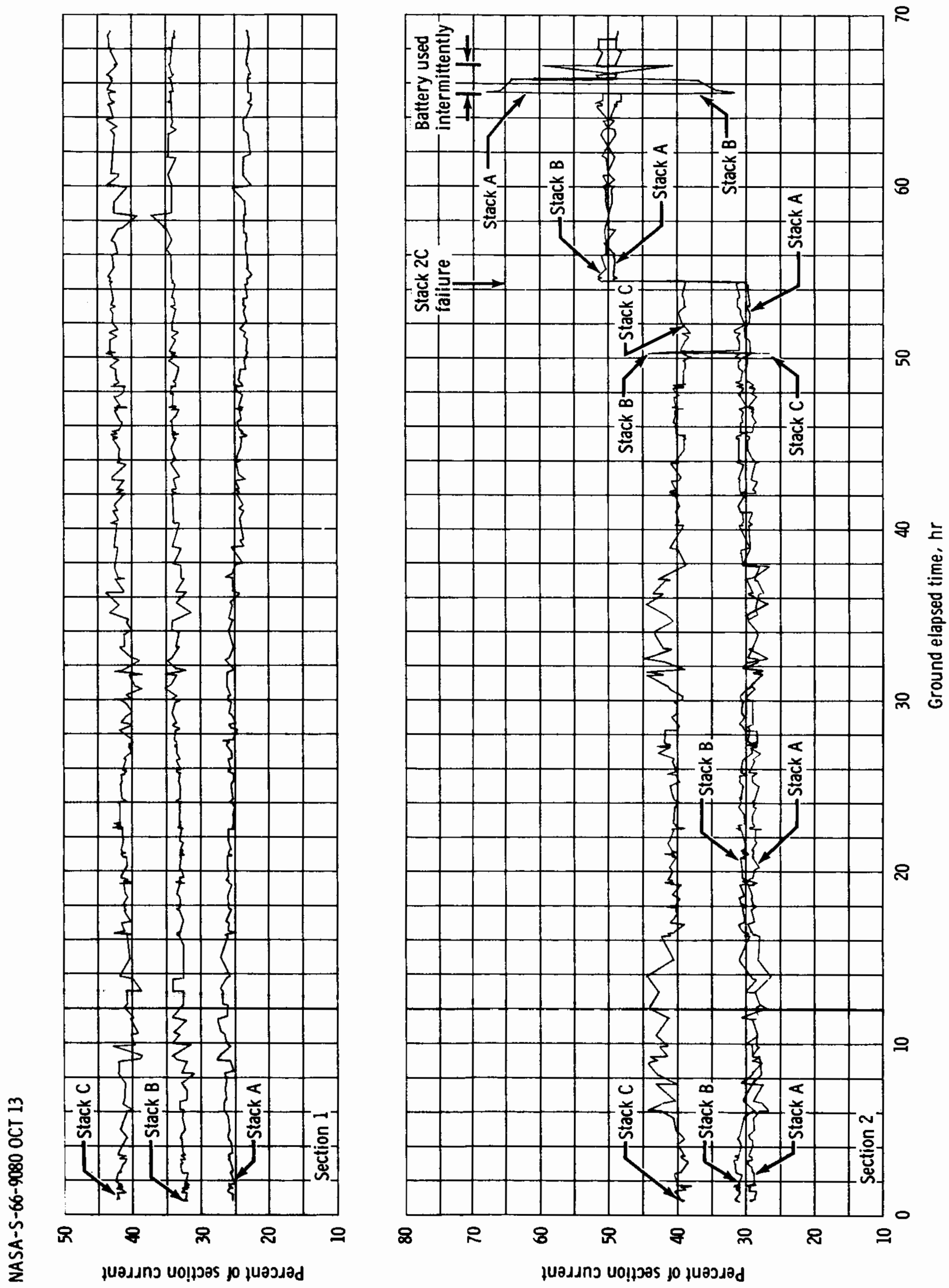


Figure 5.1.7.-4.- Load sharing between fuel-cell stacks.

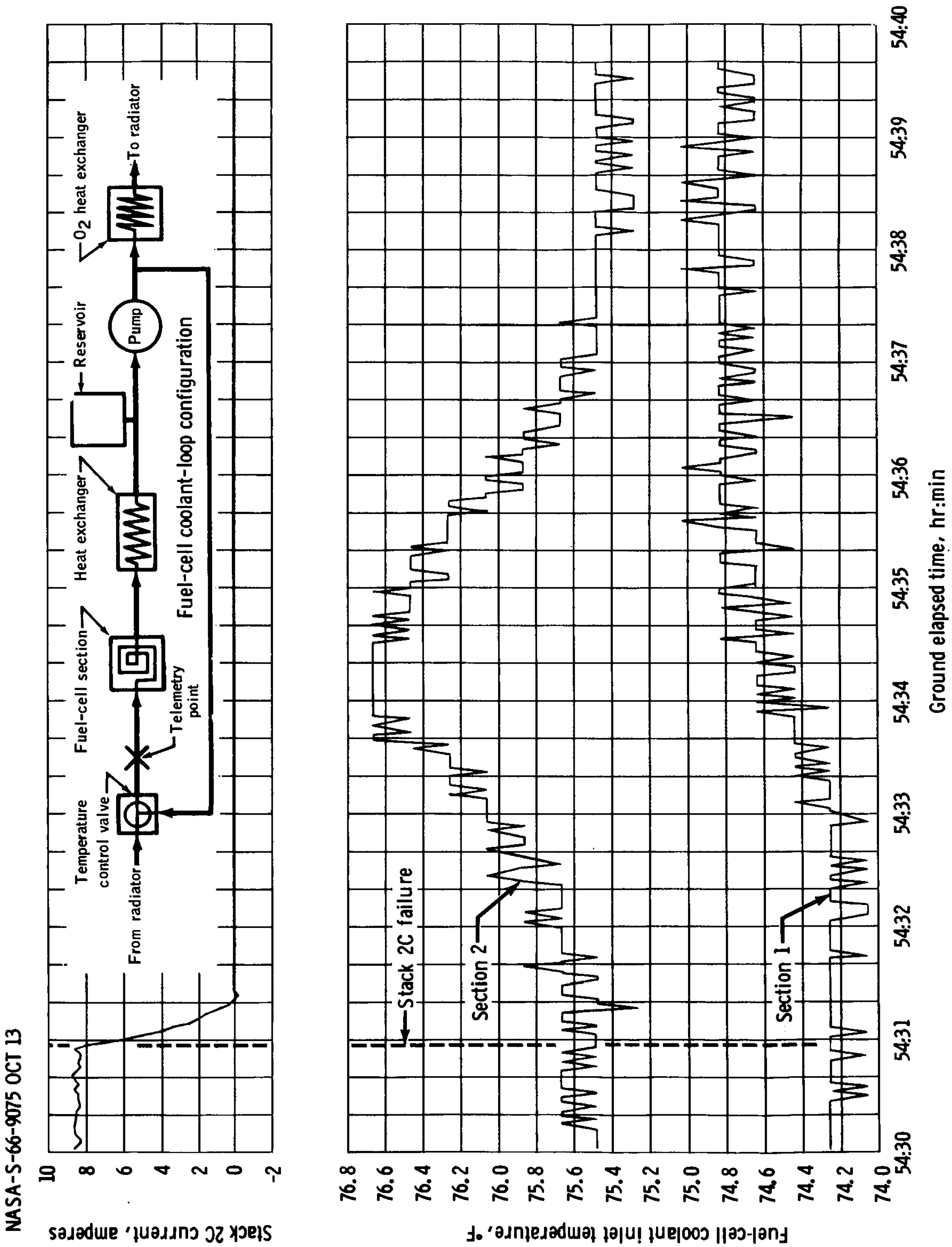


Figure 5.1.7-5. - Stack 2C failure.

5.1.8 Propulsion

Overall flight performance of the three spacecraft propulsion systems—the Orbital Attitude and Maneuver System (OAMS), Reentry Control System (RCS), and Retrograde Rocket System—was satisfactory. The performance of each system is discussed below.

5.1.8.1 Orbital Attitude and Maneuver System.-

5.1.8.1.1 Anomalies: The crew reported: (1) degraded attitude engine performance from engine no. 8 in revolution 11 and engine no. 6 in revolution 43, (2) an apparent "softness" of maneuver engine no. 15 (up-thrusting/down-firing engine) during the first rendezvous and the coincident-orbit rendezvous, and (3) an unusual momentary loss of temperature data on the pressure/temperature indicator during changes of the selector switch.

An analysis of the data showed engine no. 8 to have intermittent degradation of thrust at various times during the mission. These intermittent thrust levels were present as early as the second revolution, and, during the latter portion of the mission, the thrust reached a level as low as 30 percent of the acceptance test value. The analysis also revealed that engine no. 6 had exhibited degraded thrust; however, the degradation was small and apparently was not noticed by the crew. Analysis of additional data revealed degraded thrust from other engines; however, the thrust degradation was either so small or the periods of thruster operation were so short that a determination of actual thrust levels was not possible. The intermittent degradation of thrust required the crew to correct the rates induced from disturbance torques caused by cross coupling, and additional quantities of propellant were expended in doing this. The crew had trained for this type of condition and the degraded thrust, therefore, caused them no particular concern.

Degraded attitude engine performance has been encountered on previous missions and has been related to a reduction of propellant flow. In this mission the data indicated that the most probable cause of reduced flow was particulate contamination within the system. The most susceptible location is the trim (calibration) orifice which has a 0.034-inch diameter and does not have the protection of a filter immediately upstream.

In regard to reported degradation of engine no. 15, postflight analysis of the data concerned with this engine does not substantiate the crew's report of subnominal thrust.

Troubleshooting of the pressure/temperature indicator and its associated circuitry is in progress and has presently not revealed any cause for the reported erratic performance.

5.1.8.1.2 Propellant utilization: Propellant usage for the various activities during the mission is presented in figure 5.1.8-1. The curve shows good agreement between the overall preflight planned values and actual flight quantities. However, there were two activities in the flight plan for which insufficient quantities of propellant were allocated, the tethered vehicle evaluation and the standup EVA. The tether evaluation required 75 pounds as compared with a planned quantity of 45 pounds, and the standup EVA required 83 pounds, more than four times the predicted 18 pounds.

5.1.8.2 Reentry Control System.- No flight anomalies involving the RCS were reported by the crew. Practically all propellant was consumed from the A-ring tanks and about two thirds from the B-ring tanks. The propellant consumption by the two systems is presented in figure 5.1.8-2. The total absolute accuracy of the data is ±10 percent; for quantities determined over a short time interval, the accuracy is closer to ±5 percent.

5.1.8.3 Retrograde rocket system.- A 325.56 ft/sec velocity was predicted for the retrograde rocket system. The IGS measured value was 325.00 ft/sec.

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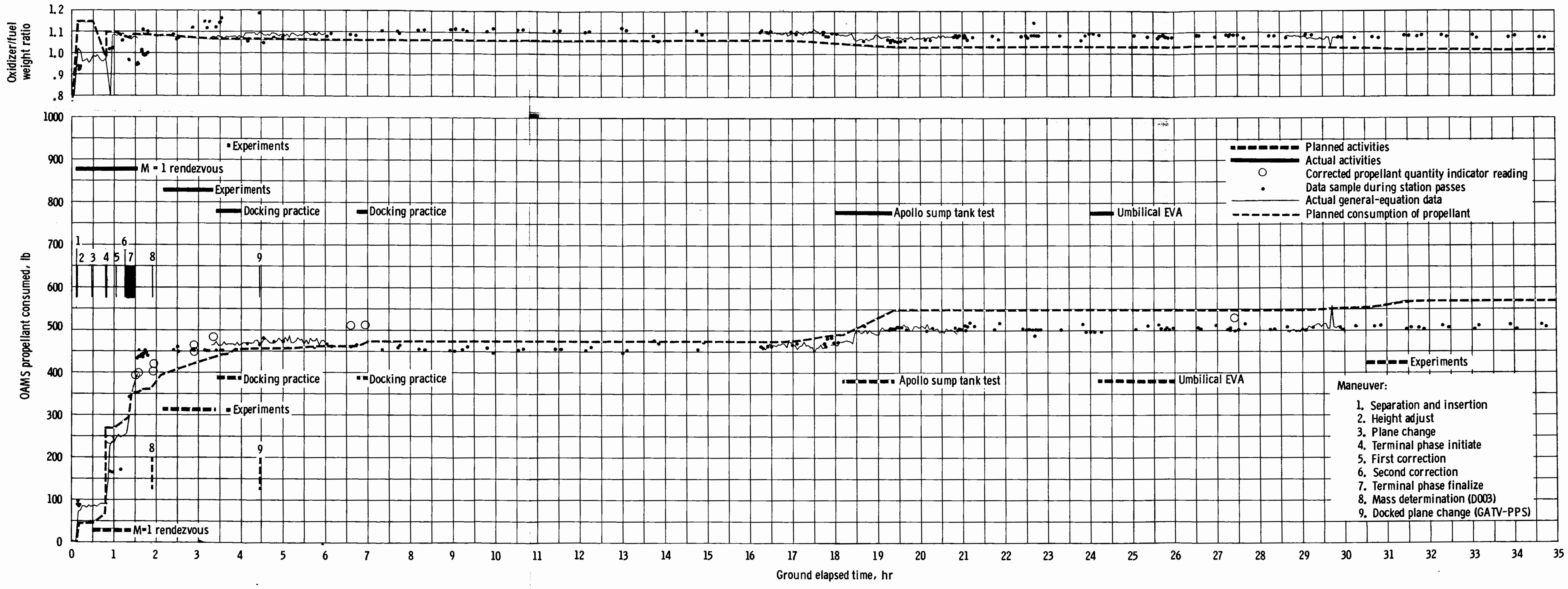

(a) 0 to 35 hours g.e.t.

Figure 5.1.8-1. - OAMS propellant consumption.

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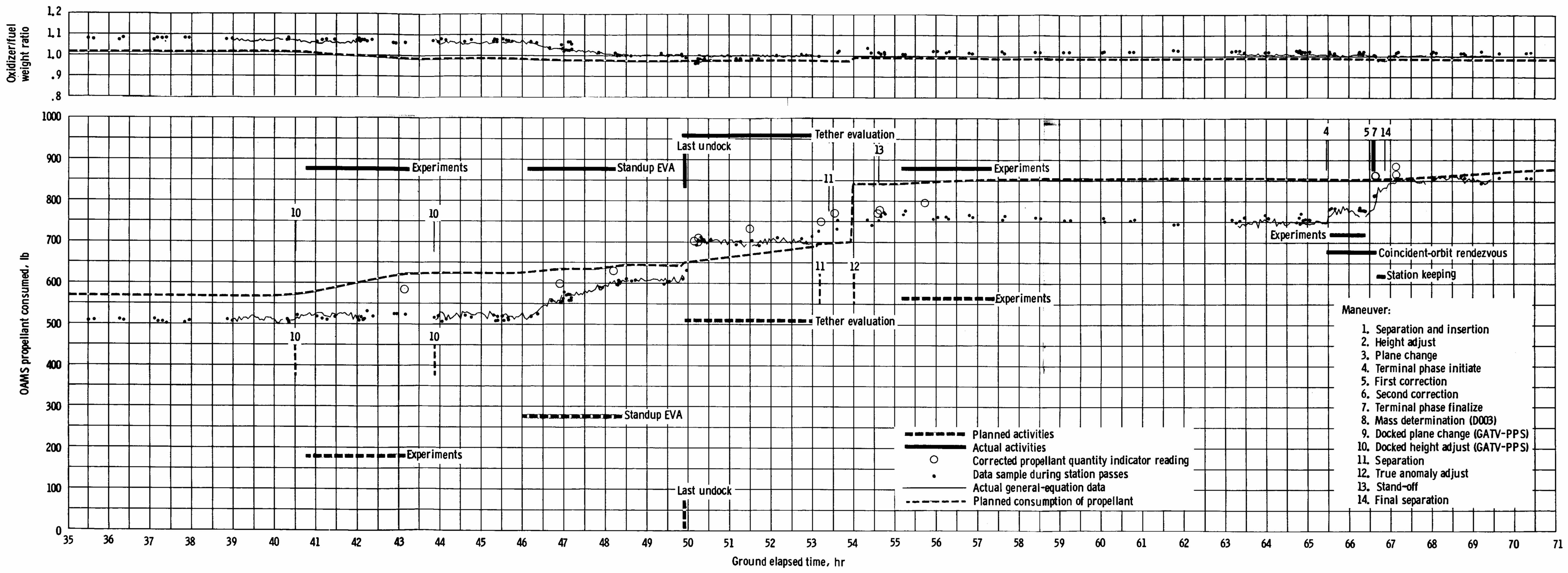

(b) 35 to 71 hours g.e.t.

Figure 5.1.8-1. - Concluded.

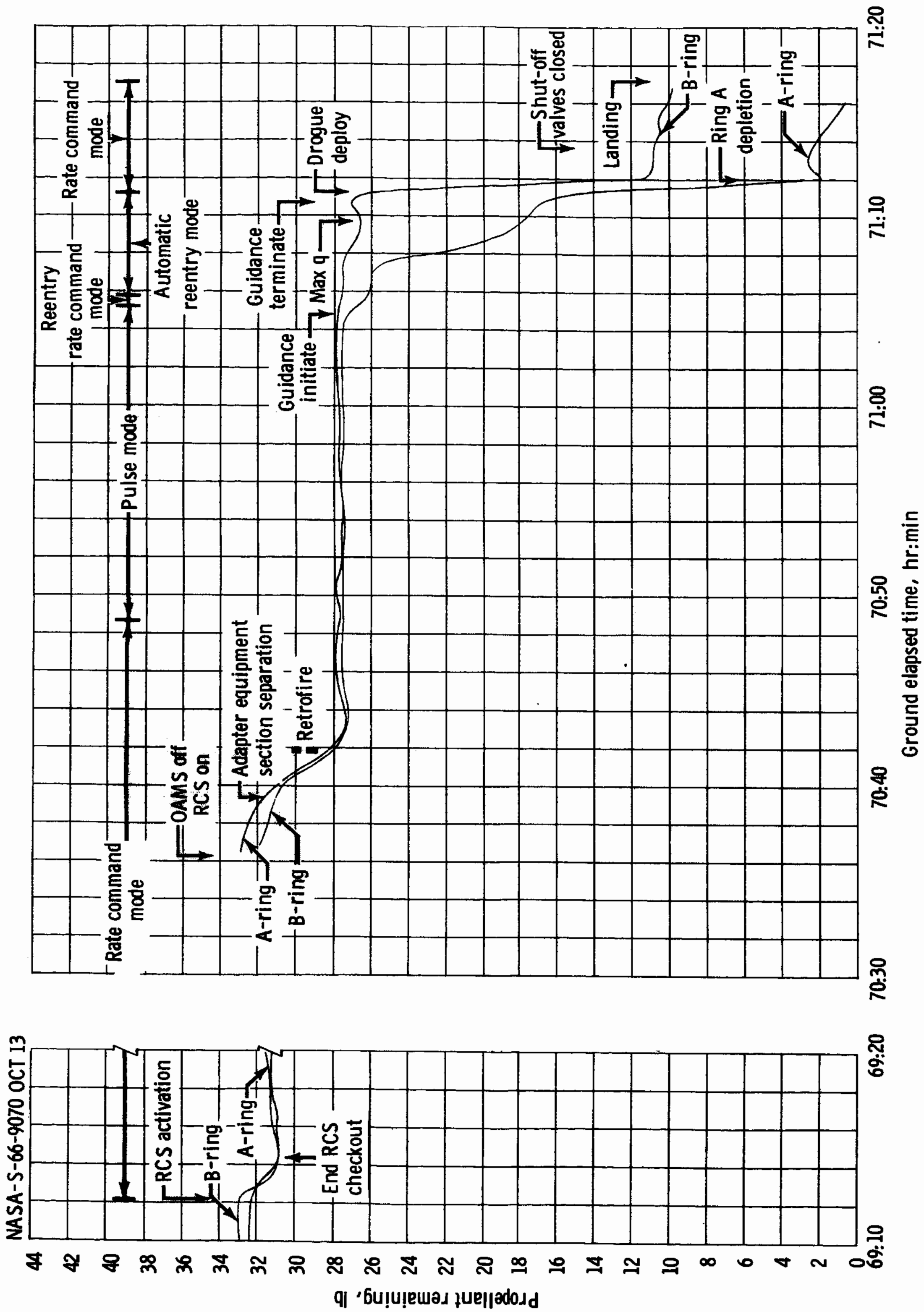

Figure 5.1.8-2. - RCS propellant consumption.

5.1.9 Pyrotechnic System

All pyrotechnic functions were satisfactory. A postflight test revealed a low resistance in the firing circuit of one of the pyrotechnic switches. Examination of the switch revealed a residue which had formed after the normal detonation of the cartridge. The switch had functioned properly and the residue was the cause of the low resistance.

5.1.10 Crew Station Furnishings and Equipment

5.1.10.1 Crew-station design and layout.- The crew-station design and layout were satisfactory for the Gemini XI mission. Minor problems or noteworthy conditions are described in the following paragraphs.

5.1.10.1.1 Displays and controls: The displays and controls functioned satisfactorily for this mission; however, the crew reported that the propellant pressure/temperature gage was intermittent while switching parameters. Immediately after switching, the meter would fluctuate between offscale low and high and then would settle out and read the correct value. Postflight testing has not duplicated the problem and a failure analysis is being performed on each component.

5.1.10.1.2 Equipment stowage: Equipment stowage was satisfactory. Stowage items required to support the M=1 rendezvous were readily available. The 30-foot umbilical was stowed in the left-hand footwell and the TV monitor for the D015 Night Image Intensification experiment was stowed in the right-hand footwell. A list of items stowed in the spacecraft is contained in section 3.1. Although the crew had no major stowage problems, they did recommend that the footwell areas not be used for stowage. Equipment was jettisoned as scheduled by the flight plan. The umbilical stowage rack was modified so that it could be removed and jettisoned; however, removal of the rack was not attempted and this was the only item that was not jettisoned as planned.

5.1.10.1.3 Lighting: Cabin lighting was satisfactory for the mission.

5.1.10.1.4 Crew furnishings: The ejection seats were not used except for restraint and support of the crew. The Gemini X crew had reported that, after insertion into orbit, it was difficult to install the D-ring/safety-pin combination. In Spacecraft 11, Velcro was added to the seat/D-ring interface to provide retention of the D-ring while the safety pin was being installed. This modification reduced the task to a one-hand operation, and the Gemini XI crew reported no difficulty.

Binding of the lap belt was also reported during the Gemini X mission but was not evident during the Gemini XI mission. A design change to the lap belt incorporated a set of guides on the buckle. These guides orient the belt to prevent it from folding over and binding as it passes through the gripping mechanism of the buckle.

5.1.10.2 Pilot's operational equipment.-

5.1.10.2.1 Still cameras: The 70-mm general-purpose camera was used for experiments and general-purpose photography. The crew had minor difficulty assembling the camera for the S011 Airglow Horizon Photography experiment. The size of the special lens assembly for this experiment interfered with the latches on the film back and required that the film back be installed before the lens, which is in reverse order from the normal procedure.

Postflight examination revealed that a screw was missing from the body of the S011 experiment magazine. This failure caused light streaks on some of the film in the magazine. Light streaks also appeared on some of the operational film. A postflight investigation indicated that the felt light seal around the dark slide had been creased by improper insertion of the dark slide in several operational magazines. These magazines apparently leaked light when the dark slide was removed and repositioned.

The 70-mm superwide-angle EVA still camera was used for photographing the earth during the EVA and during the high-altitude orbit phase. This camera operated satisfactorily with good results.

5.1.10.2.2 Sequence cameras: The two 16-mm sequence camera systems were used to expose 12 of the 15 film magazines carried in the spacecraft. The results from five of these 12 magazines were entirely satisfactory. Of the remaining seven, one magazine contained film that was slightly underexposed, four contained film that was badly underexposed, one contained film that was out of focus and smeared, and one magazine was jammed.

The underexposure occurred only when the 18-mm lens was used, and it appears that this lens was improperly set. It was noted during postflight inspection that the physical stop at the f/16 end of the iris control was approximately 1/8-inch beyond the f/16 mark. Because this lens did not have detents at the f-stops, there was no way to exactly locate the f/16 position of the iris. In the postflight debriefing the flight crew indicated that they used the procedure of rotating the lens all the way to the physical stop to set it at f/16. Densitometer measurements of the underexposed film indicate that most of it was taken with a lens setting corresponding to a position between the f/16 setting and the physical stop. This problem was not encountered with the 5-mm and 75-mm lens assemblies, because these two lenses had detents at each lens setting.

The smearing and improper focus of the film in one magazine was caused by damage to the spring on the magazine door of the camera. Postflight inspection showed that the magazine door springs in both 16-mm sequence cameras were bent out of position. The normal function of this spring is to hold the magazine in place against the aperture plate at the front of the camera. With this spring inoperative, the magazine would be free to move away from the aperture plate, and the framing pawl would not engage the film. Also, with the magazine out of position the image was not properly focused on the film. Inspection of the cameras indicates that the magazine door spring is susceptible to damage if the door is closed with the magazine only partially inserted in the camera. It is probable that the springs were damaged during the EVA film changes because of the reduction in crew dexterity in the pressurized space suits. A design change has been incorporated into the Gemini XII cameras to prevent this type of damage to the magazine door spring.

Inspection of the magazine which jammed indicated that a loose loop of film had been drawn into the metering sprocket and halted all film motion. This condition was caused by flexure of the thin-base film, permitting it to slip under the stripper plate in the lid of the magazine. To prevent this condition, a guard post which will deflect the film away from the metering sprocket has been added to the magazines for the Gemini XII mission.

5.1.10.2.3 Utility-light filter: The right utility-light filter was kicked loose during the umbilical EVA. The command pilot retrieved the filter and subsequently discarded it out the open hatch.

5.1.10.2.4 Water-metering device: The water-metering device used for drinking and rehydration of the food performed satisfactorily and no problems were reported by the crew.

5.1.10.3 <u>Pilot's personal equipment</u>.-

5.1.10.3.1 Food: Eighteen complete man-meals were provided for consumption by the crew and included rehydratable and bite-size foods similar to those provided for previous Gemini missions. There were no leaks in the rehydratable food bags, and the crew reported that the food was satisfactory. Fifteen meals were opened and most of the items from each meal were eaten. The command pilot ate very few bite-size items. Most of the food wrappers were jettisoned during the hatch-open periods.

5.1.10.3.2 Waste equipment: Removal of the launch-day urine collection devices was accomplished during the first day of the mission. No problems were encountered in their use, and they were subsequently discarded overboard.

Defecation devices were not used during this mission.

One urine transport system was provided, and no problems were reported by the flight crew.

No problems were encountered with personal hygiene items during flight. The crew made frequent use of the hygiene towels to wash their faces and hands. They reported that these towels would have been of even greater value if they had been larger.

5.1.10.4 Space suits and accessories.- The space suits operated satisfactorily except for minor discrepancies that are discussed in the following paragraphs.

5.1.10.4.1 Command pilot's space suit: The space suit configuration for the command pilot (G-4C-39 with a lightweight coverlayer, P/N A-1765, and a clear polycarbonate pressure visor) was basically the same as that used for the command pilots of the Gemini IV, V, VIII, IX-A, and X missions. Postflight inspection of the suit revealed the equipment to be in very good condition, meeting all leakage and relief valve requirements. Actual postflight leakage was 100 scc/min at 3.7 psig, one-tenth of the allowable leakage. The right-wrist-disconnect locking action showed signs of corrosion and had a tendency to stick; however, the suit had been exposed to heavy salt spray during the recovery by helicopter.

5.1.10.4.2 Pilot's space suit: The space suit for the pilot (G-4C-40) utilized the G-4C configuration pressure garment assembly of the same design as that provided the command pilot, but, in addition, it was fitted with an extravehicular coverlayer, P/N A-1817, and a polycarbonate pressure visor which included a low emissivity coating on the outside. The postflight inspection of this suit indicated the equipment to be in very good condition, meeting all leakage and relief valve requirements. Actual postflight leakage was 270 scc/min at 3.7 psig. The right-wrist-disconnect locking action also had a tendency to stick in the same manner as on the command pilot's suit.

5.1.10.4.3 Space suit accessories:

(a) Redundant locks - Both suits incorporated redundant locks on the wrist disconnects, neck rings, and the pressure-sealing zipper. These locks ensure premeditated crew action prior to opening these closures. The crew reported satisfactory operation of all closures and that the positive locking action of these redundant locks increased their confidence in suit integrity during EVA.

(b) Space suit pressure gage desiccant assemblies - The suit pressure gage on each suit incorporated a desiccant assembly to preclude pressure gage fogging during EVA. The crew reported that these gages did not fog at any time.

5.1.10.4.4 EVA sun visor: The pilot was provided with an extravehicular sun visor similar to the one worn by the Gemini IX-A pilot. After installation, the visor performed satisfactorily; however, during postflight inspection it was found to be cracked. During preparation for the EVA, the pilot installed the visor on the helmet while his suit was pressurized to 3.7 psig. The close tolerances of the visor/helmet interface and the flexibility of the visor produced considerable binding and misalignment. The pilot's inability to see his working area and the difficulty in working against the suit pressure produced high workloads which contributed to the pilot's overall fatigue and profuse perspiring prior to opening the hatch.

The flaking of the gold coating on the EVA sun visor that was reported after the Gemini X mission was not evident during this mission. The use of a visor cover at all times except during launch and EVA prevented contact of the visor with spacecraft protuberances, and no flaking occurred.

5.1.10.4.5 Visor antifog kits: Visor antifog kits, consisting of a dry wiping pad and a wet wiping pad saturated with an antifog and cleaning solution, were carried for inflight use by both crewmen. Prior to the umbilical and standup EVA periods, both crewmen wiped the inside surface of their visors with the wet pads first and then with the dry pads. No visor fogging was evident at any time during the mission.

5.1.10.4.6 Life vests: As a precautionary measure, the life vests were inflated after landing and before the helicopter pickup. The pilot reported that the left side of his vest would not fully inflate when the carbon dioxide cylinder was actuated; however, he inflated the vest orally and the vest held pressure. The problem was attributed to a faulty O-ring installation in the carbon dioxide fill valve. A failure analysis will be performed and corrective action initiated if necessary.

5.1.10.5 Extravehicular equipment.- All extravehicular equipment operated satisfactorily except the EVA sun visor which was difficult to install. Three extravehicular or hatch-open periods were conducted: (1) umbilical EVA from 24 hours 2 minutes to 24 hours 35 minutes g.e.t.,

(2) hatch-open period for equipment jettison from 25 hours 37 minutes to 25 hours 39 minutes g.e.t., and (3) standup EVA from 46 hours 7 minutes to 48 hours 15 minutes g.e.t. The activities accomplished during these periods are outlined in figure 5.1.10-1. The configuration of the equipment worn by the extravehicular pilot during the umbilical EVA is shown in figure 5.1.10-2.

5.1.10.5.1 Extravehicular Life Support System (ELSS): The Extravehicular Life Support System (ELSS) consisted of the chestpack, multiple connectors, hoses, and restraint straps, and was used for suit pressurization, ventilation, and heat dissipation during the umbilical EVA. The umbilical EVA preparations were begun approximately four hours before the hatch was opened, and the unstowage, hookup, and checkout of the ELSS were accomplished expeditiously. A few drops of water were observed in the inlet port, and this small amount indicated that the heat exchanger water supply had not significantly decreased from the 0.76 of a pound with which it had been serviced prior to launch. The ELSS emergency oxygen supply pressure was observed by the crew to be 8000 psi, indicating a full oxygen tank.

The EVA preparations proceeded more rapidly than anticipated; consequently, the ELSS donning, including checkout, was completed more than two hours prior to the scheduled hatch opening. The pilot remained on the ELSS for approximately ten minutes and then returned to the spacecraft ECS because of the lack of cooling and the higher rate of spacecraft oxygen consumption when on the ELSS. During this period the cabin was at 5 psia and the ELSS heat exchanger was not providing cooling, as it is dependent on a vacuum environment for water evaporation. The pilot reported, after the mission, that he was becoming uncomfortably warm during this 10-minute period of operation on the ELSS.

ELSS operation was resumed approximately 30 minutes before the scheduled hatch opening. The pilot began to get warm again, and this heat condition was aggravated by the difficulty in installing the sun visor on his helmet. It is apparent from his description that the pilot became quite warm and perspired significantly during this period.

The cabin was depressurized to less than 0.2 psi five minutes before the hatch was opened, and the ELSS heat exchanger began normal operation at this time. At the time of hatch opening (24 hours 2 minutes g.e.t.), the ELSS flow control was set on the medium position, and the pilot subsequently reported that the ELSS cooling was satisfactory with the medium flow.

After the hatch was opened for umbilical EVA, the pilot noted a definite tendency for him to move out of the cockpit. This effect continued after the initial outrush of gaseous flow, which lasted only five to ten seconds. The tendency to move away from the spacecraft was also suspected during the attachment of the GATV tether. The similarity of the description of this effect to the report by the Gemini IX-A crew, and the lack of this effect reported during standup EVA indicate the possibility that the gas outflow from the ELSS caused some small pressure force on the pilot while he was extravehicular. Calculations and tests indicate that the thrust directly from the outflow valve is approximately 0.05 of a pound. Further analysis and investigation are being carried out to identify the magnitude of possible pressure forces. Specific checks for the effects of ELSS outflow will be included in the next Gemini extravehicular mission.

The pilot's activities on the nose of the spacecraft involved an unusually high expenditure of energy, and, as a result, the EVA was terminated early. The air-to-ground transmissions immediately after EVA termination revealed that the pilot's vision was impaired by heavy perspiration. More detailed discussions after the mission indicated that the pilot's fatigue and the concern for his ability to complete additional high-effort tasks were the principal factors in the decision to terminate the EVA. The pilot reported that he had used high flow on the ELSS during the attachment of the GATV tether and that the cooling was adequate for comfort and comparable to ground simulations. He also reported that his face was wet with perspiration and that perspiration in his left eye had caused irritation, but that it had been tolerable. Although the EVA termination may not have been caused by vision impairment due to perspiration, the results of this EVA emphasize the limitations of a gaseous-flow cooling system. At high work levels, heavy perspiration ensues, and the gaseous flow does not evaporate all the moisture that is produced. Ground tests of the Gemini extravehicular system have indicated that satisfactory cooling and moisture control exist when the work levels and the metabolic rates are less than 2000 Btu/hr. The overheat condition encountered prior to hatch opening and the high energy expenditure in the early part of the EVA apparently exceeded the system capacity for moisture removal.

5.1.10.5.2 Thirty-foot umbilical: The 30-foot umbilical was satisfactory for the mission; however, the EVA having been terminated early, the full length of the umbilical was not used. Only about seven feet of the umbilical was deployed while the pilot was at the spacecraft nose. The umbilical used on this mission was similar to the one used for Gemini X except that it had been shortened to 30 feet to reduce the stowage bulk. The stowed umbilical did not impede the crew's movement at any time during the mission. No problems were encountered during donning, egress, or ingress, and the umbilical was jettisoned as planned.

5.1.10.5.3 Spacecraft provisions: The Hand Held Maneuvering Unit (HHMU) system was not used because of the early termination of EVA.

The pilot reported that all handrails deployed normally and that, looking aft along the adapter assembly, everything appeared to be normal.

The Apollo-sump-tank cameras, located in the adapter equipment section, were not retrieved because the pilot did not go to this area of the spacecraft.

The pilot had difficulty in installing the 16-mm camera during the EVA. A similar problem was encountered during the Gemini IX-A mission. Several design changes had been incorporated, and the camera installation for Spacecraft 11 was checked closely during preflight fit checks, with good results. The pilot reported that he had to position himself above the camera and hit it with his gloved fist to get it to engage the holder. He also reported that the camera would not rotate after installation in the mount. In order to reposition the camera, the pilot had to disengage it and then re-engage it. In order to eliminate vibration of the camera in its mount, an O-ring was used on the shaft of the camera mount. It was intended that the final movement of the mount into its receptacle would compress the O-ring, thus removing any play. The O-ring used on the shaft of the camera mount was determined to have been made of closed-cell material. It is believed that this O-ring expanded when subjected to the vacuum environment and increased the force required to compress it. This condition is being corrected for the Gemini XII mission by elimination of the O-ring.

5.1.10.5.4 GATV provisions: The pilot used the two handholds on the GATV Target Docking Adapter (TDA) to position himself while attaching the 100-foot spacecraft/GATV tether. This tether was stowed in a fiberglass container in the TDA docking cone for launch and, during umbilical EVA, was attached by the pilot to the spacecraft docking bar. The pilot expended a large amount of energy in attempting to position himself for this tether attachment. See paragraph 5.1.10.5.5 for a detailed discussion of workload and body restraint.

The pilot reported difficulty in attaching the docking bar clamp on the docking bar. The purpose of this clamp was to ensure that the tether would remain positioned at the lower end of the docking bar. During installation, the clamp rotated freely around the docking bar each time the pilot attempted to grasp the handle and tighten it. This rotation occurred several times and increased the difficulty of the task substantially over the effort required in ground simulations. When the clamp had been tightened sufficiently to engage the docking bar, it stayed in a fixed position. Thereafter, the pilot was readily able to tighten the clamp.

The pilot made one attempt to unstow the docking bar mirror, which was also located on the back of the docking cone. He was unable to remove the Velcro stowage cover on the first attempt, and, because of his fatigued condition, he elected not to expend any further effort on this task.

5.1.10.5.5 Body restraints: A short tether was used for body restraint during the standup EVA. The pilot reported that this tether stabilized his position and limited his movements so that there was no difficulty in mounting the Experiment S013 camera or performing similar tasks in the cockpit.

The loop strap on the right leg of the pilot's space suit enabled the command pilot to hold the pilot in the cockpit during the first tasks of the umbilical EVA. This restraint stabilized the pilot sufficiently to permit retrieval of the S009 Nuclear Emulsion experiment package without undue difficulty. The EVA camera mounting task was more difficult because of the O-ring problem described previously.

The lack of a handrail or handholds between the cockpit and the docking bar caused minor difficulty in EVA transit. The pilot missed the docking bar and the TDA on his first attempt to push across this 5-foot distance. After having been pulled back to the cockpit by the command pilot, he was successful in his second transit attempt.

The two handles on the TDA provided adequate restraint for the pilot's hands, but his attempts to use these handles to force his body into a sitting position on the spacecraft nose were unsuccessful. In these attempts he expended a very large amount of energy, principally in overcoming the suit mobility forces. The GATV/spacecraft tether attachment was ultimately completed as a one-handed task, in which the pilot held on with one hand and allowed his body to float freely.

The pilot reported that the restraint problems while attaching the GATV/spacecraft tether were substantially different from those experienced in zero-gravity aircraft simulations. In the aircraft simulations, he had been able to attain a sitting position on the spacecraft nose and attach the tether readily within 30 seconds. In orbit he was unable to keep himself positioned on the nose using only the handholds. His attempts to place his feet between the TDA and the spacecraft were ineffective in lowering his body onto the spacecraft nose. The principal differences between the simulation and the conditions in orbit were (1) the effects of the ELSS outflow in a vacuum, and (2) the 30-second duration of the zero-gravity period in the aircraft. Analysis of the equipment used in the aircraft simulation did not reveal any other differences which could explain the difficulty experienced in orbit.

In reviewing the problems of high energy expenditure and body restraint, the pilot reported that his difficulties became significant when he left the cockpit. In the vicinity of the cockpit, the numerous handholds around the hatch and the assistance from the command pilot provided a stable restraint condition. At the nose of the spacecraft, the pilot's body tended to float free in spite of his efforts to hold it in position. The pilot also reported that the lack of a stabilizing restraint, while at the nose of the spacecraft, drastically lowered his efficiency. A large amount of effort was expended in overcoming the space suit forces in order to produce small external forces.

The relationship between body restraint and workload for this EVA mission indicates that, when positive restraints are not available, it is possible to expend a high level of energy with little productive result. If tasks are to be attempted with one-handed or similar partial restraints, these tasks must be very simple, and particular attention must be given to avoiding work levels beyond those which can be sustained.

5.1.10.5.6 Equipment tethers and lanyards: The extensive use of tethers and lanyards proved successful, and no equipment was lost during EVA. The pilot made extensive use of the general-purpose lanyard that was attached to the ELSS restraint strap. The command pilot utilized a clothesline arrangement inside the cabin and tethered all items handed him by the pilot to this line.

5.1.10.5.7 Miscellaneous EVA equipment: The spacecraft was fitted with a special hatch closing device which was essentially a small block and tackle. The device was provided as an aid in hatch closure but was not used because the pilot encountered low hatch closing forces.

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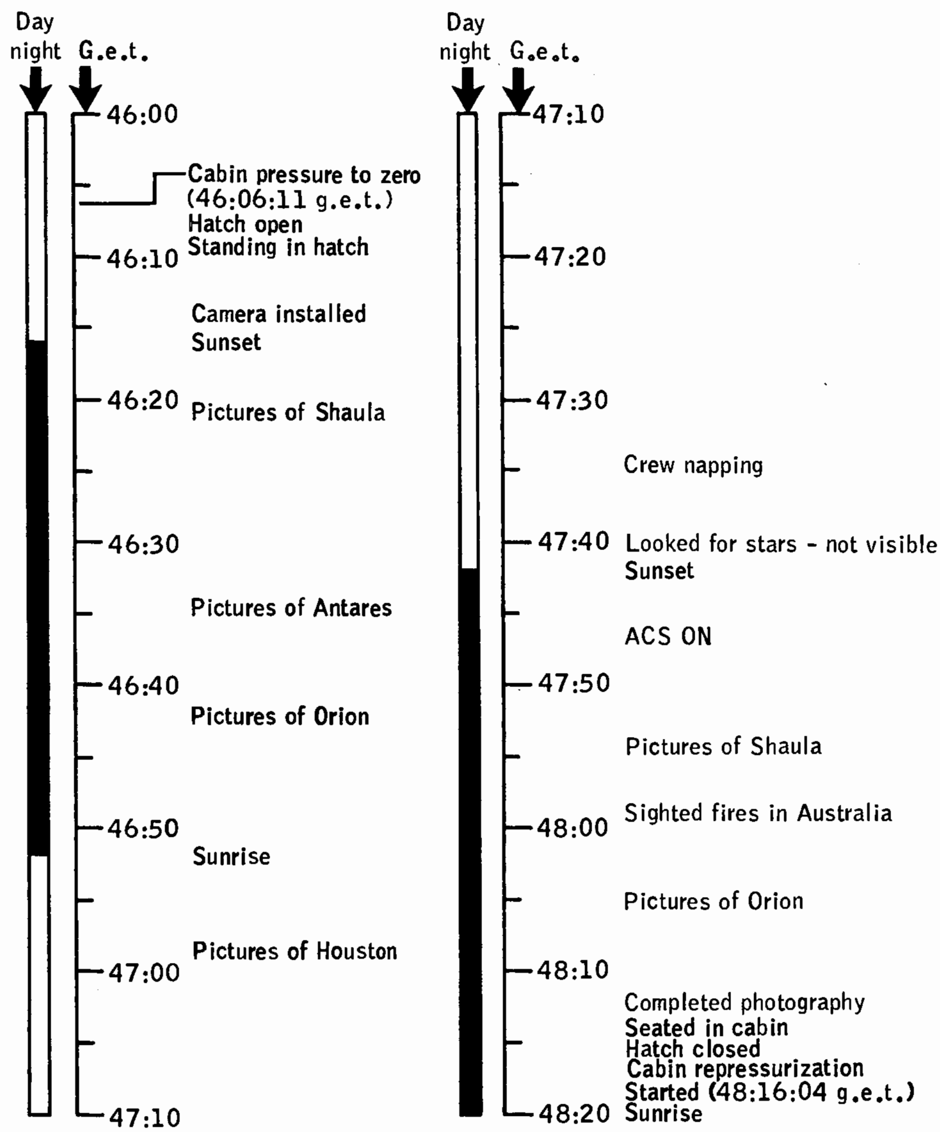

(b) Standup.

Figure 5.1.10-1. - Concluded.

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G.e.t.	
24:00	Seven minutes after sunrise
	Cabin pressure to zero (24:02:16 g.e.t.)
	Hatch open
	Standing in hatch
24:05	Handrail deployed
	S009 retrieved
	Egress
	EV camera mounted
24:10	Pilot at spacecraft nose
	Resting
	Attaching spacecraft/GATV tether
	Tether on
24:15	Tether secured
	Return to hatch
	Resting
24:20	Start film change
	Film change complete
	Resting while standing in hatch
24:25	
24:30	
	EVA camera demounted
	Ingress complete
24:35	Hatch closed
	Cabin repressuration started (24:36:10 g.e.t.)
24:40	Seven minutes before sunset

(a) Umbilical.

Figure 5.1.10-1. - EVA events.

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Figure 5.1.10-2. - Gemini XI extravehicular equipment.

5.1.11 Landing System

The parachute system provided a safe landing for the spacecraft and flight crew. All sequential events occurred when initiated by the crew and took place within established tolerances. Figure 5.1.11-1 illustrates the sequence of the major Landing System events with respect to ground elapsed time and pressure altitude.

During descent of the spacecraft on the main parachute, the Rendezvous and Recovery (R and R) section passed nearby. The crew estimated it cleared the spacecraft by less than 40 feet. Early in the program an investigation of the probability that the R and R section could recontact the main parachute indicated a 12.3 percent possibility (ref. 17). Because the precise motions of these two freely descending bodies and their effects on the recontact probability are impossible to describe mathematically, a simplified and conservative approach was taken in the analytical investigation and thus the relative high probability of recontact resulted. The study neglected such probability-reducing factors as wind gusts, parachute oscillations, parachute asymmetry which tends to produce glide, and flow field interactions between the main parachute and the drogue/pilot parachute combination.

Recontact between the R and R section and the spacecraft did not occur throughout the Landing System qualification program and ten Gemini spacecraft reentries. On several of these tests and flights, the recovery system operated under no-wind conditions which result in the highest probability of R and R section recontact. An extensive evaluation of the drop-test results indicated that the neglected factors substantially reduce the recontact probability and were probably more predominant than those which were considered. On several occasions, the R and R section approached the main canopy and then appeared to separate as a result of oscillation or flow field interaction between the two bodies. In several other tests, sufficient separation between the two bodies to preclude recontact was achieved with only a few degrees of relative glide. Therefore, it was concluded that, although a relatively large probability of recontact could be calculated, the actual probability established through test results and experience was negligible.

During the last thousand feet of descent prior to landing, a tuck or fold in the main parachute was visible in recovery films. It appeared to include three gores and to extend from the skirt half-way to the apex. This condition is caused by excess fullness of the lower rings and, although undesirable, has no detrimental effects on the performance of the parachute. Tucks of this nature were evident during the qualification program and were proven to have a negligible effect on the parachute performance.

The main parachute was recovered, but the R and R section with attached drogue and pilot parachutes sank and could not be recovered. Preliminary examination of the main parachute indicated that it was in excellent condition.

NASA-S-66-9021 OCT 7

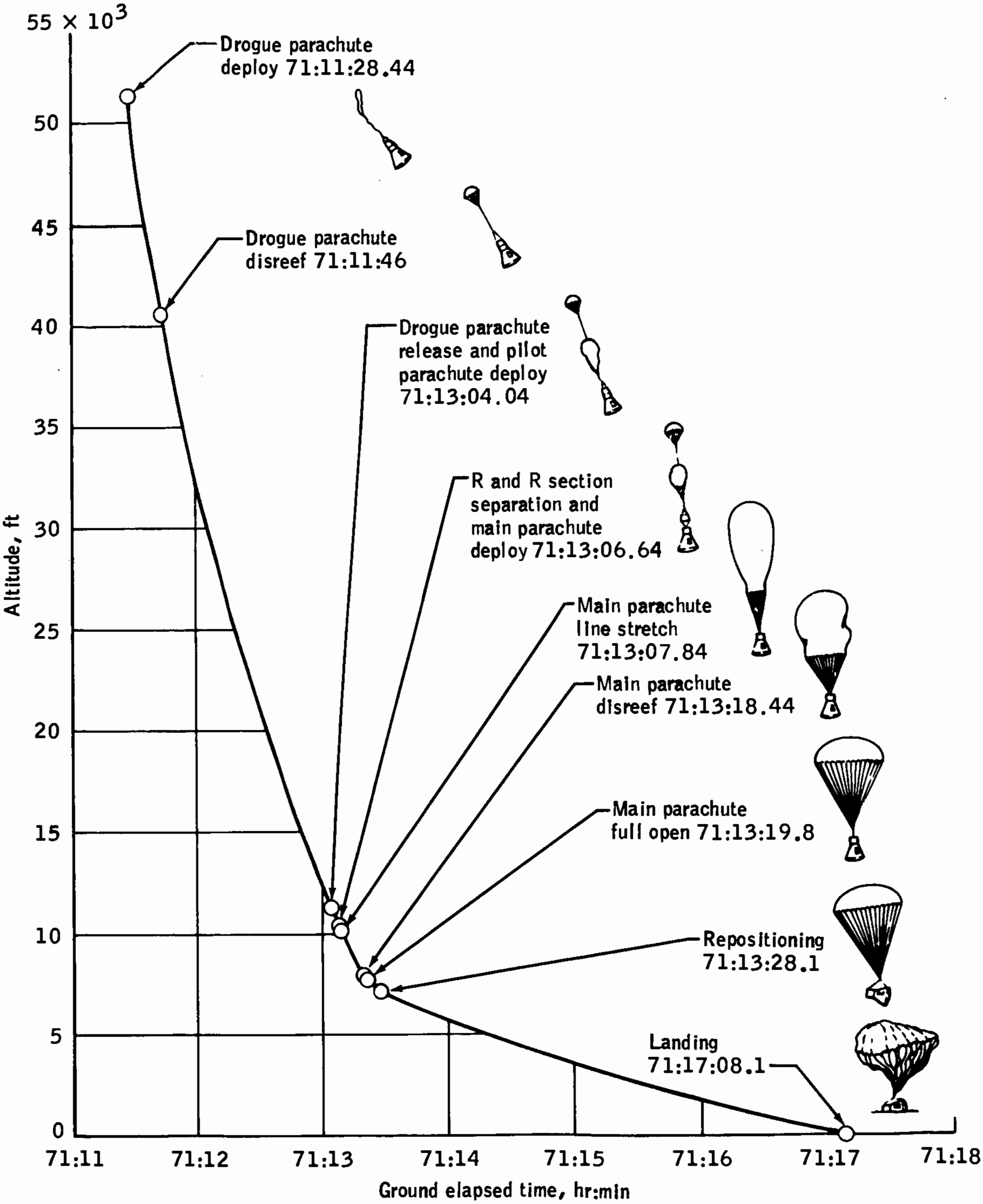

Figure 5.1.11-1. - Landing system performance.

5.1.12 Postlanding

All of the postlanding and recovery aids functioned properly. The UHF descent and recovery antennas automatically extended when the spacecraft was repositioned from the single-point suspension to the two-point landing attitude. The recovery hoist loop and the flashing recovery light were deployed when the main parachute was jettisoned by the crew, and the sea dye marker was automatically dispensed at spacecraft landing. Because of landing near the recovery ship, the crew did not turn on the recovery light or attempt to extend the HF antenna. All of these functions were verified by recovery/crew communications, photographs, and recorded data. The operational effectiveness of the recovery aids is discussed in sections 5.1.2 and 6.3.

5.2 GEMINI LAUNCH VEHICLE PERFORMANCE

The Gemini Launch Vehicle (GLV) was launched within one-half second of the planned launch time after a countdown that involved no unplanned holds. All systems performed satisfactorily and the spacecraft was inserted into a nominal orbit.

A review of the mission data identified only one item which required further investigation: the Stage I oxidizer outage was 1319 pounds, which was less than for GLV-10 but higher than that experienced on earlier Gemini flights.

Calculations performed during the countdown indicated that the nominal payload capability would be 8842 pounds and the minimum payload capability (minus three sigma) would be 8174 pounds, providing a negative payload margin of 200 pounds relative to the 3-sigma minimum. Postflight reconstructed burning-time margin was plus 1.44 seconds, indicating that the achieved vehicle performance was 8889 pounds, or 47 pounds more than the predicted nominal payload capability and 515 pounds more than the actual payload weight.

5.2.1 Airframe

The Gemini XI launch vehicle experienced flight loads and vibration environments which were normal by comparison with previous flights and were well within the structural capability.

5.2.1.1 Structural loads.- During the prelaunch phase, ground winds of approximately three miles per hour caused a maximum bending moment on the launch vehicle equal to four percent of the design-limit wind-induced bending moment.

Estimated loads on the launch vehicle during the launch phase are shown in the following table. These data indicate that the highest percentage of design loading occurred, characteristically, at vehicle station 320 just prior to first stage engine cutoff (BECO).

Maximum qα				Pre-BECO		
Station	Compression load, lb	Percent of design		Compression load, lb	Percent of design	
		Limit	Ultimate		Limit	Ultimate
276	24 390	29.0	23.2	55 610	66.2	53.0
320	129 370	42.2	33.7	275 710	89.8	71.9
935	417 600	69.7	56.7	439 910	73.3	58.6

5.2.1.2 Longitudinal oscillation (POGO).- Accelerometer data indicate the same intermittent characteristic of the suppressed longitudinal oscillation that has been experienced on previous flights. Maximum response at the spacecraft/launch vehicle interface occurred at lift-off + 117 seconds, and the amplitude, from filtered data, was ±0.12g. The corresponding frequency was 10.3 cps.

5.2.1.3 Post-SECO disturbance.- Three indications of disturbances after second stage engine cutoff (SECO) were noted from both the high-range and low-range axial accelerometer data and are shown in the following table.

Time after SECO, sec	Double amplitude, g
3.01	3.39
4.11	1.95
7.07	0.02

The crew reported sensing the first two of these disturbances as distinct, sharp "bangs," similar to those reported by the Gemini X crew.

5.2.2 Propulsion

5.2.2.1 Engines.-

5.2.2.1.1 Stage I: The Stage I engine performance throughout the flight was nominal (table 5.2-I). The engine mixture ratio at Stage I engine ignition signal (87FS1) plus 55 seconds, corrected to standard inlet conditions, was minus 1.21 percent from the acceptance test value, and was less than the 3-sigma run-to-run repeatability of ±1.38 percent attained during engine static-firing tests conducted at the engine manufacturer's facility. This lower-than-predicted mixture ratio resulted in a fuel depletion shutdown. The cause of the mixture ratio shift has not been determined at present, but further investigations are being conducted by the contractors.

The appearance of the start-transient data was normal, although the true magnitude of the chamber pressure spike was obscured by the overdamped type of transducers used on GLV-11.

The steady state thrust and specific impulse were close to the predicted values. The shutdown-transient data were normal for a fuel exhaustion shutdown.

5.2.2.1.2 Stage II: The Stage II engine performance closely agreed with the predicted values (table 5.2-II). The engine mixture ratio, corrected to standard inlet conditions, was minus 0.98 percent from the acceptance-test value, but was within the 3-sigma repeatability limits of ±2.28 percent. The start transient was within the range experienced on other GLV's, as well as Titan II missiles, and is considered to have been normal. The steady-state thrust and the specific impulse were both very close to the predicted values.

The Stage II engine shutdown was initiated by guidance command. The shutdown impulse was slightly less than that of GLV-10, as shown in the following table:

Flight	Predicted, lb-sec	Actual, lb-sec
GLV-10	36 100 ±7000	35 081
GLV-11	36 100 ±7000	34 552

Minor post-SECO disturbances were seen at approximately three, four, and seven seconds after SECO. The first two disturbances were similar to those observed on GLV-10 when chamber pressure indicated activity during both perturbations. The disturbance at seven seconds after SECO is unexplained at the time of this writing.

5.2.2.2 Propellants.-

5.2.2.2.1 Loading: GLV-11 was loaded for two launch attempts and for the actual launch. All of these loadings were within the required ±0.35 percent of the requested amounts. The propellant loading summary for the launch on September 12, 1966, is shown in the following table. The actual flight loads were calculated from the GLV-11 engine performance and propellant level sensor data.

Tank	Requested, lb	Actual, lb	Difference, percent
Stage I oxidizer	172 422	172 565	+0.08
Stage I fuel	90 129	89 994	-0.15
Stage II oxidizer	39 064	39 141	+0.20
Stage II fuel	22 122	22 181	+0.28

5.2.2.2.2 Utilization: A Stage I oxidizer outage is the amount of usable oxidizer remaining after a fuel depletion shutdown. A Stage II fuel outage is the amount of usable fuel which would have remained if all of the usable oxidizer had been consumed before command shutdown. The predicted and actual outages for GLV-11 are shown in the following table:

Stage	Type	Predicted mean, lb	Predicted maximum, lb	Actual, lb
I	Oxidizer	886	2590	1319
II	Fuel	209	622	50

The amount of propellants remaining when the Stage II engine was commanded to shut down could have sustained Stage II flight an additional 1.44 seconds. This is 0.14 of a second greater than the nominal burning-time margin of 1.30 seconds, predicted at Stage I engine ignition.

5.2.2.3 <u>Pressurization</u>.- The predicted and actual GLV-11 tank pressures for various flight times are given in tables 5.2-III and 5.2-IV. The close agreement between predicted and actual pressures indicates nominal performance of the GLV pressurization system.

5.2.3 Flight Control System

The primary Flight Control System operated satisfactorily during Stage I and Stage II flight. No flight control hardware anomalies were encountered throughout the flight. The primary Flight Control System, in conjunction with the MOD III Radio Guidance System, achieved the desired conditions at SECO for a rendezvous during the first orbit. The secondary Flight Control System performed satisfactorily throughout the flight, and switchover could have been successfully accomplished at any time during the powered phase.

5.2.3.1 <u>Stage I flight</u>.- Normal actuator disturbances occurred during the ignition transient. Peak actuator travel values recorded during the ignition and holddown period are listed in table 5.2-V.

The combination of thrust-vector and engine misalignments at full thrust initiated a roll transient at lift-off. The corrective response of the Flight Control System resulted in a maximum roll rate of 0.6 deg/sec clockwise at lift-off + 0.9 of a second. At lift-off, a roll attitude error bias of 0.10 of a degree clockwise was introduced by an equivalent engine misalignment of minus 0.02 of a degree.

The Three Axis Reference System (TARS) roll and pitch programs were performed as planned. The planned and actual rates and times are listed in table 5.2-VI. The discretes initiated by the TARS were executed within the specified time limits.

The primary (TARS) and secondary (Inertial Guidance System (IGS)) attitude error signals correlated well throughout Stage I flight. These attitude errors indicate the response of the control system to the first-stage guidance programs and to the vehicle disturbances caused by the prevailing winds aloft. The maximum vehicle rates and attitude errors which occurred during Stage I flight are presented in table 5.2-VII. The dispersions between the primary and secondary attitude error signals were the combined result of drift in the TARS and/or the IGS Inertial

Measurement Unit, errors in the open-loop roll and pitch programs, and reference-axis cross coupling within each system.

5.2.3.2 Staging sequence.- Telemetry data received during the staging sequence indicated normal staging rates and attitudes. The maximum rates and attitudes during staging are given in table 5.2-VIII.

5.2.3.3 Stage II flight.- Primary Flight Control System (TARS) pitch and yaw responses to radio guidance commands were satisfactory. The pitch and yaw steering commands, transmitted to the launch vehicle during Stage II flight, are discussed in section 5.2.5. The Stage II attitude biases resulted from thrust-vector misalignment, center-of-gravity offset from the longitudinal axis, and roll-thrust offset from the longitudinal axis. The primary (TARS) and secondary (IGS) attitude error signals were as shown in figure 5.1.5-1.

5.2.3.4 Post-SECO and separation phase.- Vehicle attitude rates between SECO and spacecraft separation were normal. The maximum rates experienced during this period are listed in table 5.2-IX.

5.2.4 Hydraulic System

The vehicle hydraulic systems performed satisfactorily during Stage I and Stage II operation. No anomalous pressures were noted during ignition transients or steady-state flight. Selected hydraulic system pressures are shown in the following table.

Event	Hydraulic pressure, psia		
	Stage I system		Stage II system
	Primary	Secondary	
Starting transient (minimum)	2734	--	--
Starting transient (maximum)	3187	3451	4039
Steady state	3042	3140	2989
BECO	2770	2819	--
SECO	--	--	2807

5.2.5 Guidance System

Performance of the Stage I and Stage II guidance system was satisfactory throughout powered flight and resulted in the spacecraft attaining acceptable insertion conditions.

5.2.5.1 Programmed guidance.- Programmed guidance, as shown by actual and nominal data in section 5.2.3 (table 5.2-VI), is considered to have been within acceptable limits. The trajectory was nominal and the errors at BECO, compared with the no-wind prelaunch nominal trajectory, were 131 ft/sec low in velocity, 184 feet low in altitude, and 0.09 of a degree high in flight-path angle.

5.2.5.2 Radio guidance.- The Radio Guidance System (RGS) acquired the pulse beacon of the vehicle, tracked in the monopulse automatic mode, and was locked on continuously from lift-off to 34 seconds after SECO. There was a 1.8-second period of intermittent lock before final loss-of-signal at 36 seconds after SECO. Track was maintained to an elevation angle of 3.4 degrees above the horizon. The average strength of the signal received at the central station during Stage II operation was satisfactory. Rate lock was continuous from LO + 28.9 seconds to LO + 370.3 seconds (30.0 seconds after SECO).

Commencing at LO + 168.35 seconds, pitch steering commands were initiated, as planned, by the airborne decoder. At that time, an initial 7-percent pitch-down steering command (0.14 deg/sec) was given for 4.0 seconds, followed by the characteristic 100-percent pitch-down steering command (2.0 deg/sec) for 3.0 seconds. The steering gradually decreased during the following 11.0 seconds to continuous pitch-down commands of less than 0.2 deg/sec until LO + 265 seconds. At this time, because of noisy tracking data, the rates became oscillatory. This particular phenomenon is a normal characteristic of tracking data when the ground guidance system is being influenced by atmospheric effects. Past experience has shown that the high frequency noise increases as the tracking elevation angle decreases. As a result, the peak amplitude of steering commands ranged from minus 0.02 deg/sec to minus 0.20 deg/sec until termination of guidance (SECO minus 2.5 seconds).

Yaw steering was initiated at LO + 168.35 seconds with the first command being sent, as expected, at LO + 172.25 seconds. As a result, yaw-left commands of 100 percent (2.0 deg/sec) were sent for 1.0 second. The steering had gradually returned within 11 seconds to yaw-right commands of less than 0.02 deg/sec, and remained within that magnitude until termination of guidance. At SECO + 20 seconds, the yaw velocity was 7.5 ft/sec and the yaw position was minus 1860 feet, as compared with the planned values of 0.8 ft/sec and minus 3947 feet (prelaunch guidance residuals due to insertion targeting accuracies).

SECO occurred at LO + 340.298 seconds at an elevation angle of 6.6 degrees above the horizon. The conditions at SECO + 20 seconds were within 3-sigma limits. Table 4.3-I shows a comparison of the actual values with the planned values. The errors at SECO + 20 seconds may be attributed primarily to the lower-than-expected shutdown thrust transient. Analysis indicates that the low shutdown transient contributed 5.7 ft/sec to the estimated total of 8.0 ft/sec underspeed at SECO + 20 seconds.

The yaw position error (smallest of any GLV launch to date) and velocity error at SECO + 20 seconds required the spacecraft to make only a 3.0 ft/sec out-of-plane maneuver in the first revolution. Vehicle attitude rates at SECO plus 20 seconds were 0.55 deg/sec pitch up, 0.52 deg/sec yaw right, and 0.42 deg/sec roll clockwise.

The ground-based A-1 guidance computer, in conjunction with the MOD III Tracking and Missile-Borne Guidance System, performed satisfactorily during prelaunch and flight. No anomalies were encountered with the airborne pulse, rate, and decoder hardware. All guidance discretes were properly generated and executed as required.

The target ephemeris data were satisfactorily transmitted and verified at approximately T minus 25 minutes between the Real Time Computer Complex at Houston and the Guided Missile Computer Facility at Cape Kennedy. After lift-off, the Inertial Guidance System updates were correctly sent by the ground-based computer and are listed in the following table.

Time from lift-off, sec		Cross-range velocity, ft/sec
Update reference	Update transmission	
100.00	105	+24.38
140.00	145	-209.47

5.2.6 Electrical

Throughout the countdown and launch, the Instrumentation Power Supply provided power at a nominal 29.7 volts and the Auxiliary Power Supply performed nominally at 30.0 volts.

5.2.7 Instrumentation

5.2.7.1 Ground.- For the launch, September 12, 1966, as well as for the launch attempts on September 9 and 10, 1966, there were 155 recorder channels utilized on the Launch Complex 19 landline system. The system was used during propellant conditioning and loading, as well as for the launch sequence. Data acquisition was 100 percent with no anomalies. The umbilical connectors separated from the vehicle in the planned sequence, and the separation sequence was complete in 0.83 of a second.

5.2.7.2 Airborne.- The airborne instrumentation system was identical to that used for GLV-9 and GLV-10. The system consisted of 188 measurements programmed for use, and there were no major anomalies. Approximately 0.5 of a second after lift-off, a momentary loss (dropout) of the telemetry signal was experienced at the ETR Telemetry Station II. Investigation indicates that the cause may have been RF signal attenuation by the exhaust flame. Receivers at Launch Complex 19 and at the ETR Telemetry Station III were not affected.

Numerous telemetry channels reflected a small oscillatory transient during the time between ignition and lift-off. This condition is considered to have been caused by the launch-pad grounding system since the transient disappeared after lift-off. The normal telemetry data loss during staging RF blackout lasted 430 milliseconds. The final loss of telemetry signal as monitored at the ETR Telemetry Station II occurred at lift-off + 433 seconds (72 seconds after spacecraft separation).

5.2.8 Malfunction Detection System

Performance of the Malfunction Detection System (MDS) during preflight checkout and flight was satisfactory. Flight data indicated that all MDS components functioned properly. MDS parameters are shown in table 5.2-X.

5.2.8.1 Engine MDS.- Actuation of the Stage I malfunction-detection thrust-chamber pressure switches (MDTCPS) and the Stage II malfunction-detection fuel-injector pressure switch (MDFJPS) were as follows:

Switch	Condition	Actuation time from lift-off, sec	Pressure, psia
Stage I			
Subassembly 1 MDTCPS	Make	-2.298	565
	Break	+153.240	550
Subassembly 2 MDTCPS	Make	-2.308	575
	Break	+153.243	560
Stage II			
Subassembly 3 MDFJPS	Make	+153.977	(a)
	Break	+340.445	(a)

[a]MDFJPS is not actuated by thrust chamber pressure but is actuated by fuel injector pressure which is a function of thrust chamber pressure.

5.2.8.2 Airframe MDS.- The MDS rate-switch package performed properly throughout the flight. No vehicle overrates occurred between the times of lift-off and spacecraft separation.

5.2.8.3 Tank pressure indications.- All tank pressure indicators performed satisfactorily throughout the flight. All paired sensors agreed within specification limits throughout the flight.

5.2.9 Range Safety and Ordnance Systems

The performance of all range-safety and ordnance items was satisfactory.

5.2.9.1 Flight termination system.- Both GLV command receivers received adequate signal for proper operation throughout powered flight and beyond spacecraft separation. The following command facilities were used during the periods of time indicated:

Time from lift-off, sec	Facility
0 to 67	Cape Kennedy - 600-watt transmitter and single helix antenna
67 to 119	Cape Kennedy - 10-kilowatt transmitter and quad-helix antenna
119 to 260	Grand Bahama - 10-kilowatt transmitter and steerable antenna
260 to 432	Grand Turk - 10-kilowatt transmitter and steerable antenna
432 to 725	Antigua - 10-kilowatt transmitter and steerable antenna

5.2.9.2 Range safety tracking system.- Missile Trajectory Measurement (MISTRAM) System I was used as the primary source for impact prediction, and the data provided accurate information through insertion.

5.2.9.3 Ordnance.- The performance of all ordnance items was satisfactory.

5.2.10 Prelaunch Operations

5.2.10.1 Launch attempts.- The propellant loading for the launch attempt September 9, 1966, was initiated at 8:51 p.m. e.s.t., September 8, 1966, and was completed at 12:29 a.m. e.s.t., September 9, 1966. At 1:30 a.m. e.s.t., a pin hole leak was detected in a spot-weld on electrical conduit no. 1 hinge support, approximately three feet below the Stage I oxidizer tank tangency point. The decision to repair the leak postponed the scheduled launch until September 10, 1966, and all propellants were unloaded from the GLV. The recycle included the repair of the tank by injecting sodium silicate (water glass) into the hole and applying a 1/2-inch-square aluminum patch, using an epoxy cement as the bonding agent.

Propellant loading was started at 9:41 p.m. e.s.t., September 9, 1966, for the rescheduled launch on September 10, 1966. This launch attempt was subsequently cancelled because of a suspected Target Launch Vehicle problem (see section 5.5). The launch was then rescheduled for September 12, 1966.

5.2.10.2 Recycle.- The 48-hour recycle operation was started immediately. Because the power-on time of the launch vehicle, projected to launch, would exceed the specification limit, power was removed from the GLV at 9:55 a.m. e.s.t., September 10, 1966, and the propellants were again unloaded from the vehicle.

5.2.10.3 Final countdown.- Propellant loading was initiated at 8:54 p.m. e.s.t., September 11, 1966, and completed 2 hours 58 minutes later. The range sequencer was started at 12:34 a.m. e.s.t. (T minus 530 minutes) on September 12, 1966. No GLV problems were encountered throughout the final countdown. The scheduled 6-minute hold at T minus three minutes was terminated after 2 minutes 21 seconds. Lift-off was accomplished at 9:42 a.m. e.s.t., without incident.

Pad damage was minimal. The launch vehicle for Gemini XII was erected at Launch Complex 19 on September 16, 1966.

TABLE 5.2-I.- STAGE I ENGINE PERFORMANCE

Parameter	Preflight prediction	Postflight reconstruction	Difference, percent
Standar' inlet condition performance			
Thrust, lb	436 872	437 596	+0.17
Specific impulse, lb-sec/lb	260.64	261.02	+0.15
Engine mixture ratio, oxidizer to fuel	1.9447	1.9212	-1.21
Oxidizer overboard flowrate, lb/sec	1106.59	1102.16	-0.46
Fuel overboard flowrate, lb/sec . . .	569.57	574.32	+0.83
Flight average performance			
Thrust, lb	463 907	463 345	-0.12
Specific impulse, lb-sec/lb	277.36	277.69	+0.12
Engine mixture ratio, oxidizer to fuel	1.9309	1.9021	-1.49
Oxidizer overboard flowrate, lb/sec	1101.54	1093.25	-0.75
Fuel overboard flowrate, lb/sec . . .	571.01	575.30	+0.75

TABLE 5.2-II.- STAGE II ENGINE PERFORMANCE

Parameter	Preflight Prediction	Postflight Reconstruction	Difference, percent
Standard inlet condition performance			
Thrust, lb	100 981	101 256	+0.27
Specific impulse, lb-sec/lb	310.61	310.74	+0.04
Engine mixture ratio, oxidizer to fuel	1.8132	1.7955	-0.98
Oxidizer overboard flowrate, lb/sec	209.70	209.40	-0.23
Fuel overboard flowrate, lb/sec	115.41	116.45	+0.90
Flight average performance			
Thrust, lb	100 715	101 266	+0.55
Specific impulse, lb-sec/lb	311.36	311.32	-0.01
Engine mixture ratio, oxidizer to fuel	1.7769	1.7683	-0.48
Oxidizer overboard flowrate, lb/sec	207.14	207.94	+0.39
Fuel overboard flowrate, lb/sec	116.32	117.35	+0.89

TABLE 5.2-III.- STAGE I ULLAGE GAS PRESSURES

Tank	Lift-off		Lift-off + 47 sec		Lift-off + 97 sec		Lift-off + 147 sec	
	Predicted, psia	Actual, psia	Predicted, psia	Actual, psia	Predicted, psia	Actual, psia	Predicted, psia	Actual, psia
Oxidizer	32.5	33.2	20.0	19.5	19.1	18.9	20.6	19.7
Fuel	29.5	29.2	23.4	24.0	22.9	23.4	24.0	24.4

TABLE 5.2-IV.- STAGE II ULLAGE GAS PRESSURES

Tank	Lift-off + 153 sec[a]		Lift-off + 203 sec		Lift-off + 253 sec		Lift-off + 333 sec	
	Predicted, psia	Actual, psia	Predicted, psia	Actual, psia	Predicted, psia	Actual, psia	Predicted, psia	Actual, psia
Oxidizer	55.5	54.7	21.0	20.8	13.1	13.0	8.4	8.9
Fuel	50.5	50.4	50.0	48.2	47.9	48.2	47.7	49.5

[a]Staging.

TABLE 5.2-V.- TRANSIENTS DURING STAGE I HOLDDOWN PERIOD

Actuator	Maximum travel during ignition		Maximum travel during holddown null check, in.
	Travel, in.	Time from lift-off, sec	
Pitch 1_1	-0.04	-2.45	+0.03
Yaw-Roll, 2_1	+0.08	-2.43	+0.02
Yaw-Roll, 3_1	+0.08	-2.42	+0.00
Pitch, 4_1	-0.10	-2.43	+0.02

TABLE 5.2-VI.- ROLL AND PITCH PROGRAMS

Program	Program times		Torquer monitor, deg/sec	Nominal rate, deg/sec
	Actual, sec	Nominal, sec		
Roll				
Start	8.46	8.48	-1.25	-1.25
Stop	20.43	20.48		
Pitch, Step 1				
Start	22.99	23.04	-0.69	-0.71
Pitch, Step 2				
Start	88.13	88.32	-0.50	-0.52
Pitch, Step 3				
Start	118.77	119.04	-0.25	-0.24
Stop	162.20	162.56		

TABLE 5.2-VII.- MAXIMUM STAGE I RATES AND ATTITUDE ERRORS

Axis	Maximum rate, deg/sec	Time from lift-off, sec	Maximum attitude error, deg	Time from lift-off, sec
Pitch	+0.19 -1.00	0.2 25.1, 66.6, 74.4, and 86.0	+1.20 -0.47	108.0 119.9
Yaw	+0.49 -0.68	81.9 88.5	+1.15 -1.05	87.5 67.8
Roll	+0.57 -1.47	0.8 9.1	+0.84 -0.10	153.2 0.4

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TABLE 5.2-VIII.- MAXIMUM STAGING RATES AND ATTITUDE ERRORS

Axis	Maximum rate, deg/sec	Time from BECO[a], sec	Maximum vehicle attitude change, deg	Time from BECO, sec
Pitch	+2.24 -1.97	0.73 0.70	-0.32	1.4
Yaw	+1.64 -0.87	0.74 0.54	+1.84	2.5
Roll	+2.23 -4.11	1.40 0.30	-1.89	1.2

[a]BECO occurred 153.30 seconds after lift-off.

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TABLE 5.2-IX.- VEHICLE RATES BETWEEN SECO AND SPACECRAFT SEPARATION

Condition	Rate, deg/sec
Pitch:	
Maximum positive rate at SECO + 2.34 sec	+1.61
Maximum negative rate at SECO + 0.11 sec	-0.25
Rate at SECO + 20 sec	+0.55
Rate at spacecraft separation (SECO + 20.66 sec)	+0.55
Yaw:	
Maximum positive rate at SECO + 15.30 sec	+0.52
Maximum negative rate at SECO + 2.58 sec	-1.60
Rate at SECO + 20 sec	+0.52
Rate at spacecraft separation (SECO + 20.66 sec)	+0.52
Roll:	
Maximum positive rate at SECO + 1.58 sec	+0.62
Maximum negative rate at SECO + 8.81 sec	-0.35
Rate at SECO + 20 sec	+0.42
Rate at spacecraft separation (SECO + 20.66 sec)	+0.42

TABLE 5.2-X.- MALFUNCTION DETECTION SYSTEM SWITCHOVER PARAMETERS

Parameter	Switchover setting	Maximum or positive (a)	Time from lift-off, sec	Minimum or negative (b)	Time from lift-off, sec
Stage I primary hydraulics	Shuttle spring	3200 psi	-2.1	2730	-2.3
Stage I tandem actuators					
No. 1 subassembly 2 pitch	±4.0 deg	0.50 deg	41.0	0.50 deg	66.0
No. 2 subassembly 2 yaw/roll	±4.0 deg	0.65 deg	87.7	0.90 deg	67.5
No. 3 subassembly 1 yaw/roll	±4.0 deg	0.30 deg	67.5	0.30 deg	67.5
No. 4 subassembly 1 pitch	±4.0 deg	0.35 deg	88.0	1.15 deg	41.5
Stage I pitch rate	+2.5 deg/sec -3.0 deg/sec	0.12 deg/sec	1.0	0.95 deg/sec	21.5
Stage I yaw rate	±2.5 deg/sec	0.43 deg/sec	82.5	0.58 deg/sec	88.8
Stage I roll rate	±20 deg/sec	0.55 deg/sec	0.9	2.50 deg/sec	153.7
Stage II pitch rate	±10 deg/sec	0.25 deg/sec	156.0	1.95 deg/sec	175.5
Stage II yaw rate	±10 deg/sec	1.60 deg/sec	155.0	1.95 deg/sec	174.5
Stage II roll rate	±20 deg/sec	2.00 deg/sec	154.8	0.25 deg/sec	156.2

[a] Positive indicates pitch up, yaw right, and roll clockwise.

[b] Negative indicates pitch down, yaw left, and roll counterclockwise.

5.3 SPACECRAFT/GEMINI LAUNCH VEHICLE INTERFACE PERFORMANCE

The requirements of the Spacecraft/Gemini Launch Vehicle interface, as defined in reference 18, were met within established specification limits.

The electrical circuitry performed as anticipated. Shorting was present during the spacecraft/launch vehicle separation event; however, no problems were experienced on either the spacecraft or the GLV. The separation event as described by the flight crew was as anticipated and was normal in all respects.

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Gemini Agena Target Vehicle, showing gravity-gradient-stabilized tether.

5.4 GEMINI AGENA TARGET VEHICLE

All Gemini Agena Target Vehicle (GATV) systems performed satisfactorily during the launch phase, and the GATV attained an orbit of 163.1 by 153.5 nautical miles at insertion.

In preparation for the first rendezvous, the GATV was gyrocompassed to a minus 90-degree attitude (engine south) using real-time commands from the Carnarvon tracking station. All four spacecraft dockings scheduled in the flight plan were accomplished, with the first one occurring at 1:34:16 g.e.t.

Flight crew comments, which were later verified by data, indicated that the L-band radar transponder transmitter was intermittent prior to the first docking and then failed completely. This unit is located in the Target Docking Adapter (TDA), and the anomaly is discussed in detail in section 5.1.5.

The transponder anomaly apparently also prevented the message acceptance pulses (MAP's) from being transmitted to the spacecraft; however, the GATV received and responded to the commands, and properly generated MAP's. (See sections 5.1.5 and 5.7.)

At 4:37:32 GATV elapsed time (3:00:07 g.e.t.), the GATV main vehicle clock skipped 16 384 seconds. During this same period, telemetry synchronization was lost twice over a period of approximately five seconds, and an apparent MAP was generated without a valid command having been sent; however, no change was noted in the vehicle status. The S026 Ion-Wake experiment was being conducted during the period in which the clock jumped. No further clock malfunctions occurred prior to landing of the Gemini spacecraft.

The GATV primary propulsion system (PPS) was fired to achieve insertion, and was also fired three times while docked with the spacecraft.

Purpose	Thrust duration, sec	ΔV, ft/sec
Insertion	185.15	8248.54
Calibration (out of plane)	3.03	110.69
High-apogee orbit	25.07	919.60
Recircularizing	22.47	919.47

The PPS firings were preceded by secondary propulsion system (SPS) Unit I firings for ullage orientation; a 20-second SPS firing was used for the insertion maneuver and 70-second SPS firings were used for the docked maneuvers.

During the umbilical extravehicular activity (EVA), the GATV attitude control system provided inertial stabilization for the docked vehicles. During the standup EVA, the GATV was used to provide stability for the star photography experiments.

After spacecraft undocking and completion of the tether evaluation, some deterioration in the GATV horizon sensor operation was noted; however, an analysis of the data indicates that sporadic operation also occurred much earlier.

Three SPS Unit II firings were made after spacecraft reentry.

Purpose	Thrust duration, sec	ΔV, ft/sec
Height adjust	15.96	47.52
Circularization	20.81	63.18
Overspecification test	68.98	215.95

After the second SPS firing, a further deterioration of the horizon sensor performance caused cancellation of the final planned PPS firing because of the inability to stabilize the vehicle within the specified attitude limits prior to firing. The attitude control gas was depleted in making minor adjustments in an attempt to analyze the problem.

The final vehicle orbit was 189.6 by 179.2 nautical miles, referenced to the Fischer ellipsoid earth model of 1960. The electrical power was depleted after approximately 180 hours of operation.

5.4.1 Airframe

Structural integrity of the GATV was satisfactorily maintained throughout the launch and orbital phases of flight.

5.4.1.1 Launch phase.- Temperature measurements on the shroud indicated that a maximum temperature of 244° F was reached at about lift-off (LO) + 160 seconds. The maximum temperature measured on the TDA was 138° F at LO + 100 seconds. The horizon sensor fairing temperature reached a maximum of 478° F at LO + 137 seconds. These maximum temperatures were slightly lower than those measured during the Gemini X mission (GATV 5005) and were reached slightly earlier in the flight. Based on data from the Target Launch Vehicle (TLV) telemetry system, the acceleration at TLV booster engine cutoff (BECO) was 6.25g, and the acceleration at TLV sustainer engine cutoff (SECO) was 2.95g.

5.4.1.2 Separation.- The GATV separated from the TLV with an average relative velocity of 41.9 in./sec, calculated using data from the separation monitor. This value compares closely with the data obtained from earlier flights and with the calculated nominal value.

5.4.1.3 Ascent maneuver.- During the ascent maneuver, there were no abnormal vibrations or accelerations indicated. This period included main engine ignition, horizon sensor cover jettison, and shroud separation. All measured temperatures were close to predicted values and also to those measured on previous flights. The aft-section temperatures started increasing at separation (LO + 300 seconds) and the peak temperatures measured on the aft bulkhead were as high as 268° F. As noted on previous flights, these peaks occurred at about PPS cutoff (LO + 559 seconds) and then decreased to normal orbital temperatures.

5.4.1.4 Docking phase.- The first physical contact of the spacecraft with the GATV occurred when docking was initiated at 1:34:06 ground elapsed time (g.e.t.) during the first revolution of the spacecraft (M=1). The accelerometers indicated that docking was quite smooth, with a lateral disturbance of less than 0.8g peak-to-peak at docking. Sequence pictures taken through the right-hand window of the spacecraft indicated only a slight misalignment between the two vehicles.

Three additional dockings were performed to allow both the pilot and the command pilot each to perform two dockings during the mission. The additional dockings occurred at about 3 hours 20 minutes, 4 hours, and 6 hours 45 minutes g.e.t. The data for all four dockings show essentially normal performance.

5.4.1.5 Orbital phase.- The spacecraft was docked to the GATV for a total of about 46 hours 39 minutes. During the three docked PPS maneuvers, and during the miscellaneous attitude maneuvers, the vibration and noise transmitted to the crew compartment were not considered problems by the crew. During the PPS firing for the high-apogee orbit, accelerations of 1.1g were measured by the spacecraft accelerometers.

Temperatures varied within predicted limits and were comparable to those experienced on previous Gemini flights. Temperature sensors on the TDA indicated a temperature range of 10° F to 100° F. The highest variation (about 80° F) was measured on the top of the TDA. Shear-panel temperatures showed similar variations. While the vehicle was in the 741.5 by 156.3-nautical-mile orbit, the measured temperatures showed no appreciable difference from those measured in the lower orbits.

Photographs of the GATV, taken from the spacecraft, show bubbles in the paint and aluminum tape used for temperature control. Similar bubbles had also been noted on the Gemini VIII and the Gemini X GATV. These bubbles are apparently caused by entrapped gases or out-gassing, rather than by blistering due to heat, and apparently do not affect the thermal control of the GATV.

5.4.2 Propulsion

The primary and secondary propulsion systems performed satisfactorily during the ascent phase and subsequent orbital maneuvers. The PPS was fired three times in orbit for the calibration and high-apogee maneuvers. The SPS Unit II engines were fired twice to circularize the orbit and once, for 69 seconds, to obtain over-limit performance data.

5.4.2.1 Primary propulsion system.- Operation of the PPS was normal in all respects. Oxidizer preflow averaged seven pounds for orbital firings, all start transients were nominal, and shutdown impulses were within the expected values. The start sequences (table 5.4-I) were essentially the same as those of the PPS firings during the Gemini VIII and X missions. The flight crew reports of start-sequence timing, and sight and sound cues confirmed normal PPS operation (table 5.4-II). At the conclusion of PPS operations, approximately 520 pounds of propellants remained in the vehicle.

5.4.2.2 Secondary propulsion system.- The SPS Unit I thrust chambers were fired for a total of 230.8 seconds and the Unit II thrust chambers were operated for a total of 105.8 seconds. SPS performance is presented in tables 5.4-III and 5.4-IV. Telemetry data of the 69-second overlimit firing did not reveal any detectable damage. Ground test data had indicated that the thrust chambers used on this GATV did not have a high heating rate; therefore, no damage was expected. The operating time, chamber pressure, and velocity gained were used in real-time to calculate engine performance and vehicle weight. The results were used to verify the ground computer program for main engine propellants remaining. Roll torques produced during Unit II firings were greater than anticipated but were within allowable limits. The roll torque may have been caused by the combination of the SPS thruster plume impinging on the PPS turbine exhaust line and/or nozzle extension and the center-of-gravity/thruster-alignment uncertainties. All SPS temperatures remained within allowable limits.

5.4.3 Communications and Command System

The performance of the Communications and Command System was normal in all aspects, except for the clock-jump anomaly discussed in the following paragraphs.

5.4.3.1 Command system.- The command system satisfactorily accomplished the proper receipt, processing, and execution of all commands. All real-time commands were verified by MAP's through the PCM telemetry system; however, because of a failure in the L-band transponder early in the flight, the spacecraft did not receive all MAP's. Later, none of the MAP's were received by the spacecraft. This anomaly is covered in detail in section 5.1.5. During the flight of the spacecraft, 1106 commands were executed and were verified by MAP's. In addition, numerous spacecraft commands were sent repeatedly because MAP's were not being received in the spacecraft. After spacecraft reentry, another 1153 commands were properly processed of which approximately 700 were stored program commands. During a 6-second interval beginning at 3:00:06 g.e.t., the GATV-clock time accumulator skipped from a time of 4:37:31.0 to 9:10:41.0. Data analysis up to the publication date of this report had revealed only that the GATV was being subjected to noise of sufficient amplitude to cause the PCM telemeter to lose synchronization. An examination of the ground-station receiver signal-strength records during this period revealed that the synchronization loss was in the vehicle. The precise coupling path of the noise into the time accumulator circuitry had not been determined. An investigation was initiated to determine the normal level of conducted interference as well as to establish the levels required to cause the anomaly.

During the GATV operations after spacecraft reentry, there was an indication of another clock jump which occurred between revolutions 77 and 88 when there was no ground tracking. At the next real-time reading, the discrepancy that existed between GATV elapsed time and GATV onboard time was 7 minutes 8 seconds. This skip was included in the investigation.

5.4.3.2 Tracking system.- The tracking system functioned normally throughout the life of the GATV, and provided excellent tracking coverage at all stations, including those passes while the docked vehicles were at the high-altitude apogee.

5.4.3.3 PCM telemetry system.- The PCM telemetry system performed satisfactorily, providing excellent data throughout the monitored flight of the GATV. Except for the synchronization losses which occurred during the clock-jump anomaly, all synchronization losses can be attributed to marginal signal strength at the ground station receivers because of low-elevation long-range tracking.

The GATV PCM tape recorder operated normally for the entire orbital phase of the GATV flight. Data obtained from the tape playback were of excellent quality and were to be used for investigating the clock skip problem.

5.4.4 Hydraulic and Pneumatic Systems

5.4.4.1 Hydraulic System.- The Hydraulic System operated properly throughout each of the PPS maneuvers. During Hydraulic System operation, the pump discharge pressure increased normally from zero to 2830 psia and occasionally to as high as 2960 psia during a maneuver. After each period of operation, the pump discharge pressure decreased to zero within two seconds after engine cutoff. Hydraulic reservoir pressure varied between 52 and 92 psig which is the normal range.

5.4.4.2 Pneumatics.- The propellant tank pressurization system functioned normally throughout the mission. Prior to lift-off, the oxidizer and fuel tanks were pressurized to 30.1 and 38.6 psig, respectively, and the helium pressurization tank was charged to 2415 psia. The pyrotechnically operated helium control valve operated properly for the pressurization of the propellant tanks. The orbital propellant tank pressure varied from 28.9 to 21.9 psia for the oxidizer tank and 47.2 to 36.5 psia for the fuel tank. These pressures were within the expected values.

5.4.4.3 Attitude control system.- The attitude control system was activated a few seconds after separation of the GATV from the TLV. The system functioned normally throughout the mission. After the GATV was placed in the final orbit, the system was deactivated by ground command. The attitude control gas was essentially depleted after 93 hours g.e.t. because of the high usage rate associated with the horizon sensor problem.

5.4.5 Guidance and Control System

The Guidance and Control System performed satisfactorily throughout the mission. Evaluation of the flight data indicated that the system performed its required functions. Guidance and control flight parameters are shown in tables 5.4-V through 5.4-VII.

5.4.5.1 Ascent guidance sequence.- All guidance and control parameters appeared normal through the ascent portion of the flight. The ascent sequence timer was started by a TLV discrete command at 278.0 seconds after lift-off. Events which occurred throughout the ascent phase are listed in table 5.4-V. Sequence-timer performance was nominal throughout its period of operation.

TLV/GATV separation was initiated at 301.13 seconds after lift-off and was completed at 302.8 seconds. Rates imparted to the GATV at separation were zero deg/sec in pitch, plus 0.05 deg/sec in yaw, and minus 0.05 deg/sec in roll.

The programmed pitch-down maneuver following separation occurred at LO + 339.0 seconds at a rate of minus 1.41 deg/sec compared with a specified value of minus 1.5 deg/sec ±15 percent. The torque rate saturated, but the initial slope of the pitch position gyro was minus 1.41 deg/sec. The ascent PPS engine firing commenced at 372.0 seconds after lift-off and lasted for 186.3 seconds. The maximum gyro deflection was minus 4.5 degrees in pitch and plus 6.8 degrees in yaw. These transients were essentially damped out in ten seconds. Roll characteristics were similar to those of previous GATV flights. The roll attitude error transient was +3.2 degrees and, within 15 seconds, was corrected to less than one degree. The PPS firing was correctly terminated by a velocity meter cutoff. This maneuver and subsequent SPS and PPS maneuvers are summarized in table 5.4-VII.

5.4.5.2 Orbit guidance sequence.-

5.4.5.2.1 Docking: The first docking occurred at 1:34:16 g.e.t. Subsequent dockings were performed at approximately 3 hours 20 minutes, 4 hours, and 6 hours 45 minutes g.e.t. The first docking was reviewed in detail and appeared to have been normal. Maximum attitude excursions for the first docking were plus 3.6 degrees in pitch, plus 5.0 degrees in yaw, and minus 7.2 degrees in roll. These excursions are larger than measured during dockings on previous missions; however, for the first time, all dockings in this flight were performed in flight control mode 1 (ACS gain low, ACS deadband wide, ACS pressure low).

5.4.5.2.2 PPS firings: There were four PPS firings, including the ascent firing, during this flight. The three firings in orbit were in the docked configuration. Performance of the Guidance and Control System during these firings is presented in table 5.4-VII.

Yaw heading errors were greater than expected during all PPS maneuvers, including ascent. These known heading errors in yaw, although exceeding preflight predictions, were within the uncertainty error limits, but were approaching the worst-case condition. The pitch heading errors were well within the uncertainty error limits. Maximum gyro excursions for the docked PPS maneuvers were plus 5.8 degrees in yaw and minus 2.8 degrees in pitch. The magnitude of the excursions in yaw indicate that the combination of GATV center-of-gravity position uncertainty, engine alignment uncertainty, actuator null uncertainty, and center-of-thrust displacement together with spacecraft center-of-gravity uncertainties resulted in the equivalent yaw center-of-gravity displacement approaching the worst-case error uncertainties.

There is good correlation between gyro position and actuator position, indicating that actual hydraulic vehicle-to-engine gains were satisfactory. This is further verified by vehicle dynamic response and control. All PPS firings were terminated by a velocity meter cutoff.

5.4.5.2.3 SPS Unit II firings: Three SPS Unit II firings were performed during the flight and all were accomplished in the undocked configuration. The attitude control system provided adequate control during all SPS firings. Larger-than-expected roll attitude excursions were evident in all three SPS Unit II maneuvers and appear to have been the result of center-of-gravity and thrust-misalignment uncertainties. These unexpected excursions also resulted in control gas usage that was slightly higher than predicted. The excess gas usage is entirely attributable to roll attitude control during maneuvers. Control gas usage during the SPS Unit II maneuvers was as follows:

SPS Unit II firing	Duration, sec	Control gas usage, lb	
		Predicted	Actual
1 (Undocked)	15.96	1.81	2.3
2 (Undocked)	20.81	1.89	2.5
3 (Undocked)	68.98	2.65	3.0

5.4.5.2.4 Heading changes: Heading changes, both docked and undocked, were made by either of two methods—programmed rates or gyrocompassing. Performance of both types of maneuvers was normal. Control gas usage for command rate maneuvers was 0.8 of a pound for an undocked

90-degree heading change and 3.5 pounds for a docked 90-degree change. This usage may be compared with the predicted 1.1 pounds for the undocked heading change and 4.8 pounds for the docked heading change.

Gyrocompassing heading changes may be summarized as follows:

Heading change, deg	Control gas usage, lb	
	Predicted	Actual
Undocked:		
90	0.5	0.5
180	1.0	1.0
Docked:		
90	2.0	1.0
180	4.0	2.0

5.4.5.2.5 Velocity meter operation: The velocity meter operated normally, and successfully commanded shutdown for all PPS and SPS Unit II engine firings. Desired and actual velocity gains for all firings are listed in table 5.4-VII.

5.4.5.2.6 Horizon sensor operation: During the late portion of the flight, a malfunction became apparent in the horizon sensor system. This was first indicated by error transients appearing on the roll output, with occasional lesser transients in pitch coinciding with the roll transient. These transients increased in frequency and magnitude as the flight progressed, until the error transients were causing rapid-movement offscale readings accompanied by apparent inhibits in pitch and/or roll. It appeared that, in addition to the system malfunction, the 100-foot Dacron webbing, which connected the spacecraft and GATV during the tether evaluation, was passing through the field of view and causing some of the erratic readings. Postflight review of the data indicates that the error transients occurred as early as revolution 27, prior to the second PPS firing; however, these were not evident in real time. This problem is being investigated.

5.4.6 Electrical System

The Electrical System performed satisfactorily and no malfunctions or anomalies were evident.

5.4.6.1 Main bus voltage.- The main bus unregulated dc voltage followed the predicted discharge characteristics of the primary batteries. The high potential (at lift-off) was 27.23 volts and the sustained potential was 24.65 volts. The relatively fast decrease (two hours) from the higher potential to the sustained level can be attributed to the long on-pad hold time of approximately three days and to the low operating temperatures.

5.4.6.2 Pyro bus voltage.- The pyro bus dc voltage, with diode isolation from the main bus, displayed normal operating characteristics. The initial high potential was 27.83 volts and the prolonged-level potential was 25.50 volts. The nominal 0.75-volt differential above the main bus was maintained.

5.4.6.3 Regulated voltages.- All dc regulated voltages remained within the required tolerance range of 27.7 to 28.9 volts. The lowest value recorded was 27.85 volts and the highest value recorded was 28.9 volts. This high value was recorded during revolutions 105, 106, and 107, long after the normal mission. Based upon data summaries, there are no correlating data, such as temperature shift, to account for reaching the upper limit, except that the instrumentation consistently favored the high side.

5.4.6.4 Inverter voltages.- The inverter ac phase voltages indicated levels generally at the lower end of the tolerance limit; the lowest value was 113 volts rms and the highest value was 116.10 volts rms. The phase AB monitor average indication was approximately one volt rms higher than the average indication.

5.4.6.5 Main bus current.- The main bus current was moderately below the nominal allocation of 14.5 amperes. This is attributable to less severe loading than anticipated during the mission and to less sustained loading of the vehicle during post-mission exercises. The lowest indicated value was 9.4 amperes and the highest value was 35.4 amperes. The reflected load responses were basically as expected, and were well within the capability of the system.

5.4.6.6 Structure current.- The indicated structure-current values were nominal, generally ranging between 0.6 of an ampere and 1.4 amperes. The maximum indication was 3.4 amperes and occurred during an unrigidizing sequence.

5.4.6.7 Capacity.- The vehicle capacity requirements were less demanding than predicted. The predicted ampere-hours per revolution was 22.9; the actual was 20.3 ampere-hours per revolution for the main mission and 20.1 ampere-hours per revolution over the total vehicle life.

The predicted total system capacity was 2360 ampere-hours; the last telemetry acquisition, in revolution 108, indicated that 2180 ampere-hours had been used. The predicted vehicle life was 6.8 days and the actual vehicle life was 7.2 days. All vehicle system electrical capacity requirements were met.

5.4.6.8 Temperatures.- The temperature indications followed expected trends for all electrical system components, consisting of five batteries, two regulators, and one inverter.

5.4.7 Instrumentation System

The Instrumentation System provided for the monitoring of 152 analog and 27 step-function (tell-tale) parameters. All instrumentation parameters were operative at lift-off and only four parameters—B-1 (fuel-pump inlet pressure), B212 (SPS Unit I plus Y chamber pressure), D-46 (gas valve cluster No. 1 temperature), and B248 (SPS Unit II plus Y skin temperature)—failed to provide satisfactory data throughout the mission.

The PPS fuel pump inlet pressure indicated a linear shift at the conclusion of the second PPS maneuver. This shift was even larger at the conclusion of the third PPS maneuver. Data prior to the third PPS maneuver indicated an increase in residual pressure from 0.4 psi to 3.7 psi. Data from the third PPS maneuver indicated an additional shift from 3.7 psi to the remaining residual pressure of 6.5 psi. A similar linear shift in this same parameter was experienced during the Gemini X mission. An orifice in the pressure transducer line was considered as a remedy for this problem; however, as a result of an evaluation of the system configuration, it was decided that a linear shift could be tolerated in this parameter.

The SPS Unit I plus Y chamber pressure transducer failed after revolution 59 and prior to revolution 75 when data indicated an abnormal residual pressure. This parameter provided good data on each of the SPS Unit I maneuvers with nominal residual pressures of 1.2 to 0.4 psig. The cause of transducer failure could not be determined because the tape-recorded data covering the period of the failure were erased and could not be transmitted.

The gas valve cluster No. 1 temperature sensor provided intermittent data during periods of GATV revolutions 35 and 36. Data prior to and after this period were nominal and this anomaly is considered to be an isolated occurrence. Data indicated that an open circuit had occurred in the sensor circuit. No conclusions can be drawn as to the cause of the anomaly since this parameter functioned normally throughout the remainder of the mission.

The SPS Unit II plus Y skin temperature did not indicate the peak temperature during the SPS Unit II maneuvers. The lower temperatures measured, when compared with ground test data and with a similar temperature monitor on the SPS minus Y monitor, indicate that an improper reattachment of the sensor had been made to the SPS thruster. This sensor had been inadvertently broken off and subsequently rewelded to the original point on the thruster. The GATV has a history of similar anomalies. Recommendations are being made to investigate the techniques of welding and rewelding of temperature sensors (thermocouples).

5.4.8 Range Safety System

Performance of the Range Safety System was satisfactory.

5.4.8.1 Flight termination system.- The range-safety command receivers received adequate signal to execute commands throughout the ascent phase. No commands were sent and no spurious commands were received.

5.4.8.2 Tracking system.- The C-band transponder was used by various radars to provide input position data for the Instantaneous Impact Predictor (IIP) computer. System performance was satisfactory.

TABLE 5.4-I.- PRIMARY PROPULSION SYSTEM START TRANSIENTS DATA

PPS maneuver	Insertion	Plane change	Height adjust	Circularization
Time of PPS FS, g.e.t.	[a]372.038	4:29:56.079	40:31:23.808	43:54:03.588
Time of PPS SS, g.e.t.	[a]558.374	4:30:00.126	40:31:49.981	43:54:27.089
Time, FS to FGGV open, sec	0.079	0.079	0.080	0.076
Time, FS to OGGV open, sec	0.047	0.047	0.038	0.038
Time, FS to TMP rapid rise, sec	0.264	0.253	0.252	0.240
Time, FS to oxidizer valve open, sec	0.379	0.352	0.405	0.338
Time, FS to OMP or OFP switch make, sec	0.937	0.875	0.941	0.884
Time, FS to both switches made, sec	1.142	0.911	1.030	0.982
Time, FS to fuel valve open, sec	1.108	0.965	1.041	0.973
Time, FS to ignition, sec	1.168	0.999	1.093	1.027
Time, FS to 75 percent thrust, sec	1.178	1.015	1.106	1.035
Firing duration 75 percent P_c to B-108 off, sec	185.145	3.032	25.067	22.466
Average PPS P_c, psia	510	490	497	504
Gas generator P_c peak, psig	527	564	515	618
Gas generator P_c average, psig	448	430	436	439
Calculated preflow (±0.5 lb), lb	10.36	6.35	7.4	7.06
Prefire OVIP, psia	976	1219	976	1140
Prefire FVIP, psia	979	1136	1015	1106
Prefire OSP, psig	45.0	26.7	22.9	23.9
Prefire FSP, psig	53.0	46.9	43.8	40.1

[a]Time from GAATV lift-off, sec.

Abbreviations

FGGV	Fuel gas generator valve	g.e.t.	Ground elapsed time	OVIP	Oxidizer venturi inlet pressure
FS	Fire signal	o/f	Oxidizer/fuel	PPS	Primary Propulsion System
FSP	Fuel suction pressure	OFP	Oxidizer feed pressure	P_c	Chamber pressure
FVAP	Fuel valve actuation pressure	OGGV	Oxidized gas generator valve	SS	Shutdown signal
FVIP	Fuel venturi inlet pressure	OMP	Oxidizer manifold pressure	TMP	Turbine manifold pressure
		OSP	Oxidizer suction pressure		

TABLE 5.4-II.- PPS NORMAL TRANSIENT EVENTS

Item	Approximate time from fire signal, sec	Astronaut indication
Fire signal	0.0	None (tanks pressurizing)
SPS Unit I start	16.0	May be visible; not audible
PPS ready signal	80.0	Noise due to propellant flow into engine area
PPS fire signal	84.0	None
PPS gas generator ignition	84.3	Visible glow; and possibly some sparks and noise at start
Oxidizer preflow starts to exit engine	85.0	Flashes at rear as oxidizer mixes with fuel-rich turbine exhaust
Main engine ignition	85.1	1 to 1.5g immediately; visible
Steady-state thrust	--	No visible indication
Engine shutdown	As commanded	Loss of thrust
Engine postflow	(Shutdown to +10)	Tailoff, spectacular, characterized by sparks in a continuous tenuous bright yellow glowing gas stream

TABLE 5.4-III.- SPS UNIT I PERFORMANCE

SPS firing	Insertion	Plane change	Height adjust	Circularization
Start time, g.e.t.	[a]354.08	4:28:47.80	40:30:15.55	43:52:55.33
90-percent P_c time				
+Y	0.255	0.253	0.240	0.250
-Y	0.245	0.250	0.280	0.233
P_c average				
+Y	81.0	78.8	80.3	81.3
-Y	79.9	78.6	78.7	80.2
Average fuel feed pressure, psia				
+Y	207.4	197.8	202.7	205.1
-Y	212.7	205.3	205.3	210.2
Average oxidizer feed pressure, psia				
+Y	207.4	197.7	202.5	205.0
-Y	212.7	205.4	205.3	210.2
Thrust duration, sec	19.95	70.32	70.29	70.27
Propellant temperature, °F				
Oxidizer +Y	66.3	76.9	62.7	66.3
Oxidizer -Y	64.5	69.9	64.5	62.7
Fuel +Y	66.3	76.9	66.3	66.3
Fuel -Y	62.7	69.9	62.7	60.9

[a]Time in seconds from GAATV lift-off.

TABLE 5.4-IV.- SPS UNIT II PERFORMANCE

SPS maneuver number	1	2	3
Start time, g.e.t.	75:32:20.88	76:15:33.27	92:15:58.70
90-percent P_c time, sec			
+Y	0.168	0.143	0.170
-Y	0.140	0.144	0.159
P_c average, psia			
+Y	90.9	92.0	92.0
-Y	93.0	94.0	95.1
Average fuel feed pressure, psia			
+Y	193.0	194.2	191.8
-Y	191.9	194.3	194.3
Average oxidizer feed pressure, psia			
+Y	194.0	194.0	192.8
-Y	194.4	196.9	196.9
Thrust duration, sec	15.96	20.81	68.98
Propellant temperature, °F			
Oxidizer +Y	66.3	66.3	60.9
Oxidizer -Y	66.3	64.5	62.7
Fuel +Y	66.3	66.3	60.9
Fuel -Y	62.7	62.7	57.4

TABLE 5.4-V.- ASCENT SEQUENCE OF EVENTS

Event	Time from lift-off, sec	
	Nominal	Actual
Lift-off	0.0	0.0
Start sequence timer	276.9	278.0
Gyros uncaged	298.8	298.1
Horizon sensor doors jettisoned		
TLV/GATV separation	300.0	301.1
Primacord and retrorockets fired		
Enable ACS	303.5	302.8
Programmed pitch-down maneuver (-1.5 deg/sec)	337.9	339.0
Programmed pitch-down maneuver off	350.9	352.0
Geocentric rate on (-3.99 deg/sec)		
Enable velocity meter		
Disable pitch and yaw pneumatics	370.9	372.0
PPS thrust initiate		
PPS thrust cutoff (velocity meter)	557.15	558.4
Enable pitch and yaw pneumatics		
Extend L-band boom antenna	564.9	566.0
ACS deadband wide	572.9	574.0
Disable velocity meter	588.9	590.1
Gyrocompassing on, low gain		
ACS gain low	695.9	697.0
ACS pressure low		
Fire horizon-sensor zero-degree position squib	702.9	704.0
Shutdown sequence timer	702.9	704.0

TABLE 5.4-VI.- HORIZON SENSOR TO INERTIAL

REFERENCE PACKAGE GAINS

Axis	Very high gain		High gain	
	Nominal	Actual	Nominal	Actual
Pitch	3.0 ±0.6	3.15	1.0 ±0.2	0.9
Roll	9.0 ±1.8	10.0	1.0 ±0.2	1.1
Yaw (gyrocompassing)	0.0	0.0	8.0 ±1.6	7.0

NOTE: All gains measured in deg/min/deg HS.

TABLE 5.4-VII.- GUIDANCE AND CONTROL SYSTEM PERFORMANCE

Maneuver number	Heading error, deg				Velocity-meter load, ft/sec	Velocity-meter cutoff time, g.e.t.	Velocity-meter tailoff[a], ft/sec	Total velocity gains, ft/sec		
	Pitch		Yaw					Desired	Velocity-meter indication	Actual
	Predicted	Actual	Predicted	Actual						
PPS ascent	-0.20	-0.89	+0.05	+1.29	8236.109	558.367 (sec after lift-off)	12.429	8248.09	8248.538	
1	-1.62	-1.06	+1.06	+2.70	104.350	4:30:00.142	6.344	110	110.694	
2	-0.95	-1.19	+2.31	+2.34	912.217	40:31:49.989	7.380	920	919.597	
3	-1.00	-1.04	+2.44	+2.65	911.441	43:54:27.105	8.027	920	919.468	
SPS 1	-0.39	+0.34	0.00	0.00	47.255	75:32:36.837	0.260	47.2	47.515	46.58
2	-0.39	+0.35	0.00	+0.06	62.920	76:15:54.085	0.260	62.9	63.180	61.83
3	-0.39	+0.16	0.00	-0.02	215.561	92:17:07.672	0.390	215.5	215.951	212.24

[a]Tailoff velocity-meter word is converted to ft/sec as follows: (32 767 - (no. of pulses) -1) × velocity-meter scale factor.

[b]Actual velocity gains are calculated as follows for SPS firings: $\Delta V = \frac{(\text{SPS average thrust}) \times \Delta t \times 32.17}{W_{avg}}$

5.5 TARGET LAUNCH VEHICLE PERFORMANCE

The performance of the Target Launch Vehicle (TLV), an Atlas Standard Launch Vehicle (SLV-3), was satisfactory. The vehicle boosted the Gemini Agena Target Vehicle (GATV) to the required velocity and position for subsequent insertion into the planned orbit. The TLV also provided the required discrete signals to the GATV for staging-system operation and for separation from the TLV.

The Gemini Atlas-Agena Target Vehicle (GAATV) was launched from Complex 14, Air Force Eastern Test Range, at 13:05:01.725 G.m.t. September 17, 1966. During the countdown, there were no holds or difficulties encountered which were attributed to the GAATV. The GAATV countdown was held for a period of 10 minutes at T minus 97 minutes (integrated countdown time) because of a hold in the spacecraft countdown. The integrated countdown was recycled to T minus 103 minutes, for a total launch delay of 16 minutes.

All times in this section, unless otherwise noted, are referenced to the 2-inch motion of the TLV as zero time.

5.5.1 Airframe

Structural integrity of the TLV Airframe was satisfactorily maintained throughout the flight. The 5-cps longitudinal oscillations normally encountered after lift-off reached a maximum amplitude of 0.91g at lift-off (LO) + 4.5 seconds. This oscillation is excited during release of the launcher hold-down arms.

Telemetered axial acceleration data indicated the following peak accelerations:

Reference	Axial accelerations, g	
	Predicted	Actual
Booster engine cutoff (BECO)	6.27	6.3
Sustainer engine cutoff (SECO)	3.09	3.0

Booster section jettison at LO + 133.86 seconds and GATV separation at LO + 300.44 seconds were normal. TLV telemetered gyro and acceleration data indicated normal transients and vehicle disturbances at these times.

Starting at approximately LO + 70 seconds, the measurement of ambient temperature on the jettison rail support in Quadrant IV of the engine compartment reflected a condition indicative of a cryogenic leak. The temperature decreased at a rate of 1 deg/sec and reached 10° F at BECO. After booster section jettison at LO + 133.86 seconds, the temperature gradually increased to 106° F at SECO (LO + 279.47 seconds). This is the sixth SLV-3 flight in which this temperature has dropped during the period between lift-off and BECO.

The other four thrust-section temperature parameters indicated slightly decreasing levels; however, the propulsion system data did not reflect any cryogenic leakage.

The maximum boost-phase temperature, recorded at BECO, was 106° F in the area of the sustainer fuel pump. Ambient pressure and temperature conditions within the interstage adapter were satisfactory. The ambient pressure exhibited a normal exponential decay during the flight. The ambient temperature increased from minus 8° F at lift-off to plus 60° F at TLV/GATV separation.

5.5.2 Propulsion System

5.5.2.1 Propulsion System.- Operation of the engine systems, utilizing MA-5 booster, sustainer, and vernier components, was satisfactory in performance and operational characteristics. A comparison of actual computed thrust with the predicted thrust levels is shown in the following table:

Engine	Condition	Thrust, lb			
		Lift-off	BECO	SECO	VECO
Booster	Predicted	330 225	379 946	NA	NA
	Actual	327 852	377 150	NA	NA
Sustainer	Predicted	56 940	80 514	79 637	NA
	Actual	56 758	80 855	80 277	NA
Vernier	Predicted	1 151	1 407	1 149	1 155
	Actual	1 166	1 422	1 081	908

NA - Not applicable

The engines started at LO minus 4.1 seconds, and ignition, thrust rise, and thrust levels were normal prior to lift-off. The booster, sustainer, and vernier engines were cut off by guidance system commands and the shutdown characteristics were as expected. The vernier system transitioned to tank-fed operation satisfactorily. The engine cutoff relay activation times and the start-of-thrust-decay times at BECO, SECO, and vernier engine cutoff (VECO) are shown in the following table:

Event	Engine relay box activation, LO + seconds	Start of thrust decay, LO + seconds
BECO	130.44	130.52
SECO	279.43	279.47
VECO	298.05	298.16

As noted in section 5.5.1, engine compartment ambient temperature data indicated a low temperature environment in Quadrant IV of the thrust section. Engine system data, however, did not indicate a cryogenic leak. Because of a history of cryogenic leakage, several design changes and precautionary measures, which were first accomplished on the Gemini X TLV (SLV-3 5305), were incorporated into this TLV. On future SLV-3 launch vehicles, seals of a new design will be installed at the sustainer engine liquid-oxygen elbow-to-dome connections. Also, use of higher engine checkout pressures is being studied.

5.5.2.2 Propellant utilization.- The propellant utilization system operated satisfactorily, although the fuel outage (510 pounds) at theoretical liquid-oxygen depletion exceeded the 3-sigma outage value of 410 pounds. The system sensed levels in the liquid-oxygen and fuel tanks at six discrete points during flight and attempted to command the value so as to end the flight with the optimum ratio of propellants remaining.

Propellant residuals at SECO were calculated by utilization of the uncover times of the instrumented head-pressure ports in the liquid-oxyge and fuel tanks in conjunction with the flow rates determined between sensor stations 5 and 6 (corrected for propellant utilization valve-angle changes after sensor station 6 uncover). Usable propellant residuals based on this method of calculation are presented in the following table:

Condition	Liquid oxygen, lb	Fuel, lb	Time from SECO to theoretical liquid-oxygen depletion, sec	Excess fuel at theoretical liquid-oxygen depletion, lb
Predicted	773	472	Not applicable	Not applicable
Actual	748	836	4.04	510

An indication of premature triggering of the liquid-oxygen time-shared oscillator was noted at LO + 177.71 seconds, LO + 216.35 seconds, and LO + 220.70 seconds. The multiple triggering gives the appearance of premature activation of the liquid-oxygen sensors 5 and 6. In all three instances, however, the signals were not of sufficient duration to pass through the 90 to 140 millisecond integrator to the liquid-oxygen monostable multivibrator and move the main fuel valve. The station 5 and 6 liquid-oxygen sensors did uncover at the expected time and correctly positioned the main fuel valve. There appears to be no relationship between the larger-than-predicted fuel outage and the erroneous signals. It should be noted that the integrator circuit was installed to prevent the system from responding to erroneous signals.

5.5.2.3 Propellant loading.- The normal propellant loading procedure was used for this vehicle. Fuel was tanked to a level 12 gallons above the 100-percent probe on September 8, 1966. A level adjustment was made on launch day due to a level change. The final fuel level was 11 gallons above the 100-percent probe. Liquid oxygen was tanked during the countdown to near the 100-percent probe and was maintained at this level until the vent system was closed. Total fuel and liquid-oxygen weights at ignition were 76 589 pounds and 173 217 pounds, respectively.

5.5.3 Flight Control System

The performance of the Flight Control System was satisfactory. Attitude control and vehicle stability were maintained throughout the flight and the proper sequence of events was performed by the autopilot programmer. Very small transients at lift-off were rapidly damped following autopilot activation at TLV 42-inch motion, as indicated by initial engine movements at LO + 0.75 of a second. The lift-off roll transient reached only 0.2 of a degree in the clockwise direction at a peak rate of 0.15 deg/sec. Vehicle first-mode bending, excited at lift-off was evident in both pitch and yaw from LO + 0.6 of a second to LO + 1.5 seconds. Maximum oscillations at a frequency of 2.3 cps reached 1.2 deg/sec peak-to-peak in pitch and 2.0 deg/sec peak-to-peak in yaw. Second-mode bending was excited by the 5-cps lift-off longitudinal oscillations. Maximum oscillations in yaw, at a frequency of 4.8 cps, only reached 0.6 deg/sec peak-to-peak and were completely damped by 12 seconds.

Gyro data provided indications that the roll and pitch maneuvers were properly executed. The usual propellant slosh and rigid-body oscillations were observed as the vehicle passed through the region of maximum dynamic pressure. Maximum booster-engine positive deflections to counteract the effects of aerodynamic loading occurred at approximately LO + 82 seconds, with an average deflection of 0.6 of a degree.

The programmer enabled guidance steering at LO + 80 seconds; however, no booster phase steering was required. TLV propellant sloshing in pitch and yaw was observed between approximately LO + 65 seconds and BECO, with negligible amplitudes indicated.

Rigid-body oscillations in pitch and yaw began at approximately LO + 65 seconds and were completely damped in pitch by LO + 90 seconds, with yaw continuing until BECO. Maximum oscillation amplitudes did not exceed 0.8 deg/sec.

The guidance-initiated staging discrete signal was indicated at the programmer input at LO + 130.29 seconds and the resultant switching sequence was successfully executed. Vehicle transients associated with BECO and booster-section jettison were not excessive, and all transients were quickly damped by the autopilot system. The vehicle first-mode bending which occurs between BECO and booster jettison was evident in the pitch and yaw planes. Maximum oscillations at a frequency of 4.5 cps did not exceed 0.8 deg/sec peak-to-peak and were damped by the time of booster jettison. Rigid body oscillations at a frequency of 0.25 cps in pitch and yaw were excited by booster jettison but did not exceed 0.7 deg/sec peak-to-peak. The oscillations were damped to negligible values by LO + 165 seconds for pitch and LO + 180 seconds for yaw. There was no evidence of TLV propellant slosh or bending during the sustainer phase.

The flight control system responded properly to all sustainer steering commands including a small spurious booster-phase steering command at LO + 103 seconds. The TLV response to the spurious command was negligible (see section 5.5.5).

The SECO signal was received by the programmer at LO + 279.43 seconds. Vernier-phase steering consisted of a very small pitch-down command and a slight yaw-right command. TLV rate and displacement-gyro signals indicated a high degree of vehicle stability throughout the vernier phase. The VECO signal was received by the programmer at LO + 298.05 seconds. GATV separation occurred at LO + 300.44, followed by a normal TLV retrorocket operation.

5.5.4 Pneumatic and Hydraulic Systems

5.5.4.1 Pneumatic System.- Operation of the Pneumatic System was satisfactory. The tank pressurization system properly regulated the liquid-oxygen and fuel ullage pressures in the main tanks during the booster phase of flight and the control system provided adequate pressurization for sustainer and vernier propulsion system control. The liquid-oxygen and fuel ullage pressures were 29.5 psig and 65.5 psig at lift-off, and 30.0 psig and 65.8 psig at BECO, respectively. The differential pressure across the intermediate bulkhead (fuel tank pressure minus the sum of liquid-oxygen ullage and head pressures) was positive throughout flight. The minimum differential pressure of 9.1 psid was recorded at LO + 2.34 seconds.

During the boost phase, 86.6 pounds of the 154.4 pounds of helium aboard the vehicle were used for pressurization of the propellant tanks.

5.5.4.2 Hydraulic System.- The booster and sustainer/vernier hydraulic subsystems supplied adequate pressure to support the demands of user systems throughout the countdown and flight.

The sustainer/vernier hydraulic pressure at LO minus 12 seconds dropped from 1940 psig to 1865 psig within 0.9 of a second. This reduced operating pressure was sustained until engine start, when flight pressure was achieved by the airborne hydraulic pump. During the flight, there was no evidence of reduced pressure and no anomalies were indicated. The pressure drop prior to engine start also was of insufficient magnitude to affect the Hydraulic System at that time.

An investigation is being conducted to determine whether the pressure drop is related to the contamination found in the ground-based Hydraulic Pumping Unit for the sustainer during the preflight hydraulic fill and bleed procedure. The pressure drop is isolated to components within the pumping unit and the source of the previously found contaminants is also isolated to this unit. The possibility of any pumping unit contaminants flowing into or from the vehicle has been eliminated because of the screens in the pumping unit.

Normal hydraulic pressure transients were indicated at engine start, followed by stabilization of system pressure at 3150 psia in the booster subsystem and 3140 psia in the sustainer subsystem, and these pressures were satisfactorily maintained until BECO and SECO, respectively. After SECO and cessation of sustainer hydraulic pump operation, hydraulic pressure was supplied to the vernier subsystem by the dual vernier-solo accumulators. The accumulators supplied pressure for 62.5 seconds after VECO before bottoming out at 840 psia.

5.5.5 Guidance System

The TLV was guided by the MOD III Radio Guidance System which operated satisfactorily throughout the countdown and flight. The five planned discrete commands and the required steering commands were received and correctly decoded by the TLV airborne equipment.

5.5.5.1 Programmed guidance.- The initial open-loop steering of the TLV, as indicated by rate and displacement gyro outputs from the autopilot, were properly accomplished. The pre-set roll and pitch programs of the Flight Control System successfully guided the vehicle into the planned trajectory (see section 5.5.3).

5.5.5.2 Radio guidance.-

5.5.5.2.1 Booster steering: The radio-guidance ground station acquired the TLV in the cube-acquisition mode, as planned, with vehicle-borne rate and track lock-on established at LO + 57.7 and LO + 58.6 seconds, respectively. Track lock-on was intermittent between LO + 103 and LO + 104 seconds, when antenna look angles were unfavorable. As a result, spurious pitch and yaw steering commands were evident during this period. Because booster steering was enabled at this time, the spurious commands were acted upon by the Flight Control System. These commands, however, were minor, reaching maximum values of less than two percent, and had a negligible effect on the vehicle attitude. Spurious steering commands can be expected during periods of intermittent track lock-on and have been noted on earlier flights. Following the period of intermittent track lock-on and the expected dropout during the BECO/staging sequence, both rate and track lock-on were satisfactorily maintained until approximately LO + 392 and LO + 397 seconds, respectively, when tracking was intentionally terminated.

Booster steering, implemented to correct open-loop dispersions, was enabled by the Flight Control System at LO + 80 seconds, as planned. No corrections were required and, therefore, no steering commands were generated. The BECO signal was received at the autopilot programmer input at LO + 130.29 seconds. The errors at BECO were 71 ft/sec high in velocity, 205 feet low in altitude, and 0.45 of a degree low in flight-path angle.

5.5.5.2.2 Sustainer steering: Sustainer steering was initiated at LO + 146.1 seconds, with initial peak commands of 55 percent pitch-up and 40 percent yaw-right. Commands were reduced to below 10 percent by LO + 150 seconds and remained below this level for the remainder of the sustainer phase. The sustainer engine cutoff signal was received at the programmer input at LO + 279.43 seconds.

5.5.5.2.3 Vernier steering: Vernier steering was initiated at LO + 279.6 seconds and consisted of approximately 0.2 of a degree pitch-down and 0.2 of a degree yaw-right commands. The VECO signal was received at the programmer input at LO + 298.05 seconds.

5.5.5.2.4 VECO conditions: The VECO conditions were very close to the planned values. The space-fixed velocity was 0.5 ft/sec low, the vertical velocity 0.6 ft/sec low, and the lateral velocity 1.0 ft/sec yaw-left.

The following table is a comparison of the filtered inflight actual insertion values with the filtered inflight desired values.

VECO conditions	Filtered inflight	
	Desired	Actual
Time from lift-off, sec	298.79	298.05
Space-fixed velocity, ft/sec	17 572.4	17 571.9
Vertical velocity, ft/sec	2 850.3	2 849.7
Yaw velocity, ft/sec	0	-1.0

5.5.6 Electrical System

Operation of the electrical system was satisfactory during the countdown and throughout flight. All electrical parameters were at normal levels and remained within tolerance.

During the period that the TLV was on internal electrical power (from LO minus 100 seconds to loss of telemetered data at LO plus 571 seconds), three intervals of inverter output voltage and frequency instability occurred. No dc power fluctuations of the inverter input supply were noted at anytime during the countdown or flight. The inverter fluctuations occurred between lift-off and LO + 111.0 seconds, between LO + 210.0 and LO + 305.0 seconds, and between LO + 515.0 and loss of telemetered data at LO + 571 seconds. Maximum 115 Vac oscillations were 0.7 of a volt peak-to-peak at a frequency of 0.7 cps. The maximum cyclic variation in the 400-cycle ac was 0.3 cps. Similar cyclic variations of the inverter outputs had occurred during the preflight checkouts of this TLV and had been noted also for the TLV used for the Gemini X mission. This condition is attributed to cycling of the flight control gyro heaters, when small electrical loads are present. In all cases where the electrical dc input or ac output fluctuations were noted, the magnitude and frequency of the variations were well within specification and no effects were noted on the systems using this power source.

5.5.7 Instrumentation System

5.5.7.1 Telemetry.- The TLV telemetry system operated satisfactorily throughout the flight. One lightweight telemetry package was utilized to monitor a total of 110 parameters on nine continuous and five commutated channels. All provided usable data for a system recovery of 100 percent.

Measurement P15T (engine compartment air temperature) indicated that an open circuit occurred at booster section jettison (staging), but the measurement provided satisfactory data during the period of predominant interest. This open circuit has occurred at this same time on other flights and is attributed to sustainer exhaust blowback.

Four potentiometer-type pressure measurements in the engine system exhibited transducer wiper-arm lift-off conditions during the flight. Qualitative data were obtained during the time interval of intermittency. This condition has occurred previously on four hydraulic pressure measurements and, in those instances, was corrected by using variable-reluctance pressure transducers.

5.5.7.2 Landline.- The landline instrumentation system provided a total of 48 analog and 57 discrete vehicle measurements. Of the 105 measurements, there was one failure. The sensor that measured the sustainer turbine inlet temperature failed to an open condition during the engine-start sequence. This sensor frequently burns open during the start sequence.

5.5.8 Range Safety System

Operation of the Range Safety System was satisfactory. No range safety functions were required or transmitted, and no spurious command signals were received or generated. Range-safety plots and telemetry readouts in Central Control were normal throughout the flight. The ground-based transmitter was turned off at LO + 312.3 seconds.

The RF signal strength received at command receiver no. 1 indicated that sufficient signal margins were available for proper operation of the RF command link at all times during the flight.

5.6 GATV/TLV INTERFACE PERFORMANCE

The Gemini Agena Target Vehicle (GATV)/Target Launch Vehicle (TLV) interface was satisfactory during the ascent and separation phase. Accelerometer and separation-monitor data indicated a normal separation sequence between the GATV and the TLV.

5.7 GEMINI SPACECRAFT/GATV INTERFACE PERFORMANCE

The performance of the spacecraft/Target Docking Adapter (TDA)/Gemini Agena Target Vehicle (GATV) interface was satisfactory throughout the flight with two exceptions: (1) the L-band system malfunction which is discussed in section 5.1.5, and (2) the TDA mooring drive system anomaly. All other systems functioned within the specification requirements of reference 19. The performance of the electrical, mechanical, and command system interface was derived from instrumentation of various systems and from crew observations.

The GATV status display panel and the acquisition and approach lights functioned normally throughout the flight. Aerodynamic shroud jettison at 383 seconds after lift-off was normal. The TDA skin temperatures are discussed in section 5.4.1.

During the first rendezvous, the GATV was initially acquired in sunlight at a range of 75 miles. The crew reported that the running lights were used and that they were very valuable for target attitude determination during rendezvous and for alignment during docking.

The planned four dockings were accomplished—two by the command pilot and two by the pilot. All undockings were accomplished without use of the spacecraft propulsion system, the separation velocity being provided by the unrigidizing motion of the TDA cone.

The second undocking was accomplished by direct hardline signal from the spacecraft, and, at that time, the mooring drive system anomaly occurred. Postseparation telemetry data indicated that the TDA latches had not reset. This was confirmed by crew observation of the latch positions and the DOCK light on the GATV status panel, prior to the third docking. The crew transmitted the RF command to unrigidize the TDA, and the proper reset indication was obtained on the status panel and from telemetry data. No additional difficulty was encountered thereafter with the mooring drive system; however, the direct hardline control was not used for the remaining undockings.

The exact cause of the mooring drive system anomaly has not been determined. An investigation of the data and an analysis of the system revealed that the most likely cause was an intermittent failure of the latch-actuation limit switch to transfer to the reset position.

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6.0 MISSION SUPPORT PERFORMANCE

6.1 FLIGHT CONTROL

The Gemini XI mission was controlled from the Mission Control Center (MCC-H) at the Manned Spacecraft Center, Houston, Texas. This section of the report is based on real-time observations and may not agree with the detailed postflight analysis and evaluation in other sections of the report.

6.1.1 Premission Operations

6.1.1.1 Premission activities.- The flight control team at MCC-H conducted simulations and provided support to Launch Complexes 14 and 19 during the premission phase. Support was provided for the Joint Combined Systems Test on August 12, 1966; the Final Systems Test on August 19, 1966; the Simultaneous Launch Demonstration on August 31, 1966; the Simulated Flight on September 1, 1966; the Precount on September 6, 1966; the initial Midcount on September 8, 1966; the Terminal Counts for the launch attempts on September 9 and 10, 1966; the second Midcount on September 11, 1966; and the final Terminal Count on September 12, 1966.

In addition to the normal in-house simulations, Flight Controller training, and confidence testing and data flow testing, supplemental targeting tests with Burroughs were conducted by the Flight Dynamics Officers. These tests included the manual setting of octal constants for the contingency procedures which are required if the launch azimuth update at T minus three minutes does not properly transfer to the spacecraft computer.

6.1.1.2 Documentation.- Documentation was adequate in all areas, and only minor changes were required after deployment of flight control personnel to the remote sites.

6.1.1.3 MCC/Network flight control operations.- The flight control personnel began deployment to the remote sites on August 25, 1966, and the Manned Space Flight Network (MSFN) went on mission status August 29, 1966. The command and telemetry data flow tests were conducted successfully and all sites were ready to support the launch.

6.1.1.4 Gemini Atlas-Agena Target Vehicle (GAATV) countdown.- The first countdown on September 8, 1966, was officially cancelled at T minus 427 minutes because of an oxidizer leak in the Gemini Launch Vehicle (GLV). On September 10, 1966, the second countdown was cancelled at T minus 140 minutes because of a suspected malfunction in the Target Launch Vehicle (TLV) autopilot. The launch countdown on September 12, 1966, proceeded smoothly until T minus 97 minutes in the Gemini Space Vehicle count when a hold was called because of a suspected leak in the left-hand hatch of the spacecraft. The count was recycled to T minus 103 minutes in the Gemini Space Vehicle count (T minus eight minutes in the Gemini Atlas-Agena Target Vehicle (GAATV) count) and after a delay of approximately 16 minutes, the count was again picked up and proceeded smoothly to lift-off.

6.1.2 Powered Flight

6.1.2.1 GAATV powered flight.- The GAATV lift-off occurred at 13:05:02 G.m.t. The entire powered flight phase was very close to the planned sequence except that cutoff was slightly low in velocity and high in flight-path angle. The trajectory high-speed data were observed to be noisy, particularly after TLV sustainer engine cut-off (SECO) and during the early period of GATV primary propulsion system (PPS) thrusting. The inclination angle was 28.85 degrees, and the nominal and actual cutoff conditions were as follows:

Condition	Velocity, ft/sec	Flight-path angle, deg	Altitude, n. mi.
Nominal	25 367	0.004	161
Final[a]	25 362	0.049	162

[a]Based on data from the Bermuda tracking station.

At the start of the PPS insertion maneuver, there was a small negative pitch (4.7 degrees) and a positive yaw (6.6 degrees). After 13 seconds, this peak transient settled out and both of the gyro systems returned to zero. The center-of-gravity offset was determined to be about twice that of the GATV for the Gemini X mission but still not large enough to cause any offset in ΔV for the in-plane PPS firings.

6.1.2.2 Period between GAATV lift-off and Gemini Space Vehicle lift-off.- Low-speed tracking data from the Air Force Eastern Test Range predicted an orbit of 156.6 by 165.0 nautical miles. A correction from the Canary Islands station confirmed the orbit as 156.1 by 165.5 nautical miles and provided a solution which gave a recommended GLV lift-off time of 14:42:25 G.m.t. with a biased launch azimuth of 99.9 degrees and the following conditions at first relative apogee:

Condition	Recommended	Nominal
X_{RA} (spacecraft trailing displacement), n. mi.	14.39	15.00
Y_{RA} (spacecraft height displacement), n. mi.	-9.79	-10.00
T'_{AP} (time of arrival at relative apogee), g.e.t., min:sec	52:03	49:47
ΔV_A (trailing displacement rate), ft/sec	3.17	0.0

The tracking data from the Carnarvon station gave a target orbit of 156.4 by 165.6 nautical miles and the following mission planning quantities:

Recommended lift-off time: 14:42:26 G.m.t.

Launch azimuth: 99.9 degrees

Built-in hold: 2 minutes 20 seconds

GE/Burroughs successfully requested Agena Ephemeris Data (AED) at T minus 23 minutes. The following quantities calculated by the Auxiliary Computer Room (ACR) were updated to the flight crew on the launch pad:

X_{RA} = 15.91 n. mi. T'_{AP} = 52 minutes 6 seconds g.e.t.

Y_{RA} = -9.83 n. mi. ΔV_A = +3 ft/sec

The launch window was two seconds in duration based on an allowable trailing displacement deviation of 14 nautical miles to accomplish the M=1 rendezvous.

6.1.2.3 Gemini Space Vehicle countdown.- The actual launch countdown took place September 12, 1966, and proceeded smoothly until T minus 97 minutes when a hold was called because of a suspected oxygen leak in the left-hand hatch of the spacecraft. The door was resealed, the countdown recycled at T minus 103 minutes, and proceeded smoothly from that point. The T minus 15-minute table-II data were generated and transferred to the Master Digital Command System (MDCS) at T minus 25 minutes. The computer octal of the targeting parameters was transmitted to guidance-and-control personnel in the blockhouse at T minus 20 minutes. The tolerances to be applied to the GE/Burroughs T minus 3-minute update and the roll gimbal angle were passed to the blockhouse guidance monitor by voice. At T minus 18 minutes, GE/Burroughs received verification of the targeting data. At T minus ten minutes, the roll program information was computed to be as follows:

Start roll program:	9 seconds
Ball reading on pad:	79 degrees (94 degrees after roll)
Launch azimuth:	99.9 degrees
Steering azimuth:	96.2 degrees

At T minus three minutes, the final oxygen heater cycle was initiated to enable the spacecraft to reach the Carnarvon tracking station before it became necessary for the crew to activate the heater again. Also, at T minus three minutes, the proper updates were sent by GE/Burroughs to MCC-H and to the spacecraft.

6.1.2.4 Gemini Space Vehicle powered flight.- The launch phase was essentially as planned. The recommended lift-off time was 14:42:26 G.m.t. The actual lift-off occurred at 14:42:26.546 G.m.t., and was reported to the crew as 0.5 of a second late. GE/Burroughs computed a steering command at 2 minutes 52 seconds g.e.t. instead of at 2 minutes 48 seconds g.e.t., as predicted. The Impact Predictor (IP) was very noisy at lift-off and GE/Burroughs was selected as the prime source at lift-off plus eight seconds. The Stage I trajectory was very close to nominal, with the maximum flight-path angle being 0.05 of a degree low and converging to the nominal at a velocity ratio $\left(V/V_R\right)$ of 0.13. The trajectory then began lofting very slightly, and, at staging, the flight-path angle was about 0.07 of a degree high. Approximately 30 seconds after lift-off, the fuel-cell section 1 oxygen-to-water delta pressure light came on, went off at staging, back on at second stage ignition, and off at second stage engine cutoff (SECO). This same indication was observed during the Gemini X mission.

The Stage II powered flight plot was nominal with very little noise. The third scale of the V/V_R vs γ plot (MCC-H gamma plotboard) had essentially no noise with the cutoff occurring well within the M=1 rendezvous limits. The cutoff conditions computed by the Real Time Computer Complex (RTCC) prior to the Insertion Velocity Adjust Routine (IVAR) maneuver were as shown in the following table:

Source	Velocity, ft/sec	Flight-path angle, deg	Number of data points	Radial velocity (R) desired, ft/sec
GE/Burroughs	25 705.9	-0.043	19	+0.18
IP (smooth)	25 711.8	-0.085	20	+0.57
Bermuda	25 655.4	-0.195	212	-0.80
IP (raw)	25 706.1	+0.023	200	-1.07

The GE/Burroughs data source was selected during the IVAR thrusting in order to allow both of the spacecraft high-speed data sources to update simultaneously. Both spacecraft source solutions degraded considerably at approximately 0:07:30 g.e.t.

The crew readout of the Incremental Velocity Indicators (IVI's) agreed very well with ground solutions at cutoff (39 ft/sec forward and 1 ft/sec out-of-plane). The crew reported thrusting 15 seconds down, which is approximately equal to 5 ft/sec. At the time the crew read out $\dot{R}$ actual, ground solutions showed a flight-path angle of +0.01 of a degree, which is equivalent to approximately 7.7 ft/sec up.

The separation and insertion maneuvers required a total of 55 seconds aft-firing time and 22 seconds of radial-firing time for a total ΔV of 49.6 ft/sec. Prior to loss of signal (LOS) at ETR, the accelerometer bias changes were measured to be very small.

After SECO and prior to the completion of insertion thrusting, radar data (IP-raw and Bermuda) became erratic. This made the proper real-time computation of the 1A-area retrofire time impossible. Since the insertion was so near nominal, it was decided that the crew should use the precomputed 1A time, if required.

6.1.3 Spacecraft Orbital Flight

The GE/Burroughs launch vector was transferred into the orbit phase because of the poor quality of the high-speed radar data from spacecraft tracking. This meant that the transferred vector did not reflect any of the thrusting at insertion. It was decided that no calculations would be made until the low-speed solution from the Antigua station was available. This tracking showed the insertion orbit to be 87 by 151 nautical miles. The low-speed solution from Antigua data was accepted, and a Docking Initiate Logic (DKI) plan was computed to establish the out-of-plane maneuver. The solution predicted a 100 ft/sec out-of-plane maneuver with a node 12 seconds prior to terminal phase initiate (TPI). These data were obviously incorrect so no plane change was passed to the crew over the Ascension station as had been planned. When the Ascension station low-speed data were interrupted after nine data points and a DKI was generated to check the out-of-plane maneuver, the solution predicted a 4.4 ft/sec maneuver out-of-plane at 0:12:06 g.e.t. This essentially confirmed the crew calculations of approximately 3 ft/sec and the crew elected to use the onboard solution. The remaining data from Ascension were included in the solution and a TPI backup maneuver was calculated. The Two Impulse Processor was used to compute the terminal phase maneuver in both the ACR and the RTCC. The TPI backup solution was based on the vector from the Eglin Air Force Base station for GATV revolution 1 and the vector from the Ascension Island station for the first spacecraft revolution and passed to the crew over the Tananarive station. The ground backup, onboard closed-loop, and onboard backup TPI solutions were as follows:

Ground (passed to crew)	Onboard closed-loop	Onboard backup
Initiate time = 49 min 43 sec g.e.t.		
ΔV_X = +139.6 ft/sec	140 ft/sec fwd	140 ft/sec fwd
ΔV_Y = +17.0 ft/sec	27 ft/sec dn	22 ft/sec dn[a]
ΔV_Z = -6.6 ft/sec	5 ft/sec lt	4 ft/sec lt
X_{RA} = +18.9 n. mi.		
Y_{RA} = -8.6 n. mi.		

[a]Reported by the crew postflight as 27 ft/sec down.

Ground (passed to crew)

R = 22.7 n. mi.

$\dot{R}$ (closing) = 107.0 ft/sec

The TPI firing occurred just before the spacecraft reached the Carnarvon station in the first revolution. The Orbital Attitude and Maneuver System (OAMS) propellant quantity, as read onboard, was 70 percent after TPI and 56 percent just prior to docking. The reading from the Carnarvon station was about two percent higher than the ground computed value.

Over Hawaii in revolution 1, the command pilot reported that he felt that the no. 15 down-firing maneuver thruster was not providing full thrust. While station keeping over the United States in revolution 1, the crew reported that no message acceptance pulses (MAP's) were being received after transmission of commands to the GATV. The commanded functions were being executed, however, and MAP's were received on the ground. The crew was given approval for docking, which was accomplished over the Texas station on revolution 1. After docking, MAP's were received when commands were sent over the hardline.

When the crew reported they were station keeping, they were requested to turn off the GATV C-band transponder until after they had passed over the United States on revolution 1. After this, the GATV C-band and S-band transponders were turned on and the spacecraft reentry C-band transponder was turned off, and they were left in that configuration for the remainder of the mission.

After docking, the onboard OAMS Propellant Quantity Indicator (PQI) was 55 percent. This value was approximately 3.5 percent higher than the ground-computed value. Ground computations indicated that approximately 423 pounds of propellant were used for the M=1 rendezvous, leaving 250 pounds of fuel and 275 pounds of oxidizer. Additional onboard gage readings were taken at Hawaii in revolution 2, at ETR in revolution 3, at Hawaii in revolution 4, and at Tananarive in revolution 5. These readings all correlated to within three percent of the ground-computed value. The Tananarive revolution 5 reading of 43 percent was taken after docking practice. At this time, it was estimated that approximately 225 pounds of fuel and 255 pounds of oxidizer remained.

During the first revolution, the decay rate of oxygen pressure was approximately 500 psi/hr at a power level of 50 to 60 amperes. The rendezvous orbit was 156.3 by 165.7 nautical miles based on data through the Antigua station in spacecraft revolution 2.

At the Coastal Sentry Quebec tracking ship during revolution 3, an additional radar problem was mentioned by the crew. It had been noted that radar lock could not be obtained during the last series of dockings, although commands were apparently still being accepted by the GATV.

The docked GATV primary propulsion system (PPS) calibration firing was calculated based on data from the Carnarvon station for GATV revolution 3 and passed to the Agena Systems Engineer. The pertinent quantities of this maneuver are listed below:

Time of maneuver, g.e.t. 4:28:48

ΔV, ft/sec 110

Yaw, deg . . . . -90

Pitch, deg 0

The maneuver occurred on time and the crew readout of residuals and the ground report of computer readouts showed the maneuver to be very close to nominal. The readouts were as follows:

	$\Delta\dot{Z}$	$\Delta\dot{X}$	$\Delta\dot{Y}$
Onboard computer	110.4	2.7	3.3
Residuals	110.4	2.7	3.3
Guidance, Navigation, and Control (GNC)	108.8	2.2	1.2

The orbital parameters after the maneuver, as predicted from tracking by the Hawaii station during revolution 5, were 157.6 by 166.5 nautical miles.

At 7 hours 45 minutes g.e.t. the spacecraft was powered down for the first sleep period. At 8 hours g.e.t., the Reentry Control System (RCS) heater light came on. The crew turned the heaters on and left them on for the rest of the flight.

At 16 hours g.e.t., the crew ended their sleep period and powered up the spacecraft. At the Texas station in revolution 12, the crew reported that the no. 8 thruster (yaw left) was showing degradation. When trying to yaw left, the spacecraft also rolled right, thus indicating a degraded no. 8 thruster. A detailed procedure for checking out this thruster was transmitted to the crew from the California station in revolution 17, and the check was performed over the Texas station in revolution 17. The results indicated that the thruster was actually degraded.

Preparation for the umbilical extravehicular activity (EVA) was initiated at 20 hours 10 minutes g.e.t. Total EVA preparation took approximately two hours, which was about two hours less than the time allotted. After two hours of EVA preparation, the crew reported that they had gone back to the spacecraft Environmental Control System (ECS) to conserve oxygen. At 22 hours 5 minutes g.e.t., the command pilot performed his suit integrity check, which indicated a 0.145 psi decay rate in 30 seconds. The pilot performed his suit integrity check just prior to hatch opening, and although the suit pressure was not on telemetry, the pressure was read on the cuff gage and the decay rate was reported to be less than 0.1 psi in 30 seconds. The hatch was opened at 24:02:02 g.e.t. over the United States in revolution 15. During the EVA, the pilot became fatigued and had a problem with perspiration interfering with his vision so the EVA was terminated at approximately 24 hours 30 minutes g.e.t., between the Ascension and the Tananarive stations in revolution 16.

Over the Texas station in revolution 16, the hatch was again opened to discard equipment used during the EVA. The list of articles jettisoned was used to determine the new center of gravity. The spacecraft aerodynamics were then computed by the RTCC and the ACR. These quantities were loaded into the RTCC and remained unchanged for the remainder of the mission.

Over the United States in revolution 17, the crew reported that they had intermittent indications on the temperature side of the OAMS pressure/temperature gage. (Editor's note: Postflight crew debriefings revealed that the intermittent indications had occurred only during switching between parameters.)

Over the Coastal Sentry Quebec in revolution 18, the crew reported they could hear a tone of approximately 1000 cps when the cryogenic (CRYO) quantity switch was placed in the O_2 or H_2 position. This was theorized to be the 400 cps inverter output to the quantity sensor being rectified in some manner to give an 800 cps ripple which was being coupled into the audio circuit. At 31 hours 30 minutes g.e.t. over the Coastal Sentry Quebec in revolution 20, the hydrogen pressure was raised to 290 psi to obtain pressure decay rates as compared to quantity for an evaluation of the heat leak on the hydrogen bottle. At this point, the crew entered their second sleep period.

The crew was contacted by the Canary Islands station in revolution 25, and they reported having been awake for about 20 minutes and that the command pilot's window was so dirty that he was questioning the quality of any pictures taken through it. Over the Kano station in revolution 25, the crew reported that MAP's were received only after the second transmission of each command to the GATV. A tape playback from the Canary Island station showed that two MAP's were received by the ground stations for each of two commands sent to the GATV during acquisition of the spacecraft signals at the station.

Prior to the high-altitude GATV PPS maneuver, which was to occur over the Canary Island station in revolution 26, the ACR computed the injection maneuver to optimize for an OAMS-only reentry into recovery area 28-1. The midpoint of the optimized OAMS maneuver was at 190 degrees true anomaly, and the maneuver had a magnitude of 240 ft/sec. The PPS maneuvers for the high-apogee exercise were calculated for loading into the GATV velocity meter. The maneuver quantities for the posigrade firing were:

Time of maneuver, g.e.t.	40:31:39
ΔV, ft/sec	920
Pitch, deg	0
Yaw, deg	0
PPS start sequence	C
Flight control mode	7

The parameters for the retrograde PPS maneuver were:

Time of maneuver, g.e.t.	43:54:17
ΔV, ft/sec	920
Pitch, deg	0
Yaw, deg	180
PPS start sequence	C
Flight control mode	7

The posigrade height-adjust maneuver occurred over the Canary Islands in revolution 26 and tracking from that station showed the orbit following the maneuver to be 156.3 by 741.7 nautical miles as compared to the desired orbit of 156.0 by 740.2 nautical miles.

The crew called up onboard computer data following the posigrade maneuver and confirmed an almost perfect maneuver. The retrograde PPS maneuver was recomputed based on post-posigrade maneuver tracking and was updated as follows:

Time of maneuver, g.e.t. 43:52:55

ΔV, ft/sec 920

At 41 hours g.e.t., over the Carnarvon station in revolution 26, it was noted that the telemetry quality was better than expected with only minor telemetry and beacon dropouts. This indicated that the telemetry and beacon equipment performed above expectations at the increased slant ranges.

The retrograde maneuver from the high-energy orbit was performed over the United States in revolution 28. Post-retrograde maneuver orbital parameters were as follows:

	Desired	Actual
Apogee, n. mi.	163.5	164.2
Perigee, n. mi.	156.3	156.3

The crew called up onboard computer data which indicated 918 ft/sec aft, confirming a nominal firing.

Standup EVA preparation was initiated at 44 hours 5 minutes g.e.t. over the Canary Islands in revolution 28. After passing the Carnarvon station in revolution 28, it was determined that 78 pounds of fuel were required for completion of the flight plan, excluding a second rendezvous. It was estimated that 200 pounds of fuel remained, giving an excess of propellants of 260 pounds at a mixture ratio of 1.16.

Over the United States in revolution 28, both suit integrity checks were performed with decay rates of 0.2 psi in 30 seconds for the command pilot and 0.1 psi in 30 seconds for the pilot. At 46:05:50 g.e.t. over the Tananarive station in revolution 29, the cabin was depressurized for the standup EVA and the hatch was opened at 46 hours 7 minutes g.e.t.

The S013 Ultraviolet Astronomical Camera experiment was accomplished at this time at an expenditure of 25 pounds of fuel. Standup EVA was completed as planned, and the hatch was closed at 48 hours 15 minutes g.e.t., over Hawaii in revolution 30. A detailed L-band radar test procedure was formulated and transmitted to the crew from the California station in revolution 30. At the Tananarive station in revolution 31, the crew reported another command problem—commands could not be entered and MAP's could not be obtained from the GATV unless the L-band was turned on. At Carnarvon in revolution 31, it was reported that the electronic timer circuit breaker had been inadvertently opened and had remained open for four or five minutes. The Carnarvon summaries (onboard computer) showed spacecraft elapsed time lagging by 3 minutes 8 seconds. When queried, the crew stated that the command problem had probably occurred in the interval that the electronic-timer circuit breaker was open.

Final undocking, in preparation for the tether evaluation, occurred over Hawaii in revolution 31. A gage cutoff of 2.5-percent propellants remaining had been decided upon as the point where the crew were to suspend all flight plan activities. This point was the minimum deemed necessary, including gage uncertainty, for retrofire preparation. A gage reading of 10 percent was determined to be the termination point for the tether evaluation. This information was transmitted to the crew. The tether evaluation was completed at Hawaii during revolution 33, and the crew reported that they actuated the index jettison switch twice before the docking bar and tether separated from the spacecraft. (Editor's note: The pyrotechnic device for jettisoning the docking bar has a 2 1/2-second time delay after actuation. This delay is required for certain abort sequences.)

During the tether evaluation, the problems of no MAP's and no lock-on recurred frequently. GATV flight controllers reported no GATV L-band power output during the entire pass over the Texas station in revolution 31. This indicated that the L-band problems were in the GATV transponder and not in the spacecraft radar. In revolutions 33 and 34, the crew further evaluated the L-band, after separating from the GATV, and the results were the same.

After tether release, instead of a 3 ft/sec retrograde separation maneuver, a second-rendezvous prephasing posigrade maneuver was performed. The second rendezvous approach consisted of setting up a phase difference between the two vehicles in coincident orbits and initiating a transfer at a given time to effect intercept after 292.0 degrees of orbital travel (ωt = 292 degrees). The desired phase difference of 0.25 of a degree (approximately 15 nautical miles) was established by performing a small posigrade maneuver followed by an almost equal retrograde maneuver one revolution later. The maneuvers were computed as follows based on the vector from the Pretoria station for GATV revolution 34:

	Separation	Stand-off
Time of maneuver, g.e.t.	53:24:56	54:37:27
ΔV, ft/sec	8.8	8.9
ΔV_X, ft/sec	+5.1	-5.0
ΔV_Y, ft/sec	-7.1	-7.4
ΔV_Z, ft/sec	0.0	0.0
Thrusters	Forward (posigrade)	Aft (retrograde)

At 54:21:50 g.e.t., over the Coastal Sentry Quebec in revolution 34, the hydrogen-tank annulus squib was detonated. At Hawaii in revolution 34, at 54 hours 37 minutes g.e.t., the output of fuel-cell stack 2C was observed to be zero. The crew was asked for an onboard readout, which confirmed the ground indication, and stack 2C was turned off for the rest of the mission.

A playback of the dump data reflected the beginning of stack degradation at 54:27:57 g.e.t. and the output current read zero 21 seconds later at 54:28:18 g.e.t. which indicated a membrane failure.

Over the Rose Knot Victor tracking ship in revolution 35, at 55 hours 15 minutes g.e.t., the secondary B-pump was turned off to reduce the power load to obtain an increased bus voltage for the D015 Night Image Intensification experiment. The five remaining stacks continued to operate for the duration of the mission without noticeable degradation. Over the Rose Knot Victor in revolution 36 at 58:22:00 g.e.t., the hydrogen pressure was again increased to 294 psi to determine the performance of the tanks after activating the squib and to determine whether the activation of the squib decreased the heat leak of the bottle. At this point, the crew entered a sleep period.

Over the United States in revolution 40, the crew was awakened. Over the Canary Islands revolution 41, the rendezvous intercept update quantities were transmitted to the crew. The intercept maneuver was computed based on a desired initiation time of 65:27:21 g.e.t. The existing altitude differential was zero and the phase lag was approximately 0.4 of a degree, slightly greater than the predicted 0.25 of a degree. First estimates of the intercept maneuver based on the vectors from Carnarvon in GATV revolution 41 and from Woomera in spacecraft revolution 40 were as follows:

Time of maneuver, g.e.t.	65:27:21
ΔV, ft/sec	15.1
Thrusters	Forward
Range at initiation, n. mi.	25.1

The final TPI provided to the flight crew at the Canary Islands in revolution 41 was based on an interrupt of the vector from Antigua in spacecraft revolution 41 and was computed as follows:

Time of maneuver, g.e.t.	65:27:21
ΔV, ft/sec	15.0
ΔV_X, ft/sec	-8.7
ΔV_Y, ft/sec	+12.1
ΔV_Z, ft/sec	+1.4

Tracking after the maneuver, along with elevation angle readouts from the flight crew, indicated that the transfer trajectory was close to nominal. Since the flight crew was unaided by onboard radar, a decision was made to provide them with a ground-computed estimate of a midcourse correction to be applied at ωt = 34 degrees. The following estimate was given in directional ΔV components along the line-of-sight to the target:

Time of maneuver, g.e.t.	66:30:00
ΔV, ft/sec	6.0 (forward), 2.4 (right)

At 66 hours 30 minutes g.e.t., while conducting an experiment, the crew reported they had the GATV in view, directly overhead. This rendezvous is of significance since the closed-loop L-band radar was inoperative, and the crew flew all ground-computed maneuvers with the exception of the midcourse correction, which was completed using the onboard backup solution. At final separation, the crew performed a 3 ft/sec retrograde separation maneuver.

A propellant quantity indication of nine percent had been read by the crew over the United States in revolution 41, and at the completion of the second rendezvous, the propellant quantity indication was five percent (approximately 35 pounds of fuel remaining). Ground computations and onboard gage readings correlated to within one percent during this phase of the mission. Ground computations, based on telemetry just prior to adapter separation, indicated approximately 26 pounds of fuel and 67 pounds of oxidizer remaining.

During the second rendezvous, the crew performed a sequence of the S030 Dim Sky Photographs/Orthicon experiment and main battery no. 3 was used to increase the main bus voltage to prevent a horizontal synchronization problem with the television monitor. The battery was required from 65 hours 33 minutes to 66 hours 19 minutes g.e.t. During this period the output was approximately nine amperes. Battery no. 3 was again used from 66 hours 55 minutes to 67 hours 10 minutes g.e.t., and from 67 hours 16 minutes to 67 hours 56 minutes g.e.t. in order to maintain the main bus voltage over the 22.5 volts required for possible operations of the computer.

Mission monitoring engineers in Houston determined late in the mission that the no. 6 thruster (pitch up) was probably degraded. When queried by the Canton station in revolution 43, the crew replied that there seemed to be a slight degradation in that thruster.

Accelerometer biases were checked continually throughout the entire mission. These bias values never differed appreciably from the loaded values, so no updates were necessary.

Over Carnarvon in revolution 44, the crew reported that they were loading Module IV in preparation for reentry. The 45-1 preretrofire load was transmitted to the spacecraft when it was over the United States in revolution 43. The retrofire data that were input into the RTCC were:

Time of retrofire, G.m.t.	13:24:03
Landing	
Revolution no.	45
Area	1
Geodetic latitude, north	24 deg 18 min
Geodetic longitude, west	70 deg 0 min

6.1.4 Reentry

Retrofire occurred on time at 70:41:36 g.e.t. (13:24:03 G.m.t.) over Canton Island in revolution 44. The crew reported four good retro-rockets and an automatic retrofire sequence. The Incremental Velocity Indicator (IVI) readouts were 303 aft, 1 right, and 118 down. Telemetry data received at Hawaii showed the retrofire velocities to be 303.8 ft/sec aft, 1.3 ft/sec right, and 118.7 ft/sec down. Tracking data after retro-fire were used to compute a backup bank angle of 49 degrees and a time after retrofire to reverse bank angle of 26 minutes 37 seconds. The bank angle transmitted to the crew was 44 degrees and incorporated a 5-degree bias to account for the shift in the center of gravity. An initial down-range indication of 63 positive (up-range) was computed from flight crew readouts of the IVI's.

After communications blackout, the crew reported that all systems were operating normally and that the automatic reentry had appeared to be satisfactory. The RCS propellants remaining at loss of telemetry were 11.1 pounds in the A-ring and 24.7 pounds in the B-ring. Final telemetry indications showed the cross-range error to be 0.67 of a nautical mile and down-range error to be 0.14 of a nautical mile.

The entire reentry was flown in the automatic closed-loop mode with the Inertial Guidance System (IGS) landing point at 50K feet reading 70 degrees 0.6 minutes west and 24 degrees 19.7 minutes north.

6.1.5 Gemini Agena Target Vehicle Orbital Flight

The GATV was gyrocompassed to minus 90 degrees over Hawaii during revolution 1 in preparation for the M=1 rendezvous. As the spacecraft was closing in for the initial rendezvous during GATV revolution 2, the crew reported intermittent L-band radar lock with the GATV, as well as erroneous readings of azimuth and elevation and failure to receive MAP's. The crew transmitted a command for acquisition lights off and verified the function occurred. Telemetry MAP's were received on the ground for this and all other commands transmitted. The GATV telemetry parameter for L-band-transponder RF output exhibited erratic behavior during the same period. It was thought that switching antennas would correct the problem, but, during the antenna switching, no MAP's were received. It was determined that all commands were being executed even though no MAP's were being received so approval for docking was given from the Texas station in revolution 2.

Docking occurred over the United States on GATV revolution 2, and was performed in flight control mode 1. This was the first time a docking was accomplished in this mode. No noticeable attitude control system (ACS) gas was used. In previous flights, flight control mode 6 was used for docking which resulted in higher ACS gas usage than anticipated due to high docked gains and high horizon sensor gains resulting in excessive torquing of the roll and yaw gyros. After docking, the GATV was gyrocompassed to +90 degrees. The spacecraft had no problem in receiving hardline MAP's after docking. Although the crew reported occasional receipt of RF MAP's at close range during docking practice, no L-band radar RF output was ever again observed via telemetry. Indications were that, during GATV revolutions 2 and 3, the GATV L-band transponder experienced a partial, then a complete failure.

During the docking practice in GATV revolution 3, the crew reported both of the Target Docking Adapter (TDA) DOCK and RIGID lights were extinguished after spacecraft separation had been effected by use of the spacecraft hardline unrigidize switch. The cone-unrigidize command was then transmitted from the spacecraft, whereupon the DOCK light illuminated. Inasmuch as the hardline and L-band commands enable essentially the same circuitry, it was concluded that the condition was probably caused by an unrigidize limit switch failing to close properly during the first sequence. No further problems were reported.

At 4:37:31, GATV ground elapsed time, the vehicle time word (vehicle clock) skipped ahead by 16 384 seconds, indicative of a spurious "1" appearing in the 2^{14}-second-clock-register position. Telemetry playback of this event indicated possible correlation with anomalous switching in the L-band beacon dipole/spiral automatic search circuitry. No further clock anomalies occurred prior to spacecraft reentry.

Three PPS and three SPS maneuvers were accomplished during the mission. PPS maneuver no. 1 was a docked calibration maneuver and occurred over Hawaii during revolution 4. This out-of-plane maneuver had a ΔV of 110 ft/sec and resulted in an orbit of 157.6 by 166.5 nautical miles.

A slight vehicle yaw transient due to center-of-gravity offset was noted during PPS operations. A peak transient of approximately 6.6 degrees in yaw and 4.7 degrees in pitch was observed, but it was back to zero after 13 seconds. This was noted on all PPS maneuvers, but the magnitude was so small that compensation during PPS maneuvers was not necessary.

The second docked PPS maneuver took place at the Canary Islands in revolution 27. This maneuver had a ΔV of 919.7 ft/sec and resulted in an orbit of 156.3 by 741.5 nautical miles. Due to the fuel flow rate being 0.3 lb/sec less than anticipated at insertion, a higher vehicle weight resulted. This higher weight required a longer firing time to reach the desired ΔV for both the 750-nautical-mile and the return maneuvers. The longer firing time would have resulted in a firing-time-remaining that was lower than the ten percent allowable. Therefore, in order to maintain the ten-percent firing-time-remaining after altitude run, the planned altitude was lowered from 750 to 739 nautical miles.

The third docked PPS maneuver occurred over the Texas station in revolution 28. This maneuver had a ΔV of 919.5 ft/sec and resulted in an orbit of 156.2 by 164.2 nautical miles.

Over Hawaii in GATV revolution 32, the crew undocked and began the tether evaluation. The rotational tether evaluation was accomplished by turning off the ACS and rotating the two-vehicle system on a 100-foot tether. The rates were determined by the GATV gyros to have reached a maximum of 1 deg/sec, creating approximately 0.001g.

After completing the tether evaluation the spacecraft separated from the GATV over Hawaii in GATV revolution 34. The GATV was then stabilized and later gyrocompassed to minus 90 degrees in preparation for the second rendezvous. For the duration of the mission, following separation after the tethered station-keeping evaluation, the L-band-transponder automatic-search (antenna-switching) indications were not as had been expected. No antenna cycling was observed at regular 6-second intervals, and infrequent changes of state occurred at random.

In GATV revolution 43, an anomaly was discovered in the horizon sensor output. This caused the postponement of the first planned SPS firing. The problem started with small excursions in the roll horizon sensor output channel and was first thought to be the tether or some other object passing close to one of the horizon sensor heads (located about eight feet back of the TDA on the underside of the GATV). During the second rendezvous, the crew confirmed the position of the tether as being straight up. Since the tether could now be ruled out as causing the problem, the problem was attributed to the horizon sensor. An analog record of the horizon sensor output was sent to the GATV contractor for analysis, and they concluded that the problem was in the horizon sensor electronics. The GATV was allowed to stabilize in flight control mode 1 (a control mode in which the excursions in the horizon sensor roll channel would not greatly affect the roll or yaw gyro position) and the two SPS circularization firings were made inertially.

The first SPS Unit II firing took place over Hawaii in revolution 48. The ΔV was 47.3 ft/sec and resulted in an orbit of 153.7 by 190.3 nautical miles.

The second SPS Unit II firing occurred over the Rose Knot Victor in revolution 49. The ΔV was 62.9 ft/sec and resulted in an orbit of 187.7 by 191.7 nautical miles. Between the first and second SPS firings, the problem in the pitch channel of the horizon sensor had become much worse. After the second SPS firing, the horizon sensors were turned off and the GATV was allowed to coast inertially while the horizon sensor outputs were observed.

The GATV was then stabilized in flight control mode 1 and guidance tests, consisting of gyrocompassed and commanded yaws, were performed to determine the capability to maneuver and maintain a specific heading. During this time the horizon sensor problem randomly reoccurred, making precise vehicle attitude determination uncertain. This necessitated a decision to delete the PPS propellant-depletion firing because vehicle attitude might have caused reentry. The SPS over-specification firing was substituted because it would not cause the GATV to reenter immediately.

The 70-second over-specification firing occurred over the Texas station in revolution 59. This firing had a ΔV of 215.5 ft/sec and resulted in an orbit of 181.2 by 191.0 nautical miles. Tracking after this firing indicated the GATV heading was within ±4 degrees of the intended 0, +90, 0 vehicle heading. After the completion of this firing, the ACS gas remaining was insufficient to allow further GATV maneuvers.

On September 16, 1966, in GATV revolution 60, MCC-H terminated GATV support. A team of Flight Controllers went to the station at Corpus Christi, Texas, to continue tests of the GATV electrical system. The vehicle weight and consumables remaining at the end of MCC-H support were as follows:

PPS ΔV, ft/sec	784.14
SPS ΔV, ft/sec	302.6
PPS firing time, sec	6.42
SPS (Unit II) firing time, sec	88.3
Vehicle weight, lb	4032.5
Control gas remaining, lb	0.0
Ampere hours remaining, A-h	940.0

6.2 NETWORK PERFORMANCE

The network was placed on mission status for Gemini XI on August 29, 1966, and supported the mission satisfactorily. The GAATV lift-off occurred at 13:05:02 G.m.t. on September 12, 1966. The Gemini Space Vehicle lift-off occurred at 14:42:27 G.m.t. on September 12, 1966, and the spacecraft landing occurred at 13:59:34 G.m.t. on September 15, 1966.

6.2.1 MCC and Remote Facilities

The network configuration and general support provided by each station are indicated in table 6.2-I. For this mission, the station at Guaymas, Mexico, was released from all support other than air-to-ground remoting, S-band radar tracking, telemetry receive and record, and teletype and voice communication. The purpose of the release was to permit the station to complete the installation of modifications for the Apollo missions. Figure 4.3-1 shows the location of the worldwide network stations. In addition, approximately 15 aircraft provided supplementary photographic, weather, telemetry, and voice-relay support in the launch and recovery areas. Selected North American Air Defense Command (NORAD) radars tracked the Gemini Launch Vehicle (GLV), Target Launch Vehicle (TLV), Gemini Agena Target Vehicle (GATV), and the spacecraft.

6.2.2 Network Facilities

Performance of the network is reported on a negative basis by system and site. All performance not discussed in this report was satisfactory.

6.2.2.1 Telemetry.- No major problems were encountered in the telemetry area. Several minor problems with hardware were resolved by use of backup equipment. A total of two minutes of telemetry data was lost during the mission, one minute and 45 seconds due to an operator error involving the Eastern Test Range (ETR) subcable. Positive corrective action has been taken; however, with the large volume of good quality data available, this loss was not significant.

6.2.2.1.1 Radar: Radar tracking during the mission was excellent. The only noteworthy problem occurred during spacecraft insertion when the Mission Control Center-Houston (MCC-H) reported that data from the Bermuda station and from the ETR were noisy and scattered. As a result, orbital determination was not refined until data were received from the

Ascension Island station. Cause of the rough data is still unknown at this time and investigations are continuing. The tracking ship Wheeling did not acquire track during spacecraft revolutions 1, 2, and 3 because of the difficulty involved with using nominal pointing data on a moving ship. The Goddard Space Flight Center (GSFC) was requested to generate 15-second pointing data for use as an additional acquisition aid. This was done and the Wheeling successfully tracked on subsequent passes.

6.2.2.1.2 Acquisition aids and timing: All acquisition aid systems operated satisfactorily during the mission with no significant problems. Only one timing problem occurred. The Woomera station reported that the hours digit was missing in the binary coded decimal timing. An on-site quick fix was accomplished with no loss of data.

6.2.2.1.3 Command: Minor hardware problems were experienced at the Antigua, Grand Bahama Island, and Texas sites. These problems did not adversely affect the mission because redundant equipment was available in each case. Command handover operations were outstanding.

6.2.2.2 <u>Computers</u>.-

6.2.2.2.1 Real Time Computer Complex: The mission was supported satisfactorily by the Real Time Computer Complex (RTCC)- Houston program; however, several minor problems were noted.

(a) During the Gemini Space Vehicle launch phase, a go/no-go was not obtained from either the Bermuda station or the Impact Predictor high-speed radar sources. A postflight investigation has determined that the Bermuda radar was off track, and that a radar bias existed between the Impact Predictor radars at Grand Turk Island and Antigua Island such that the Impact Predictor radar data could not be used to compute reasonable solutions.

(b) Radar data from the Wheeling tracking ship was not usable during the mission, probably due to station-location coordinates which were not consistent with the radar data received. Also, because of a program error, the station coordinates of the Wheeling could not be corrected in the program. A new program tape was made during the mission and was available had it become necessary to use the Wheeling data. This problem has been corrected for the Gemini XII mission.

(c) When computing the two-impulse maneuver solutions in support of the coincident-orbit rendezvous, it was determined that the formulation of the two-impulse program was not designed to compute solutions from equal-period coplanar orbits. A procedure was devised during the mission to circumvent this problem.

(d) The Communications Processor did not acknowledge receipt of a Digital Command System preretrofire-update command load sent to the Carnarvon station. A check of the RTCC output to the Communications Processor verified that the RTCC did send the load to the Communications Processor.

(e) An automatic stop occurred in the GATV Digital Command System program which automatically generates maneuver loads (as opposed to building the load manually). This stop inhibited the load generation. The problem was caused by the maneuver load being generated for a maneuver some eight hours in advance, and there were no stations in the station-contacts table that far in the future. The load could have been generated manually; however, when ground elapsed time became sufficiently close to the time for the maneuver, stations were available in the station-contacts table to which the load could be sent and the problem was resolved. This condition has been recognized and will be handled correctly during the Gemini XII mission.

(f) A telemetry computation of ampere-hours used by the spacecraft systems was made on a telemetry playback and should not have occurred; however, due to an erroneous time received for spacecraft elapsed time in the tape playback, the computation was done for 14 hours in the future. Because of the program logic, which assumes that the elapsed time is no earlier than present time, the computation could not be redone until present time exceeded the erroneous elapsed time. For the Gemini XII mission, a procedure will be followed to ensure that the computation will not be performed on a telemetry playback.

(g) A problem was found in the differential correction program which causes the next data point to have an erroneous time label, consequently, these data cannot be used to produce a usable differential correction. This can occur only when data are missing, and the probability is low that this situation will reoccur; therefore, corrective action is not required for the Gemini XII mission.

6.2.2.2.2 Real Time Computer Facility: No significant problems were encountered with the Real Time Computer Facility at Cape Kennedy.

6.2.2.2.3 Goddard Real Time System: No significant problems occurred with the Goddard Real Time System.

6.2.2.2.4 Remote Site Data Processors: The performance of the Remote Site Data Processors was satisfactory throughout the mission.

One interesting problem occurred at the Carnarvon station on launch day. The computer at the Carnarvon station faulted when a GATV summary message was requested. It was determined that the computer would fault regardless of which format was in PCM ground station no. 2. A contingency procedure was developed so that both spacecraft and GATV summaries could be generated by switching the PCM format in ground station no. 1 during the spacecraft pass. No data were lost. When the Carnarvon station came back up to support the mission on F + 1 day, the problem had disappeared and did not reoccur during the remainder of the mission.

6.2.2.3 Communications.-

6.2.2.3.1 Ground communications: There were no major communications problems during the mission. The Wheeling tracking ship was late in receiving certain necessary documentation for air-to-ground remoting equipment. The Wheeling also developed an antenna problem after the ship had left port. A new antenna was fabricated aboard ship and communications were reestablished. Several problems were encountered with command lines to Cape Kennedy; however, considerable improvement over previous missions was noted. Overall, communications were very good to excellent throughout the mission.

TABLE 6.2-I.- GEMINI XI NETWORK CONFIGURATION

Stations[a] \ Systems	Acquisition aid	Air-to-ground remoting	C-band radar	Digital Command System	Data routing and error detection	Downrange uplink	Flight controller, air-to-ground	Flight controller, manned	Gemini launch data system	GLV telemetry	High-speed radar data	High-speed telemetry data	Biomedical remoting	Radio frequency command	Remote-site data-processor summary	S-band radar	Delayed time telemetry	Riometer	Recovery antenna telemetry	R and R telemetry	Real-time telemetry display	Teletype	Voice (SCAMA)
MCC-H		X		(X)			X				X				X		X				X	X	X
MCC-K	X	X		X	X				X	X	X	X	X				X		X	X	O	X	X
A/C		X																		X			
ANT	X	X		X			X					X	X	X			X		X	X	O		
ASC		X		X															X	X			
BDA	X	X		X			X				X	X	X	X		X	X			X	O	X	X
CAL	X	X		X												X				X		X	X
CNV			[b]X			X				X			X		X					X	X		
CRO	X		X	X			X	X					X	X	X	X	X	X		X	X	X	X
CSQ	X			X			X	X					[X]	X	X		X			X	X	X	X
CTN	X	X																		X		X	X
CYI	X		X	X			X	X					X	X	X	X	X	X		X	X	X	X
EGL	X		X																			X	X
GBI	X	X	X			X				X		X	X	X		X	X		X	X	O		
GTI	X	X	X			X				X		X		X		X	X			X	O		
GYM	X	X														X						X	X
HAW	X		X	X			X	X					X	X	X	X	X			X	X	X	X
KNO	X	X																		X		X	X
MLA			X																				
PAT			X																				
PRE			X																				
RKV	X				X			X	X				[X]	X	X		X			X	X	X	X
WHE	X	X		X																X		X	X
TAN	X	X																		X		X	X
TEX	X	X		X		X						X	X	X		X				X	(*)	X	X
LIMA																		X					
WHS	X		X																			X	X
WLP[c]			X													X						X	X
WOM	X		X																			X	X

[a]Location of stations is shown in figure 4.3-I.

[b]Wind profile measurements in support of recovery operations.

[c]If available.

(X) Master DCS

O Remoting

[X] Post-pass biomed remoting

(*) Real time and remoting

6.3 RECOVERY OPERATIONS

6.3.1 Recovery Force Deployment

Recovery plans and procedures were established for the Gemini XI mission to assure the rapid location and safe retrieval of the flight crew and the spacecraft, following any conceivable landing situation. Planned and contingency landing areas were defined in accordance with the termination-of-mission probabilities. Planned landing areas included the launch site, launch abort, primary, and secondary areas. All landing areas other than these were considered to be contingency landing areas.

Department of Defense (DOD) forces provided recovery support in each of the various landing areas. The level of support provided was commensurate with the probability of a landing occurring within a particular area and with any special problems associated with such a landing. Table 6.3-1 contains a summary of those forces committed for Gemini XI recovery support. The planned landing areas in which support forces were positioned for search, on-scene assistance, and retrieval, were located and defined as follows:

(a) The launch site landing area was that area in which a spacecraft landing would have occurred following an abort prior to launch or during the early part of powered flight. It included the area in the vicinity of Launch Complex 19 and extended seaward along the ground track for a distance of 41 nautical miles. Recovery force deployment in this area is presented in figure 6.3-1.

(b) The launch abort landing area was the area in which a spacecraft landing would have occurred following an abort after approximately 100 seconds of flight but before insertion into orbit. This area originated at the seaward extremity of the launch site area and was bounded by the most northern and southern planned launch azimuths. A map of the area and an indication of the recovery support provided is presented in figure 6.3-2.

(c) Secondary landing areas were located within or near three recovery zones spaced such that a rapid recovery capability existed at frequent intervals throughout the flight. These zones were located in the East Atlantic, West Pacific, and Mid-Pacific.

(d) Primary landing areas included the region within or near the West Atlantic zone, and were supported by the primary recovery ship. The planned end-of-mission landing area for the beginning of revolution 45 was located near this zone, centered at 25 degrees 0 minutes north latitude and 70 degrees 0 minutes west longitude. Because areas within the West Atlantic zone were designated go/no-go areas and a high probability existed that the mission would be terminated with a landing in this zone, a Landing Platform Helicopter (LPH) ship with a helicopter detachment was assigned for recovery support. In addition, tracking and fixed-wing search/rescue aircraft were staged in the vicinity to assist in the recovery operation. Figure 6.3-3 illustrates the recovery zone concept and the support provided for the secondary and primary landing areas.

Provisions for recovery support in the event of a contingency landing consisted of fixed-wing search/rescue aircraft on alert at staging bases. These bases were located such that any point on the Gemini XI ground track could be reached within 18 hours after notification of spacecraft landing and included the following:

Bermuda	Dakar, Senegal
Lajes, Azores	Okinawa
Mauritius Island	Pago Pago, American Samoa
Perth, Australia	Lima, Peru
Hickam, Hawaii	San Diego, California
Tachikawa, Japan	

Where possible, preselected contingency aiming points were designated near the planned recovery zones or at positions that were close to recovery forces at the staging bases. Figure 6.3-4 shows the staging bases utilized and the contingency lines near where aiming points might have been selected.

6.3.2 Location and Retrieval

Retrofire was initiated so that landing would occur in the West Atlantic recovery zone just after the beginning of revolution 45. The U.S.S. Guam (LPH 9) was positioned at 24 degrees 17.4 minutes north geodetic latitude and 70 degrees 01.4 minutes west longitude, near the selected aiming point. Fixed-wing search/rescue aircraft and aircraft from the U.S.S. Guam were positioned in an array as shown in figure 6.3-5.

Spacecraft landing occurred at 13:59:34 G.m.t. on September 15, 1966, at 24 degrees 15.4 minutes north latitude and 70 degrees 0.0 minutes west longitude, 2.6 nautical miles from the aiming point. Position data were determined by LORAN fixes taken at the time of recovery and were checked against celestial fixes taken during the morning and evening of the day of recovery. The position of the spacecraft at the time of retrieval was 24 degrees 15.8 minutes north latitude and 70 degrees 1.1 minutes west longitude. Figure 6.3-6 shows the Gemini XI spacecraft landing position and figure 6.3-7 shows the relative aiming, landing, and pickup positions.

The following is a sequence of events as they occurred prior to and during the recovery operation on September 15, 1966:

Greenwich mean time, hr:min	Ground elapsed time, hr:min	Event
13:24	70.42	Retrofire
13:55	71:13	Electronic contact by U.S.S. Guam
13:56	71:14	Visual sighting from U.S.S. Guam
13:59	71:17	Spacecraft landing
14:00	71:18	First swimmers in water
14:01	71:19	Flight crew reported in good condition
14:06	71:24	Flotation collar attached and partially inflated
14:07	71:25	Flight crew elect helicopter pickup
14:08	71:26	Flotation collar fully inflated
14:11	71:29	Raft attached to spacecraft
14:12	71:30	Flight crew in raft
14:19	71:37	Both crewmembers aboard helicopter
14:23	71:41	Rescue helicopter with flight crew aboard U.S.S. Guam
14:40	71:58	U.S.S. Guam 150 yards from spacecraft

Greenwich mean time, hr:min	Ground elapsed time, hr:min	Event
14:42	72:00	Ship's boat launched
14:48	72:06	Spacecraft being towed to ship
14:50	72:08	Spacecraft alongside ship
14:55	72:13	Spacecraft lifted from water
14:58	72:16	Spacecraft onboard U.S.S. Guam, and collar removed

The spacecraft main parachute was successfully retrieved. The Rendezvous and Recovery (R and R) section of the spacecraft was sighted during descent, but, as expected, it started to sink after landing because it did not contain flotation material. Recovery of the R and R section was not required; however, recovery swimmers attempted retrieval and followed it to a depth of 120 feet, where automatic inflation of their life vests forced them to abandon the section and return to the surface.

6.3.3 Recovery Aids

6.3.3.1 UHF recovery beacon (243.0 mc).- Signals from the spacecraft recovery beacon were received by the following aircraft:

Aircraft	Initial time of contact, G.m.t.	Altitude, ft	Initial reception range, n. mi (a)	Receiver
Search 1 (SH-3A)	13:57	8 000	16	SPP
Search 2 (SH-3A)	13:57	8 000	16	SPP
Search 3 (SH-3A)	13:57	4 000	3	SPP
Air Boss (P-3A)	13:58	10 400	60	SPP
Rescue 1 (HC-130H)	13:58	23 000	195	AN/ARD17

[a] In all cases, the reception ranges are distances between aircraft on-station positions and the spacecraft landing point and are not maximum obtainable ranges.

6.3.3.2 HF transceiver (15.016 mc).- The HF antenna was not erected, and the transceiver was not activated.

6.3.3.3 UHF voice transceiver (296.8 mc).- All recovery forces in the primary landing area reported good voice contact with the spacecraft after 13:52 G.m.t., and recovery aircraft obtained satisfactory bearings on UHF voice transmissions from the spacecraft.

6.3.3.4 UHF survival radio (243.0 mc).- The UHF survival radio was not activated.

6.3.3.5 Flashing light.- The flashing light erected properly but was not activated by the flight crew.

6.3.3.6 Fluorescein sea dye marker.- The sea dye marker diffusion was normal, and was still satisfactory when the spacecraft was retrieved approximately an hour after landing.

6.3.3.7 Swimmer interphone.- At 14:09 G.m.t. the swimmers contacted the flight crew by using the recovery interphone. No difficulties were encountered in communicating with the crew.

6.3.4 Postlanding Procedures

The spacecraft landed very close to the recovery ship and was observed during descent on the parachute. After spacecraft landing, the recovery swimmers deployed immediately, established communications, and began installation of the flotation collar.

Inflation of the flotation collar was very slow due to a restriction in the CO_2 line. For the past year, CO_2 valves designed for the Apollo flotation collar have been used to replace the similar Gemini valves when they became unserviceable. These valves are interchangeable except for the outlet fitting that goes to the flotation tube. To compensate for this difference, a coupling and a nipple (fig. 6.3-8) must be inserted in the line between the valve and the flexible tubing that connects directly to the tube on Gemini collars. These additional fittings caused the restriction and the resulting slow inflation of the collar on Gemini XI. If the coupling and nipple are tightened excessively, the nipple will bottom out on the valve body, thereby restricting or completely stopping the flow of carbon dioxide to the flotation collar (see inset, fig. 6.3-8). This can happen only when Gemini collars are fitted with Apollo-type valves. The swim teams are well aware of this problem and have checked the collars to be used on Gemini XII. Also, there are always four collars, two in the primary swim helicopter and two in the backup helicopter. It is highly improbable that all four would be unsatisfactory. This is the only time an incident has occurred with the Gemini collars.

After collar inflation, the crew egressed the spacecraft and were transported to the U.S.S. Guam by helicopter. Spacecraft retrieval was normal, with no difficulties encountered, and observations were as follows:

(a) The HF antenna was not extended.

(b) The flashing light was erected.

(c) The dye marker was released.

(d) Both UHF antennas were erected.

(e) Both windows were about 75 percent fogged over, and a sooty deposit was on the outside of each.

(f) The heating effects appeared normal and were similar to previous spacecraft.

(g) The left pitch-down B-ring thruster leaked very slightly and the leak stopped about 30 minutes after retrieval.

(h) A horizon scanner door was stuck open.

(i) The pyrotechnic for the fresh air door had detonated.

(j) A gouge was in the lower right area of the heat shield. Also, a depression and two black marks were noted in the upper left area. The swimmers reported that these were there when they arrived on the scene.

(k) The interior of the spacecraft looked good and no moisture was found. All gear was properly stowed. The Environmental Control System hoses were not interconnected.

(l) Both ejection seat D-rings were pinned. The drogue mortars were not pinned.

(m) The hatch seals looked good.

(n) No cabin odors were detected.

Approximately two hours after landing, the news-pool film was picked up by STARS (Sea To Air Recovery System). Approximately 20 hours after landing, the flight carrying the data and film departed for Patrick Air Force Base. All urgent-return items were delivered to Patrick Air Force Base and to the Manned Spacecraft Center at Houston. The flight crew departed the U.S.S. Guam for Cape Kennedy at approximately 8:00 a.m. e.s.t., September 16, 1966. The spacecraft was off-loaded at Mayport, Florida, at approximately 12:30 a.m. e.s.t., September 16, 1966, and deactivation procedures were started.

6.3.5 Spacecraft Reentry Control System Deactivation

The Landing Safing Team (LST), consisting of NASA and spacecraft contractor engineers and technicians, was responsible for deactivating the RCS according to the procedures of reference 23. The deactivation was to be accomplished at the Mayport Naval Station, Mayport, Florida, in order to safe the system prior to transporting the spacecraft aboard a USAF C-141 to the spacecraft contractor's facility in St. Louis, Missouri.

Immediately following the arrival of the U.S.S. Guam at Mayport at 11:30 p.m. e.s.t. September 16, 1966, the spacecraft was off-loaded from the hangar deck of the ship. The RCS shingles had previously been removed on the ship, and, since no visual damage was apparent to the system, the deactivation procedures were immediately initiated by the LST. Prior to system flushing, raw propellant samples were taken for an analysis which indicated that the propellant in both rings met the required cleanliness specifications. The weights of the propellants remaining in the spacecraft before deactivation were as follows:

Ring	Fuel	Oxidizer
A	3 ounces	4 ounces
B	5 pounds 1 ounce	5 pounds 14 ounces

Personnel on the recovery ship had reported that the No. 2 thruster of the B-ring had been venting oxidizer. No visible toxic vapors were observed during the deactivation; however, bubbles were observed coming up through the flush fluid in this particular thruster.

Deactivation procedures were completed at 4:00 p.m. e.s.t., September 17, 1966, and the spacecraft was delivered to the contractor facility in St. Louis, Missouri, the same day. Following delivery, the RCS was vacuum dryed in an altitude chamber and the postflight analysis was started.

TABLE 6.3-I.- RECOVERY SUPPORT

Landing area	Maximum access time, hr:min		Support
	Aircraft	Ship	
Launch site area:			
Pad	0:05		4 LARC (amphibious vehicles) 1 LCU (large landing craft with spacecraft retrieval capabilities)
Land	0:10		1 50-ft MRV (Missile Retrieval Vessel) 2 LVTR (amphibious vehicles with spacecraft retrieval capabilities) 3 M-113 (tracked land vehicles)
Water (if flight crew eject)	0:02		3 CH-3C (helicopters) with rescue teams
Water (if flight crew are in spacecraft)	0:15		
Launch abort area:			
A-1	4:00	11:00	1 LPH (landing platform helicopter), 3 DD (destroyers) 1 AO (oiler)[a], and 4 aircraft on station (1 HC-97 and 3 HC-130)
A-2	4:00	38:00	
B	4:00	5:00	
C	4:00	12:00	
D	4:00	36:00	

[a]Deployed to this area primarily for logistic purposes; however, it also provided recovery support in the East Atlantic Zone.

TABLE 6.3-I.- RECOVERY SUPPORT - Concluded

Landing area	Maximum access time, hr:min		Support
	Aircraft	Ship	
Primary:			
West Atlantic	1:00	4:00	1 LPH from area A, station 3
Secondary:			
East Atlantic (Zone 2)	0:30 (strip alert)	6:00	1 DD, 1 AO[a]
West Pacific (Zone 3)	0:30 (strip alert)	6:00	2 DD, rotating on station
Mid-Pacific (Zone 4)	0:30 (strip alert)	6:00	1 DD, 1 AO[b]
End-of-mission (45-1):	1:00	4:00	1 LPH (from West Atlantic Zone) 2 P-3A (Air Boss 1 and 2) 6 SH-3A (3 search, 1 photo, and 2 swimmer) 2 HC-130 (rescue air-craft)
Contingency:			25 aircraft on strip alert at staging bases throughout the world
Total			8 ships, 9 helicopters, 33 aircraft

[a]Deployed to this area primarily for logistic purposes; however, it also provided recovery support in the East Atlantic Zone.

[b]Deployed in this area for logistic purposes; however, it also provided recovery support in the Mid-Pacific Zone.

NASA-S-66-8995 OCT 4

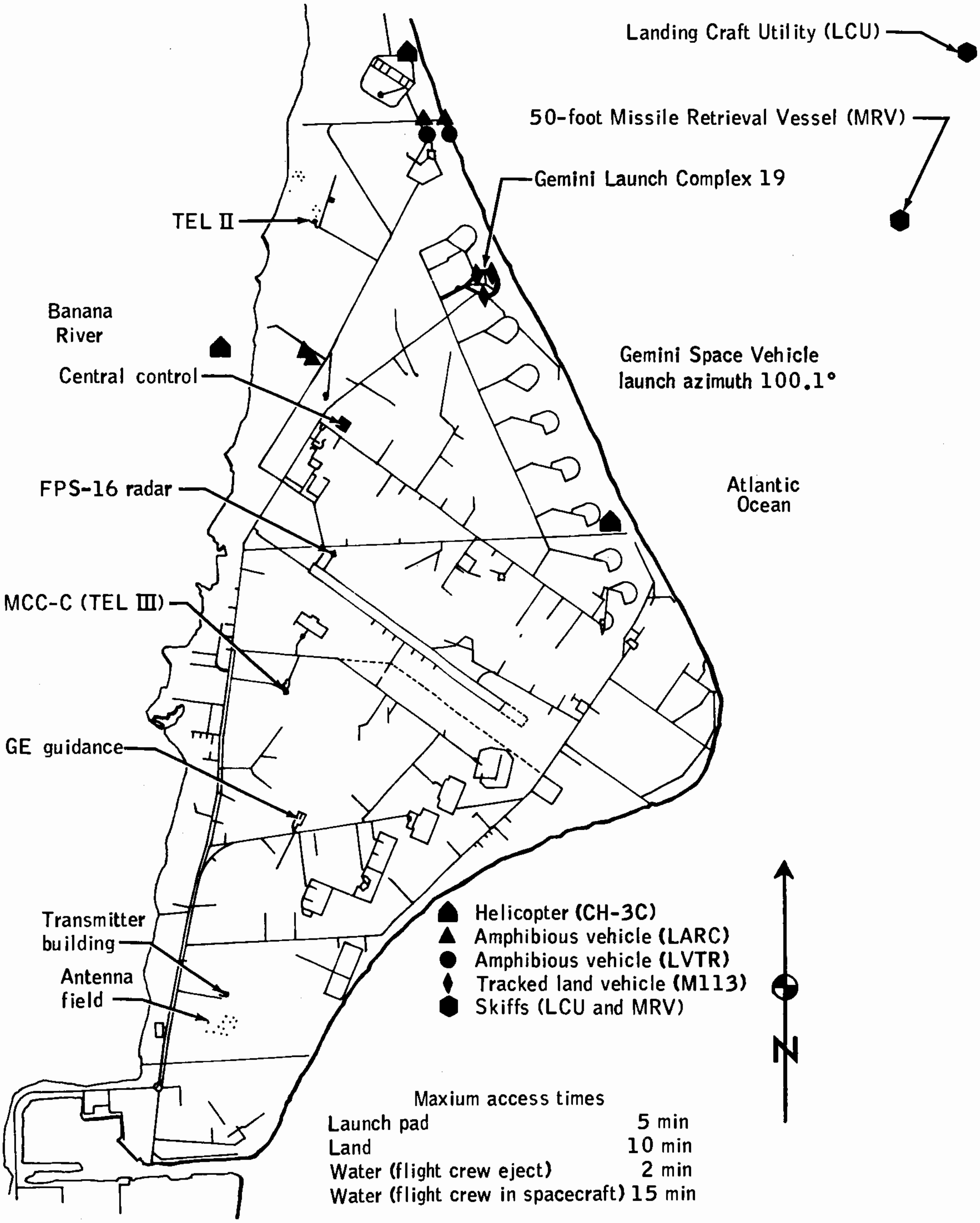

Figure 6.3-1. - Launch site landing area recovery force deployment.

NASA-S-66-9000 OCT 5

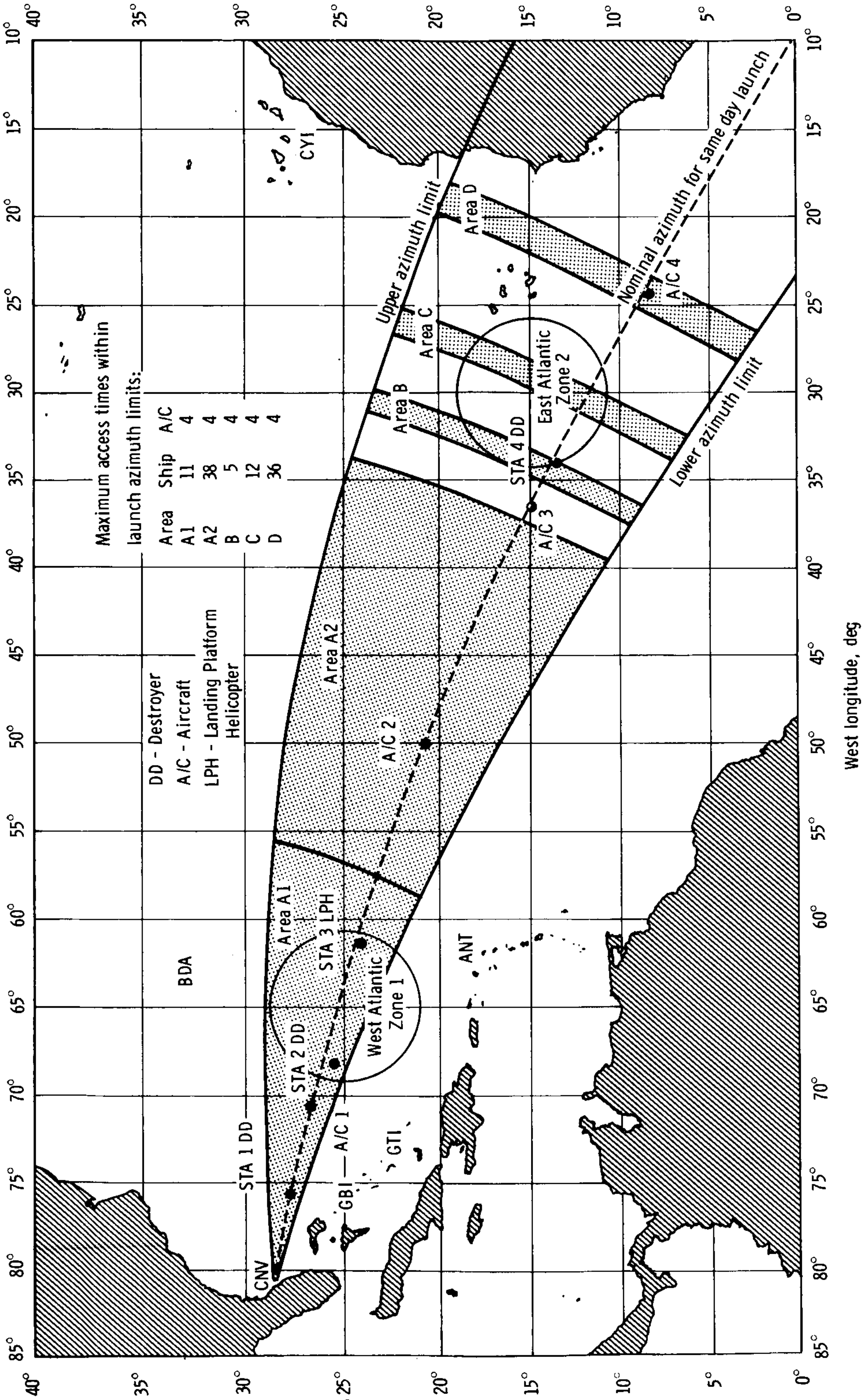

Figure 6.3-2. - Gemini XI launch abort areas with recovery ship and aircraft deployment.

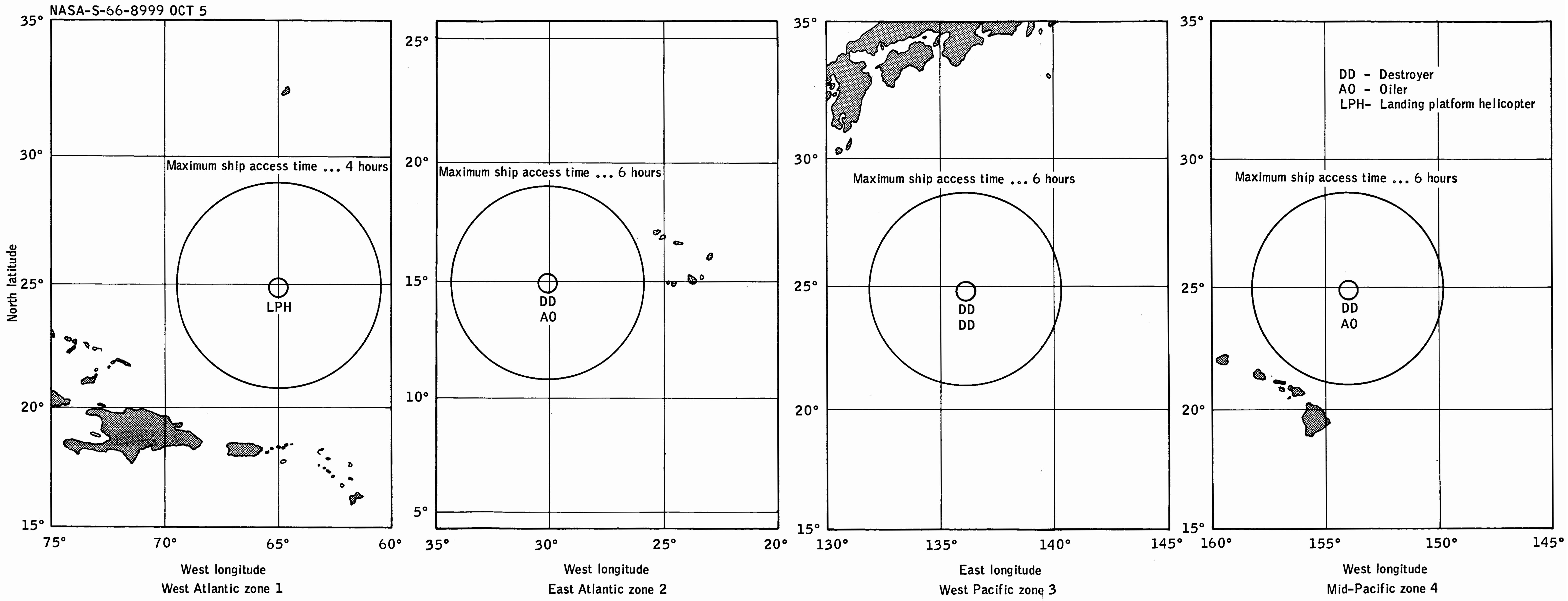

Figure 6.3-3. - Gemini XI landing zone location and force deployment.

NASA-S-66-9013 OCT 5

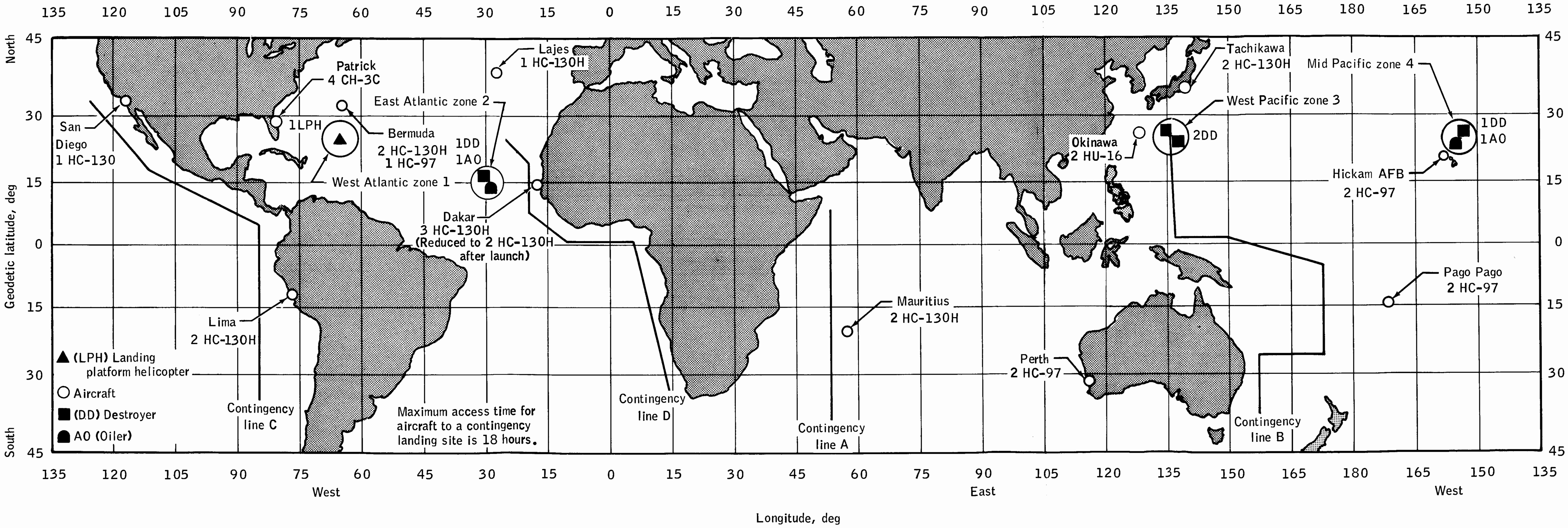

Figure 6.3-4. - Contingency recovery force deployment.

NASA-S-66-9050 OCT 11

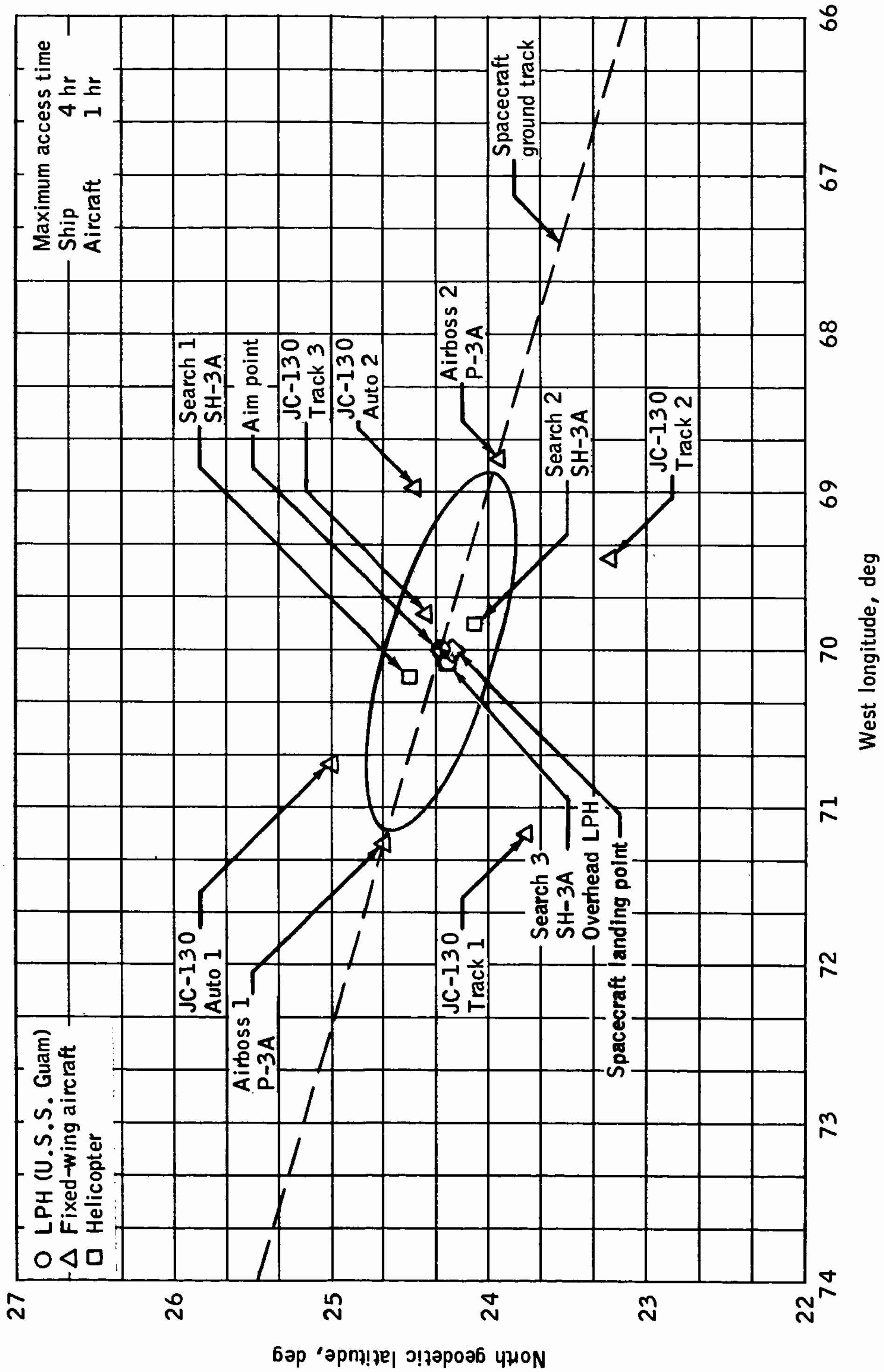

Figure 6.3-5.- Recovery force and network aircraft deployment in primary landing area.

NASA-S-66-9020 OCT 6

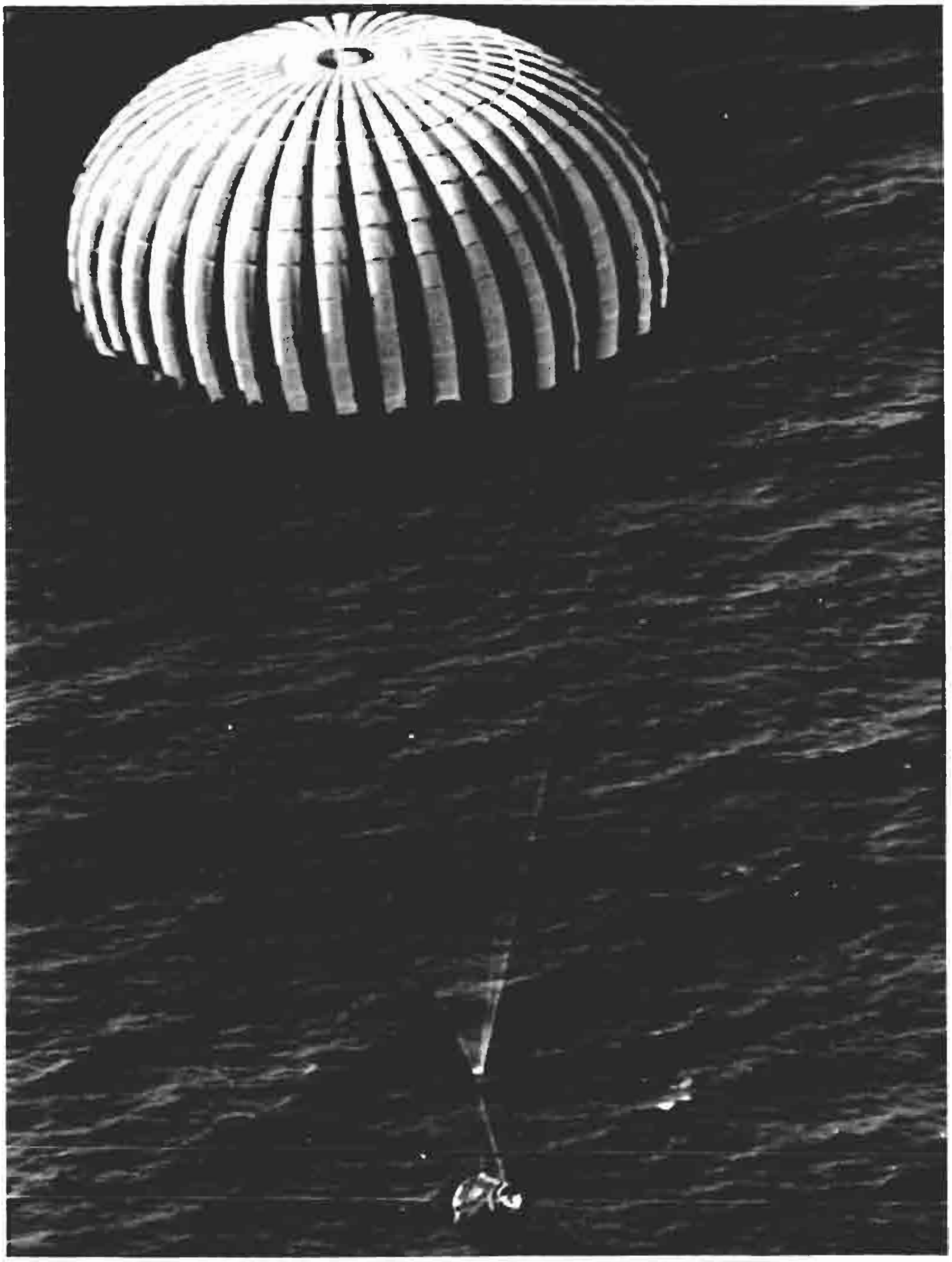

Figure 6.3-6. - Spacecraft 11 immediately before landing.

NASA-S-66-9007 OCT 5

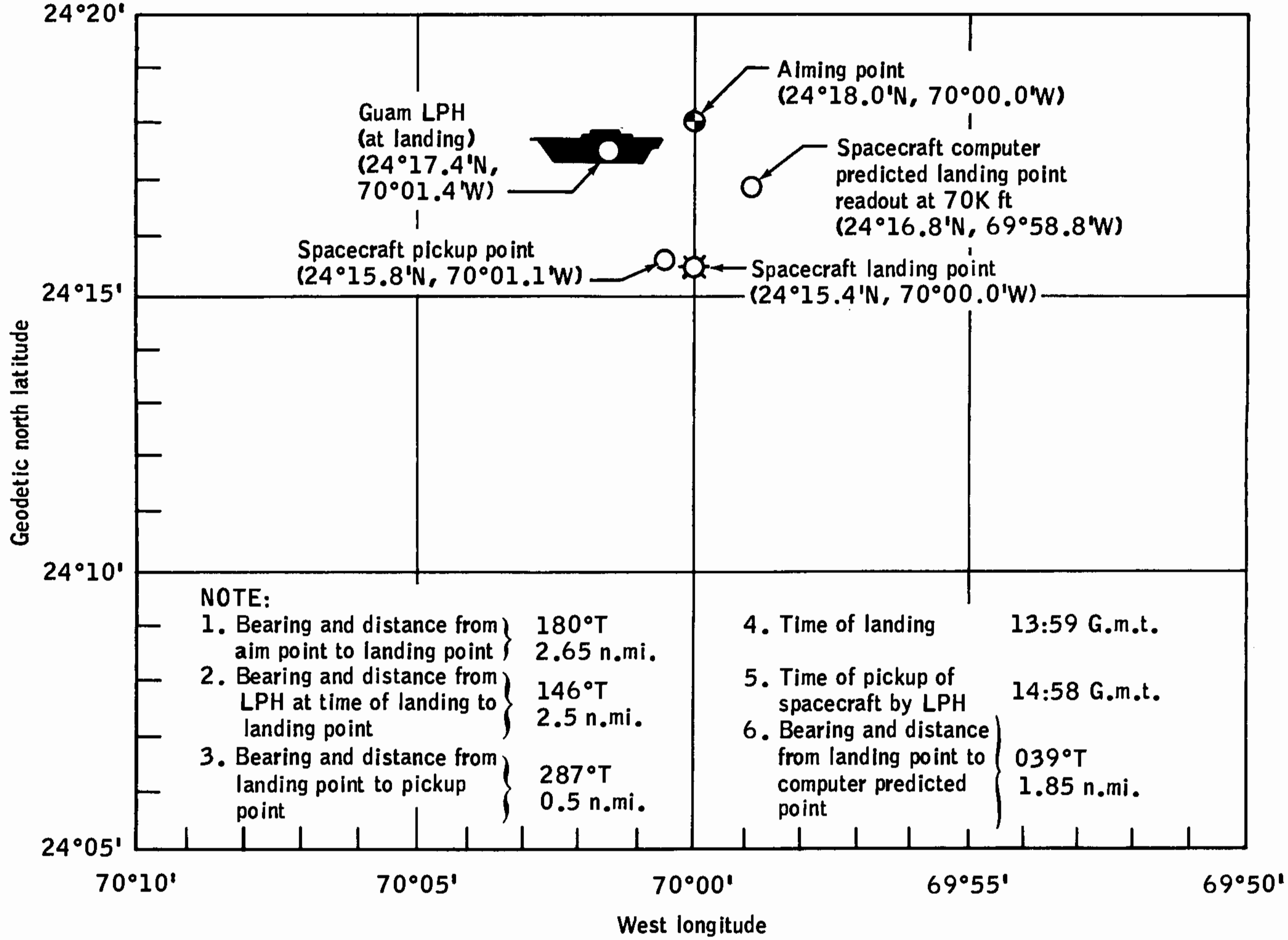

Figure 6.3-7. - Spacecraft landing information, as determined on the prime recovery ship.

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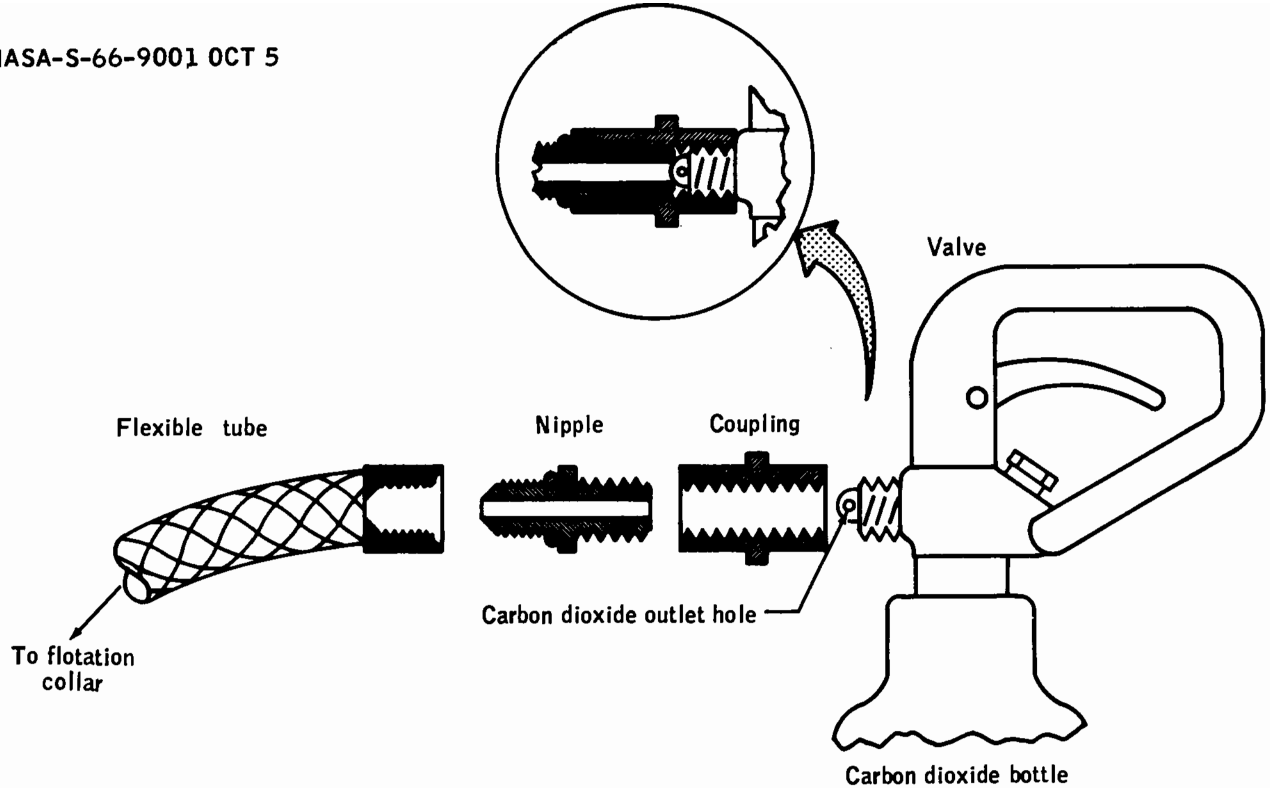
NASA-S-66-9001 OCT 5



When nipple and coupling are tightened excessively, as shown in inset, the nipple bottoms out on the valve body - note that the carbon dioxide outlet is on the sides, not through the end.

Figure 6.3-8. - Type of valve and coupling used on Gemini XI flotation collars.

UNCLASSIFIED

7.0 FLIGHT CREW

7.1 FLIGHT CREW PERFORMANCE

7.1.1 Crew Activities

The flight crew performed all planned activities and enhanced the accomplishment of all mission objectives except for the umbilical extravehicular activity (EVA) which had to be terminated because of pilot fatigue after spacecraft/GATV tether hookup and retrieval of the S009 Nuclear Emulsion experiment package. Figure 7.1.1-1 is a timeline of the mission activities.

7.1.1.1 Prelaunch to rendezvous.- The crew countdown and prelaunch spacecraft checkout activities proceeded normally. Crew reports and confirmation of events were received throughout powered flight, and the 40 ft/sec separation maneuver was accomplished resulting in a nominal orbit insertion. The crew completed the insertion checklist and then performed all required spacecraft maneuvers to effect a rendezvous with the Gemini Agena Target Vehicle (GATV) in the first spacecraft revolution. This was a demanding crew task from the standpoint of work to be accomplished, accuracy required, and decisions to be made. A complete description of the rendezvous operation is contained in section 7.1.2.

7.1.1.2 Extravehicular activity.- The extravehicular activity (EVA) consisted of an umbilical EVA and a standup EVA. An additional hatch opening was completed after the umbilical EVA to allow for jettisoning the EVA equipment. All EVA was accomplished while the spacecraft was docked to the GATV. This mode provided the desired vehicle control and freed the command pilot so that he could assist with the handling of the umbilical deployment during the umbilical EVA.

7.1.1.2.1 Umbilical extravehicular activity: Umbilical EVA preparation began at 20 hours 11 minutes g.e.t. as planned. The four hours of EVA preparation time allotted in the flight plan proved to be too much time. At 21 hours 3 minutes g.e.t. the crew commented they were ahead of schedule, and they powered down the spacecraft for a rest. The EVA preparation sequences were resumed again at 22 hours 52 minutes g.e.t. The pilot had considerable difficulty in attaching the sun visor to his helmet. This caused the pilot to become overheated and to perspire heavily before opening the hatch.

The hatch was opened at 24 hours 2 minutes g.e.t. in accordance with the flight plan. It was noted at this time that there was a tendency for all loose objects, including the pilot, to be pushed through the hatch opening. The crew believed that this effect lasted approximately 5 seconds; however, the pilot noted a less pronounced tendency to move away from the spacecraft throughout the umbilical EVA period. The pilot was restrained in the hatch area by the command pilot holding a strap on the right leg of the pilot's suit.

After the pilot had egressed the spacecraft, the forward adapter handrail was deployed. The wrist tether was attached to the Experiment S009 Nuclear Emulsion package and, after two attempts to pull it free, it was retrieved and handed to the command pilot for stowing. Difficulty was encountered in mating the EVA camera bracket to the adapter mount. The pilot had to position himself above the camera and apply an impulsive force to engage the bracket. The pilot rested briefly before pushing off from the hatch area. He then grasped the Reentry Control System (RCS) thrusters and pushed himself toward the Target Docking Adapter (TDA). He missed the TDA on the first attempt and the command pilot pulled him back to the hatch area by a slight tug on the umbilical. The next attempt was successful and the pilot positioned himself on the Rendezvous and Recovery (R and R) section of the spacecraft for attaching the spacecraft/GATV tether. This positioning task was not as easy as had been demonstrated in the zero-g simulations in an airplane. Considerable difficulty was encountered in maintaining the desired straddled position that would have allowed freedom of both hands. The pilot could maintain the desired position only by holding to the handhold on the TDA with his left hand. This position required the pilot to attach the tether to the spacecraft while using only his right hand and this complicated the installation. Another problem in attaching the tether was that the clamp spun on the docking bar when an attempt was made to tighten it. Once the clamp was tightened sufficiently to provide some friction, the tether connection was completed. During this period, the pilot was working extremely hard and was becoming fatigued in addition to perspiring freely.

An unsuccessful attempt was made to unstow the docking-bar mirror. One pull was made on the cover of the mirror; it did not deploy and no further effort was made to unstow it.

The pilot returned to the hatch area and changed the film in the EVA camera in preparation for the D016 Power Tool Evaluation experiment. In trying to rotate the camera bracket to the experiment position, it was found that the bracket would not rotate and had to be removed from the mount and replaced in the proper position. At this time, the crew reevaluated the remaining EVA workload, and, based on the work remaining and the difficulty of the work already accomplished, they decided to terminate further umbilical EVA. Ingress was normal and hatch closing presented no problem.

Crew activities during the post-ingress period were in accordance with established procedures and the equipment to be jettisoned was loaded into the jettison bag. At 25 hours 37 minutes g.e.t. the hatch was opened and the ELSS and the jettison bag were dumped overboard. The pilot performed this task with his lap belt secured, and he jettisoned the equipment out-of-plane and retrograde. The hatch was closed at 25 hours 39 minutes g.e.t. All aspects of the equipment jettison were nominal.

7.1.1.2.2 Standup extravehicular activity: To allow the crew time to eat breakfast, preparations for the standup EVA were started later than scheduled. EVA preparation began at 44 hours 39 minutes g.e.t. and proceeded according to the checklist, and the hatch was opened on schedule at 46 hours 7 minutes g.e.t.

The tendency for loose articles to float out the hatch was not noticed when the hatch was opened. Also, the pilot had no trouble maintaining his position of standing on the seat. The S013 Ultraviolet Astronomical Camera and its bracket were installed as planned, and the first nightside sequence of this experiment was successfully completed.

During the dayside pass, the lens for the S013 camera was changed, general photography was accomplished, and the crew rested. The crew reported that the circuit breaker for the suit fan no. 1 was inadvertently opened during this pass. The open circuit breaker was closed without causing any problem.

The second nightside sequence of the S013 experiment was also successfully completed, and the hatch was closed at 48 hours 15 minutes g.e.t., about six minutes prior to sunrise.

All scheduled crew activities were accomplished during the standup EVA. A more detailed description is contained in section 7.1.2.

7.1.1.3 Orbital activities.- All orbital activities were accomplished in accordance with the flight plan schedule and procedures, with the exception of the umbilical EVA, which was previously reported. The following paragraphs briefly describe the more significant crew accomplishments, and greater detail is contained in section 7.1.2.

Following the second eat and sleep period, the crew performed the first docked GATV primary propulsion system (PPS) firing at 40 hours 30 minutes g.e.t. and raised the apogee altitude to 741.5 nautical miles. During the high-apogee revolutions, the crew obtained excellent photographic data to fulfill all the requirements of the S005 Synoptic Terrain and S006 Synoptic Weather experiments. These photographs are of exceptional quality and subject matter. At 43 hours 53 minutes g.e.t., the second docked PPS maneuver was performed and lowered the apogee back to 164.1 nautical miles.

Standup EVA started at 46 hours 7 minutes g.e.t. and continued for 2 hours and 8 minutes, during which time all the scheduled activities were performed and objectives were accomplished.

The tether evaluation was initiated as scheduled; however, the tether initially deployed under intermittent tension caused by interference by the stowage container or by the Velcro which attached the tether to the GATV. After about 50 feet of the tether had deployed, it again became entangled in the Velcro or caught in the stowage container; however, with appropriate spacecraft maneuvering it was freed and the test proceeded as planned. The crew gave an excellent report on the behavior of the two vehicles, and the observed tether dynamics provided added insight into the mechanics of tethered flight. The crew obtained invaluable photographic data to supplement their description. The sequence photography taken during tethered flight was underexposed; however, there is ample image definition to serve engineering purposes.

By rotating the tethered system, a small artificial gravity field was established in orbit. The system stabilized after each perturbation, indicating that this technique may be a means of long-term station keeping with minimum propulsion fuel requirements. Though an artificial gravity was produced, as determined by a crew test of movement of objects in the spacecraft, the level was below the physiological threshold of the crew.

In addition to the planned activities, a coincident-orbit rendezvous was scheduled in real time for the third day of the mission. The crew accomplished a separation maneuver and a stand-off maneuver during revolutions 33 and 34. The terminal phase initiate (TPI) maneuver was performed during revolution 41. Terminal maneuvers were accomplished during revolution 42 and resulted in a successful rendezvous at 66 hours 40 minutes g.e.t. During this period, the scheduled experiment activities were successfully accomplished.

7.1.1.4 Experiments.- Thirteen experiments were assigned to this mission. Two of these were deleted prior to the launch day. The M407 Lunar UV Spectral Reflectance experiment was deleted prior to launch due to the lack of an adequate portion of the moon's surface being illuminated. The S029 Libration Regions Photographs experiment had to be deleted because the libration regions of the moon were in unfavorable locations for photography during the mission. Eleven experiments were flown on the mission, of which only one, the D016 Power Tool

Evaluation, was not attempted. The crew completed the remaining ten experiments as planned, and all experiment goals were met.

7.1.1.5 Retrofire and reentry.- Experiment and operational equipment stowage for reentry was completed with no significant problems. During the last revolution, the platform was aligned blunt end forward (BEF) using the Orbital Attitude and Maneuver System (OAMS) in the platform mode. Numerous attitude cross-checks were made by the crew using yaw track, star patterns, and the spacecraft guidance platform to assure correct spacecraft attitude prior to retrofire. The preretrofire checklist items were completed normally and crew observations were similar to those of prior Gemini crews.

The retrorockets were fired automatically and the pilot actuated the manual retrofire sequence as a backup. The retrofire event was flown in rate-command control mode to hold the retrofire attitude with no difficulty. Spacecraft attitude was maintained by reference to the Flight Director Indicator (FDI). A slight misalignment in yaw was noted by the crew during the firing of retrorocket no. 4, but the problem was easily corrected. Incremental Velocity Indicator readings were 303 ft/sec aft, 1 ft/sec left, and 118 ft/sec down, and were within expected limits.

After jettisoning the adapter retrograde section, the crew selected the single-ring (A) pulse mode of the RCS, and this mode was used until approximately 290K feet altitude. The crew rolled the spacecraft to 44 degrees left, which was the backup angle, and held this angle until guidance initiate. At 290K feet altitude, guidance was initiated, after which the reentry rate-command mode was selected, and the crew rolled spacecraft to the right to full lift, and the needles matched.

At 272K feet altitude, the automatic reentry mode was selected and a nominal reentry resulted. At 90K feet, the crew activated the second ring of the RCS in automatic reentry moae. The crew switched to the rate command mode at 70K feet, and no large excursions were noted. The drogue was deployed at 50K feet altitude, at which time the crew noted small excursions in pitch and yaw. The main parachute was deployed at 10.6K feet altitude and provided a normal descent.

7.1.1.6 Landing and recovery.- The landing point was approximately 2.5 miles from the planned landing point, as reported by the recovery ship. Landing was normal, and shortly afterwards a rescue helicopter from the U.S.S. Guam deployed the swimmers. The installation of the flotation collar was normal with the exception of improper inflation of the left side of the collar. No crew difficulties resulted. The crew completed the postflight checks and egressed to the liferaft from the left-side hatch. Helicopter pickup of the crew was normal, and the crew was flown immediately to the prime recovery ship.

7.1.1.7 Mission training and training evaluation.- The Gemini XI training plan was based on the fact that the crew had trained together as the backup crew for the Gemini VII mission, and that the command pilot had flown as pilot on the Gemini V mission. All training was accomplished in accordance with the Gemini XI Training Plan. A summary of training accomplished by the crew is shown in table 7.1.1-1.

The Gemini Mission Simulator and the Rendezvous Simulator were used to train for the first spacecraft revolution (M=1) rendezvous. A large amount of time was spent preparing for possible failures such as in the radar. This preparation proved to be a significant factor in achieving the M=1 rendezvous because they did have a radar problem but were able to complete the rendezvous. The Translation and Docking Simulator and the Gemini Mission Simulator were used to practice docking and station-keeping maneuvers. These tasks proved to be no problem during the mission. The Gemini Mission Simulator, with the crew in a hard suit configuration, was also used to practice the entire mission, including loose equipment usage and stowage. This training proved invaluable as a significant factor in allowing the crew to stay on the flight plan. The zero-g aircraft, the Gemini Mockup, and the air-bearing table were used to practice and develop EVA procedures. These training devices did not simulate the zero-g environment closely enough to predict the problems that were encountered during flight. The zero-g aircraft proved to be a good trainer for spacecraft ingress and egress but left a definite need in other aspects of zero-g training.

The crew utilized the facilities of the Morehead Planetarium to train for experiments, meeting there with the principal astronomical experimenters to train in star aiming to achieve the desired results.

TABLE 7.1.1-I.- CREW TRAINING SUMMARY

Activity	Training time, hr						
	Command pilot				Pilot		
	Gemini V[a]	Gemini VII[b]	Gemini XI	Total	Gemini VII[b]	Gemini XI	Total
System briefings	58.00	74.75	68.25	201.00	74.75	68.25	143.00
Spacecraft tests	73.28	75.25	73.50	222.03	82.75	70.50	153.25
Gemini Mission Simulator	108.67	101.75	151.08	361.50	101.50	135.75	237.25
Rendezvous Simulator	34.00	41.00	51.50	126.50	41.00	42.00	83.00
Dynamic Crew Procedures Simulator	14.00	11.50	14.83	40.33	2.50	6.17	8.67
Translation and Docking Trainer	N/A	10.50	8.00	18.50	9.00	8.50	17.50
Egress training	12.00	5.50	6.00	23.50	9.50	6.00	15.50
PTT	N/A	1.50	5.25	6.75	1.00	4.42	5.42
EVA briefings	N/A	15.00	10.00	25.00	15.00	10.00	25.00
Air briefings	N/A	N/A	1.00	1.00	10.00	10.00	20.00
Zero-g flying	4.00	12.00	5.58	21.58	20.50	11.42	31.92
Mockup - EVA walkthrough	N/A	4.00	46.50	50.50	11.50	46.50	58.00
Flight plan briefings	N/A	N/A	55.50	55.50	N/A	50.00	50.00
Planetarium	34.00	6.50	18.00	58.50	17.00	20.50	37.50
Experiments	N/A	N/A	37.50	37.50	N/A	33.50	33.50

N/A - not applicable

[a]Command pilot was pilot during Gemini V mission.

[b]Command pilot and pilot were backup crew for Gemini VII mission.

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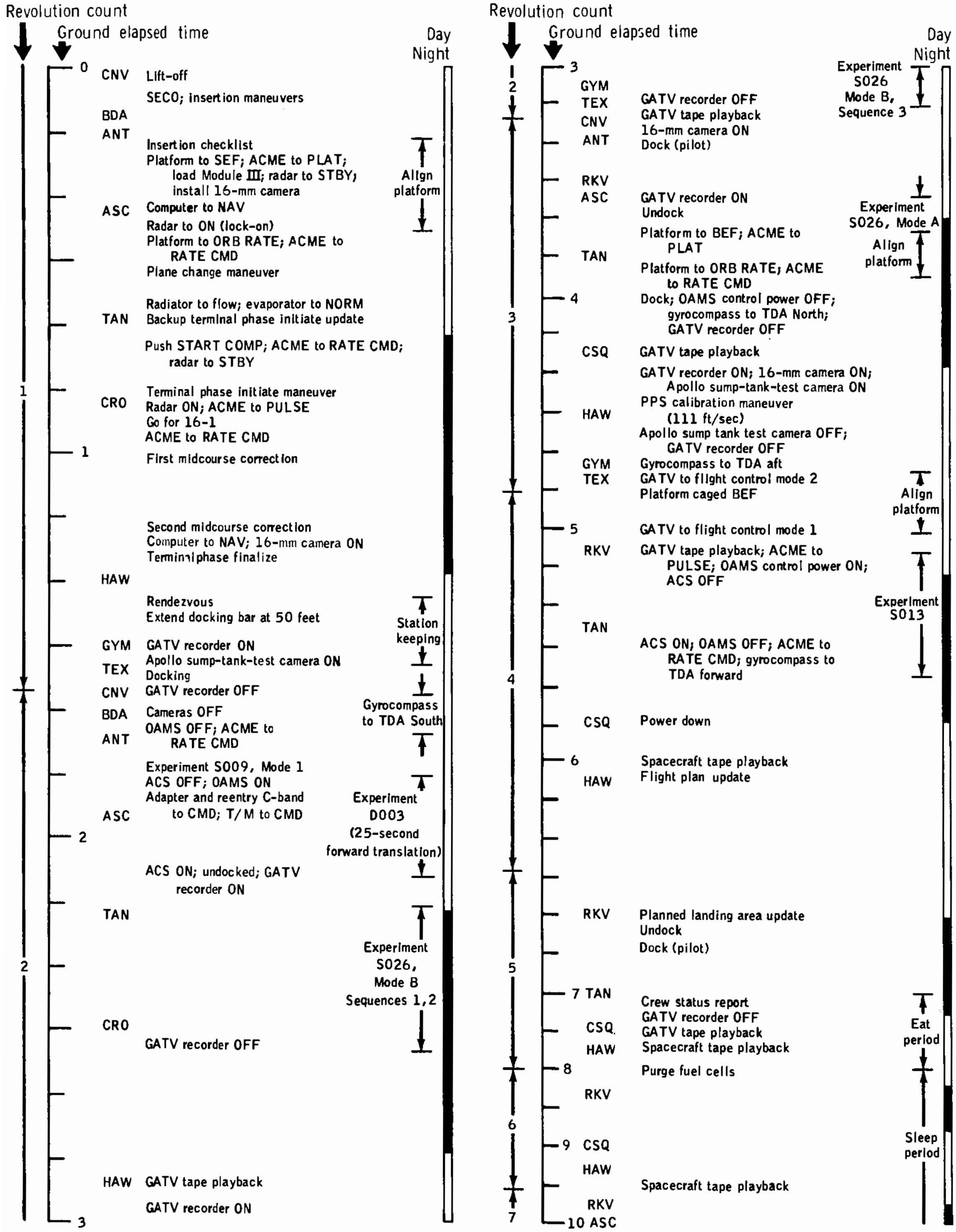

(a) 0 to 10 hours g.e.t.

Figure 7.1.1-1. - Summary flight plan.

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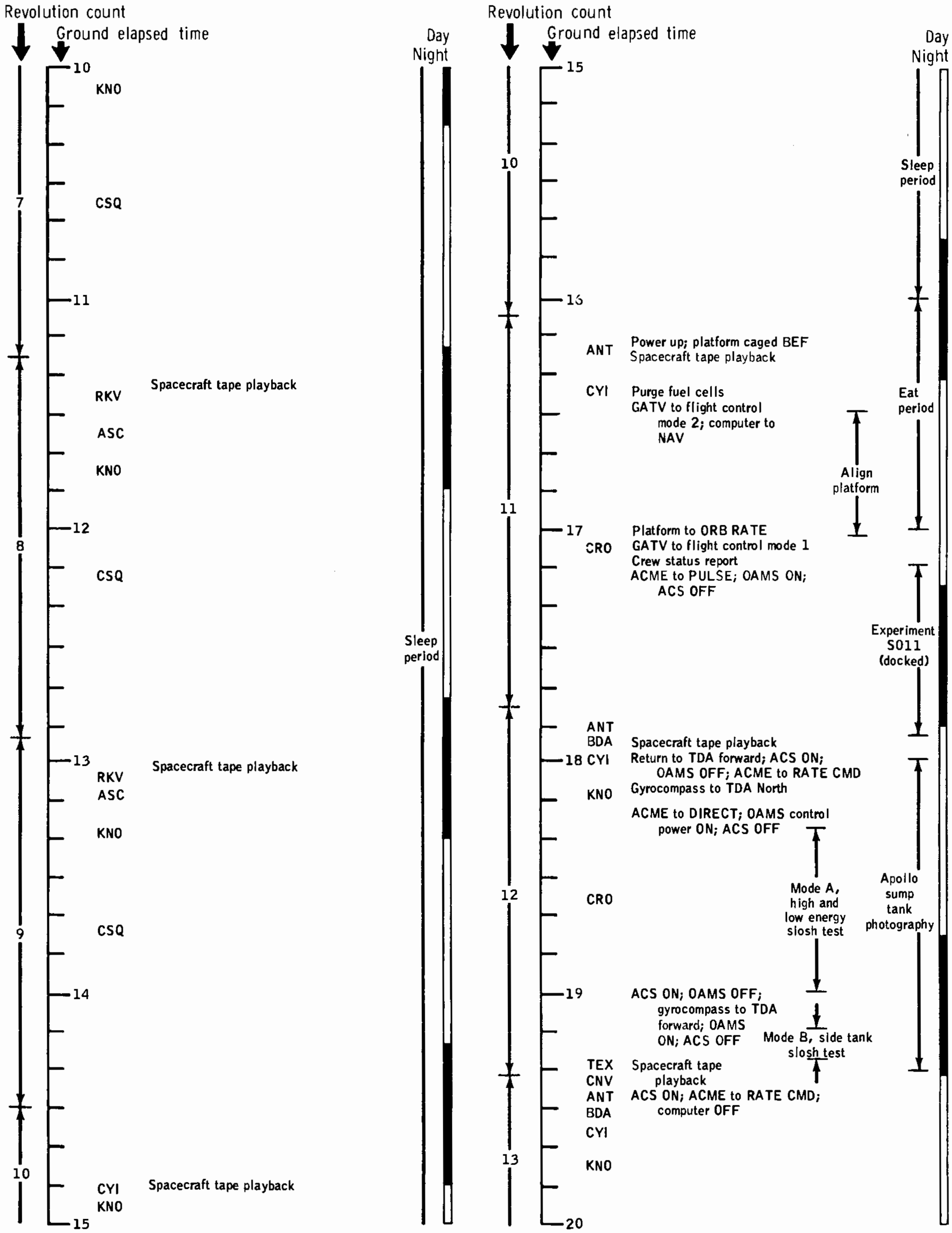
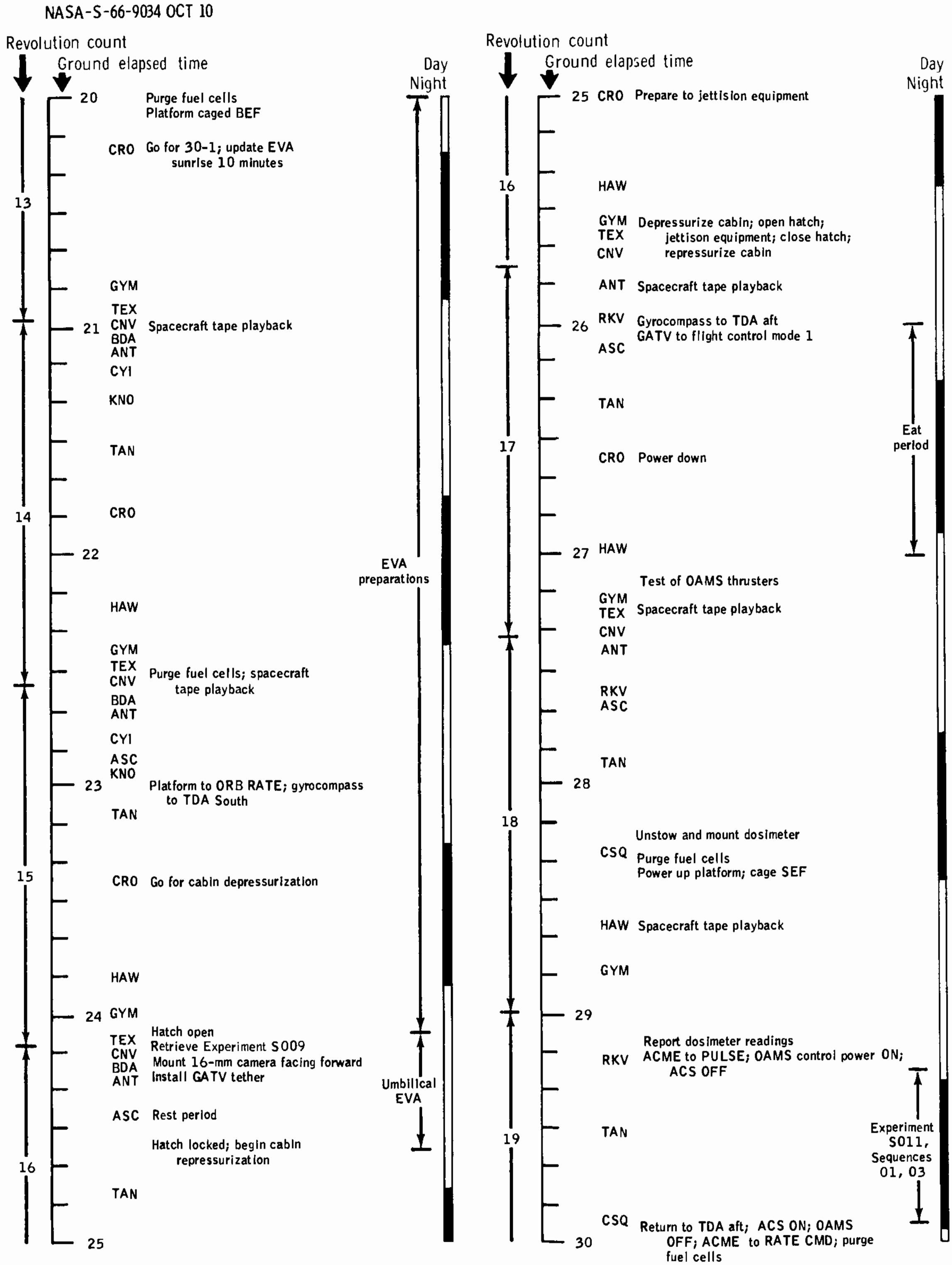


(b) 10 to 20 hours g.e.t.

Figure 7.1.1-1. - Continued.



(c) 20 to 30 hours g.e.t.

Figure 7.1.1-1. - Continued.

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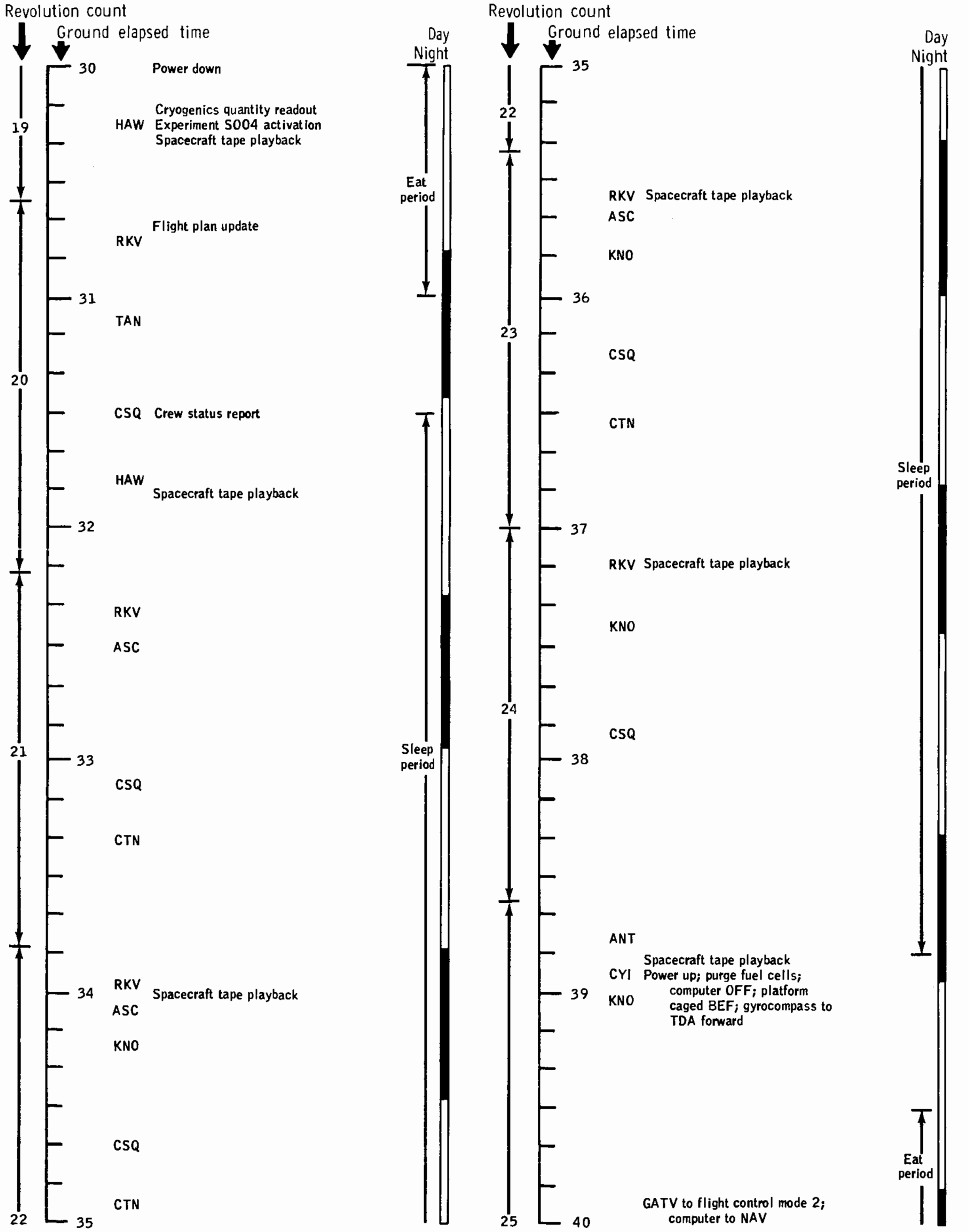
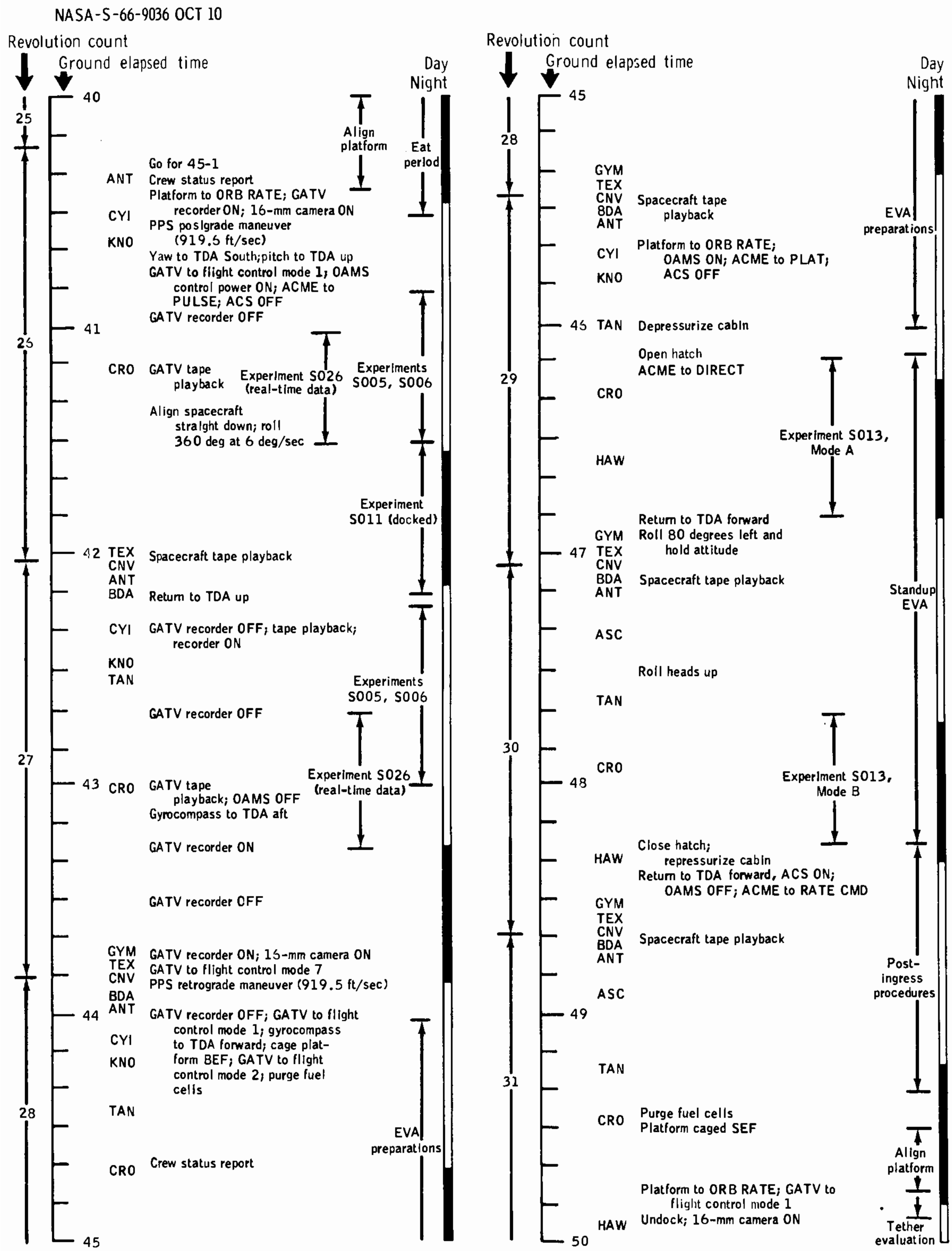


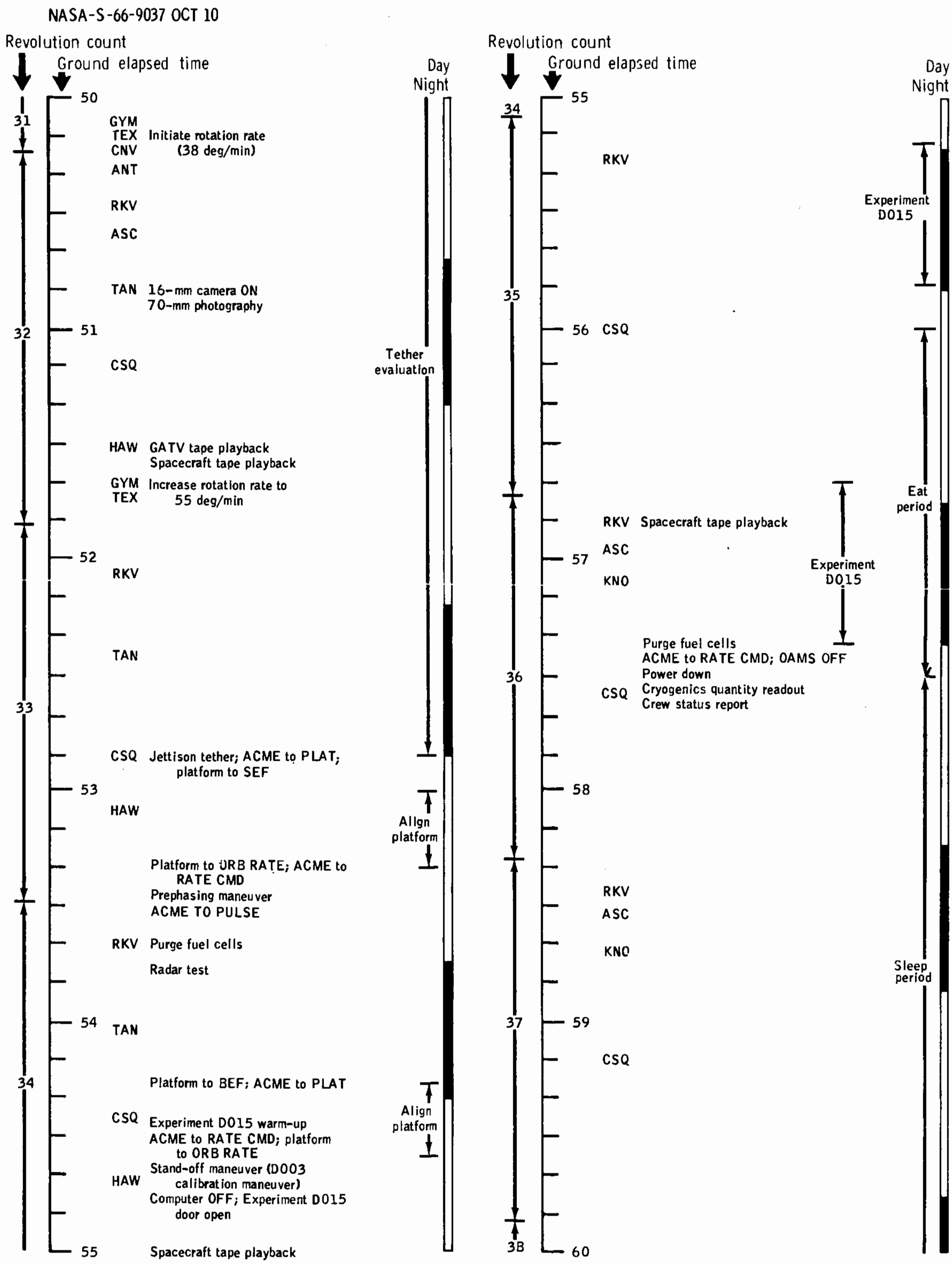
(d) 30 to 40 hours g.e.t.

Figure 7.1.1-1. - Continued.



(e) 40 to 50 hours g.e.t.

Figure 7.1.1-1. - Continued.



(f) 50 to 60 hours g.e.t.

Figure 7.1.1-1. - Continued.

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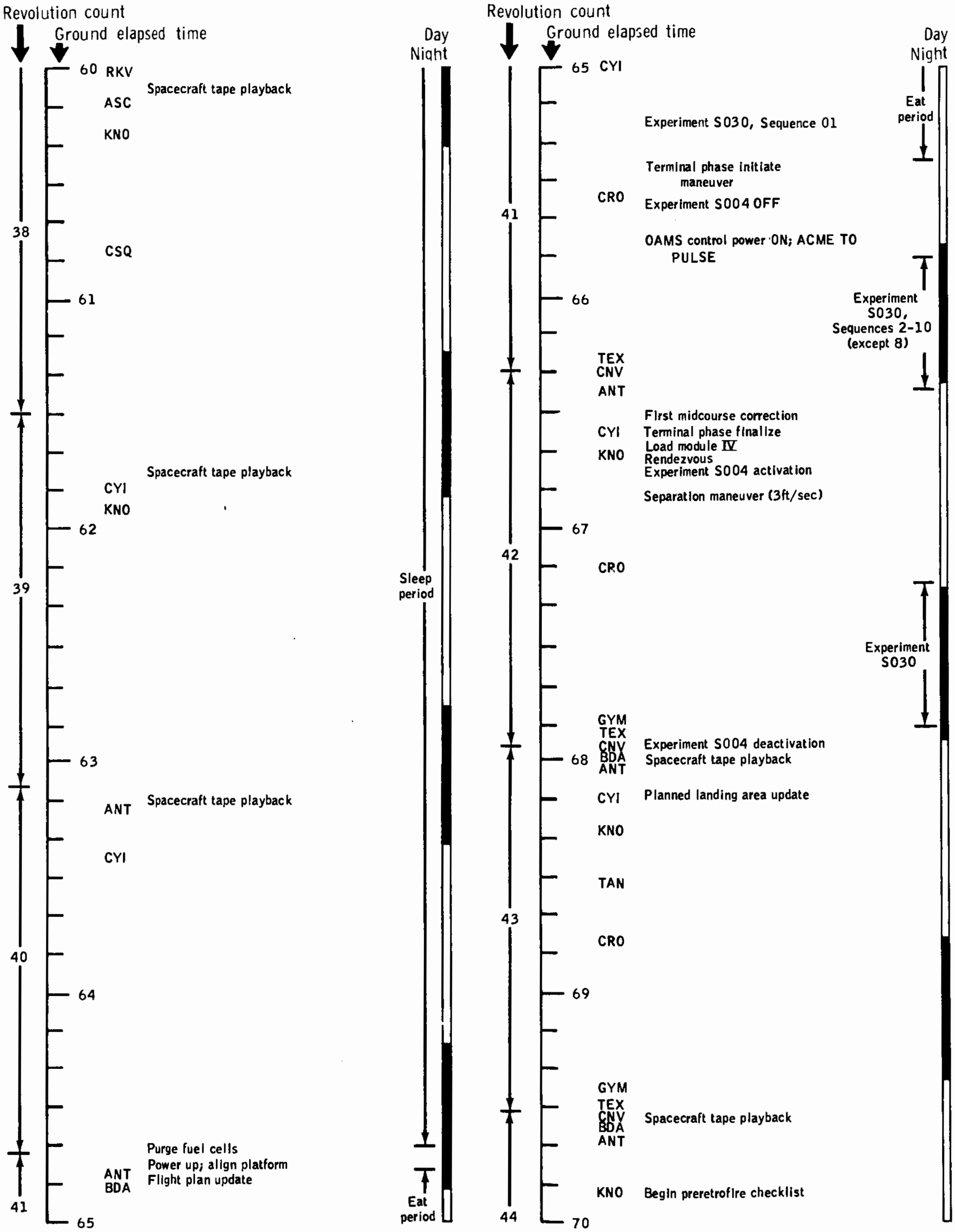
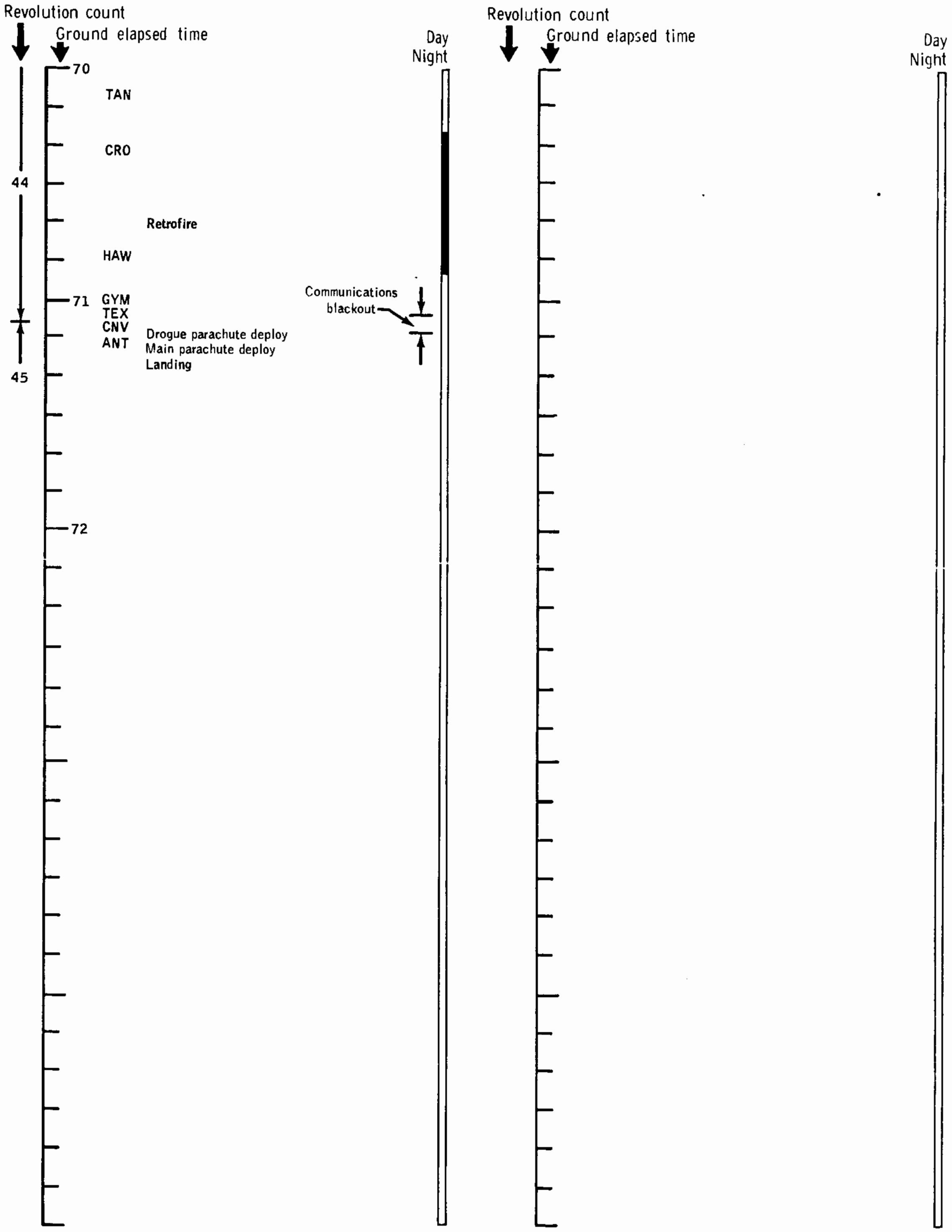


(g) 60 to 70 hours g.e.t.

Figure 7.1.1-1. - Continued.

NASA-S-66-9039 OCT 10



(h) 70 to 72 hours g.e.t.

Figure 7.1.1-1. - Concluded.

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Astronauts Richard F. Gordon, pilot, and Charles Conrad, Jr., command pilot.

7.1.2 Gemini XI Pilots' Report

7.1.2.1 Prelaunch.- Crew insertion was accomplished in accordance with the countdown procedure and was on time until the cabin purge. Approximately two minutes after the cabin purge had started, the white-room crew suspected that there was a leak around the edge of the left-hand hatch, and a hold was called just prior to lift-off of the Gemini Atlas-Agena Target Vehicle (GAATV). The hatch closing sequence was recycled, and the count was resumed after an approximate 15-minute delay. The problem with the hatch was later determined to have been a procedural error. Communications after hatch closure, using the press-to-talk position rather than the voice operated transmitter (VOX) position, were very good. The Environmental Control System (ECS) maintained the proper temperature levels throughout the terminal count.

7.1.2.2 Powered flight.- Powered flight was normal in all respects. The pitch and roll programs and staging were all on time. At staging, the pilot noticed the red flash reported by previous Gemini crews. The only problem encountered during first stage flight was the glare of the sun shining through the command pilot's window starting at approximately 1 minute 20 seconds after lift-off and lasting for 20 seconds. Sunshades had been provided to reduce the sun glare to avoid obscuring the command pilot's instruments; however, the sunshades were not sufficient for this purpose. The command pilot had to shade his eyes with his hand in order to read the instruments during this portion of the flight. The sunshades, however, turned out to be very useful during orbital operations. After staging, radio guidance initiate did not occur at 2 minutes 48 seconds as expected; however, Inertial Guidance System (IGS) initiate did and the radio guidance initiate occurred four seconds later at 2 minutes 52 seconds after lift-off. The crew had been briefed that this might occur and did not consider it unusual. Second stage flight was normal in all respects with second stage engine cutoff (SECO) occurring at 5 minutes 40 seconds after lift-off. Approximately four seconds after SECO, the second stage engine emitted two loud bangs (post-SECO disturbances) which have been referred to as "Green Man." The crew heard these rather than felt them, and again, having been briefed on this phenomenon, they did not consider the occurrence unusual.

7.1.2.3 Insertion.- After SECO and prior to spacecraft separation, the Incremental Velocity Indicator (IVI) indicated 41 ft/sec forward and 1 ft/sec left, out-of-plane. Spacecraft separation from the Gemini Launch Vehicle was commanded at 6 minutes g.e.t. The separation velocity applied was 2 ft/sec forward, after which the Insertion Velocity Adjust Routine (IVAR) read 39 ft/sec forward and 1 ft/sec left. The crew performed the maneuver using the Flight Director Indicator (FDI) references which were selected in the COMP - ATT positions. The pilot computed the firing required to correct the downrange position error. A 15-second firing of the top thruster was applied, and the resultant gain in forward velocity was removed. During this time, the pilot recorded the remaining information from the computer in order to compute the out-of-plane correction to be applied at 29 minutes 40 seconds g.e.t. After these computations were made, the insertion checklist was completed.

7.1.2.4 Platform alignment.- At approximately 10 minutes g.e.t., the guidance platform was aligned by going from FREE to small end forward (SEF) and using the pulse mode of the attitude control system. The FDI roll and yaw indicators were centered, and the command pilot visually aligned the nose of the spacecraft with the horizon for pitch reference. The scanner light was checked to see that the scanners were locked on the horizon, and, at this time, the platform mode of the control system was selected for the automatic alignment, which continued until 22 minutes 30 seconds g.e.t. At that time, the command pilot selected the pulse mode and continued aligning the platform manually until 25 minutes g.e.t. The platform was then switched to orbit rate, and orbit rate compensation was initialized in the computer.

7.1.2.5 Out-of-plane correction through initiation of closed-loop rendezvous computations.- A second out-of-plane correction of 3 ft/sec left was applied at the computed time of 29 minutes 40 seconds g.e.t. Immediately after applying this correction, the spacecraft was pitched up to 32 degrees above the horizon, the radar was switched on, and radar lock-on with the Gemini Agena Target Vehicle (GATV) occurred immediately thereafter. At the computed time of 27 minutes 29 seconds g.e.t., the elapsed timer was started counting up from zero. After radar lock-on, the computer was switched to the rendezvous mode and preparations were made for the terminal phase of the rendezvous. The GATV was acquired visually in daylight at a distance of approximately 75 nautical miles. Radar boresight was checked against the optical boresight. With the radar indicators centered, the GATV appeared 1/2 of a degree pitch up and 1/2 of a degree yaw left in the optical sight.

7.1.2.6 Terminal phase initiate.- Terminal phase onboard computations were made by measuring the pitch angle at 14 minutes and at 16 minutes after elapsed timer start. The resulting computations were 140 ft/sec forward, 27 ft/sec down, and 4 ft/sec left. The computer was started at 20 minutes 30 seconds from elapsed timer start and the closed-loop solution was computed. It was 140 ft/sec forward, 27 ft/sec down, and 5 ft/sec left. The ground solution had been transmitted as 139.6 ft/sec forward, 17 ft/sec down, and 6.6 ft/sec right. At this time, the closed-loop solution was chosen as primary and the spacecraft was pitched down to the computed attitude displayed on the FDI. Initiation of the TPI maneuver commenced at 22 minutes 24 seconds after elapsed timer start and was completed at 25 minutes 36 seconds. Radar lock was never broken during the period that the spacecraft was pitched down below the horizon.

7.1.2.7 First midcourse correction.- The necessary measurements were made at 32 minutes, 33 minutes 30 seconds, and 35 minutes from elapsed timer start to compute the onboard backup first midcourse correction. This was computed at 3 ft/sec aft and 6 ft/sec up. The closed-loop solution displayed from the computer at 36 minutes from elapsed timer start was 1 ft/sec forward, 4 ft/sec up, and 4 ft/sec right. This solution was accepted and appropriate thrusts were applied to zero all IVI's.

7.1.2.8 Second midcourse correction.- Approximately two minutes before the computer started to select the seven radar data points for computing the second midcourse correction, the command pilot noticed the radar indicators drift off in pitch and yaw. The pitch indicator drifted up three degrees and the yaw indicator drifted right three degrees. By checking optically, it was determined that this was a drift in the indicators and not an actual drift of the target. At this time, the pilot tried to select the spiral antenna through the GATV command system and failed to receive a message-acceptance-pulse (MAP) light. It was determined that there was a malfunction in the radar system, and the decision was made to compute and use the backup solution for the second midcourse correction. The measurements for this correction were taken at 44 minutes, 45 minutes 25 seconds, and 47 minutes after elapsed timer start. The backup solution was computed as 2 ft/sec forward and 1 ft/sec up. By this time, the radar pitch indicator had returned to the null position and agreed with the optical track; however, the yaw indicator had drifted from three degrees right, through zero, to three degrees left. At 48 minutes from elapsed timer start, the closed-loop solution was displayed on the IVI's as 1 ft/sec forward, 3 ft/sec up, and 11 ft/sec right. The backup solution with no out-of-plane correction was used for the maneuver. The computer was then switched from the rendezvous mode to the navigation mode, addresses $\Delta\dot{X}$, $\Delta\dot{Y}$, and $\Delta\dot{Z}$ were zeroed, and the pilot set up the command to the computer for inertial indicators. The command pilot had the GATV centered optically when the pilot sent the command to the computer for inertial indicators.

7.1.2.9 Braking and docking.- The inertial indicators were centered and line-of-sight rates were observed, using the optical sight, while the GATV was still in darkness. The digital range and range-rate information from the radar was good. At approximately three miles, it was noticed that not only was the flashing light visible but so were the two bottom running lights. At this time, the range rate was approximately 50 ft/sec and closing, with the spacecraft in the forward quadrant. At approximately 2 1/2 miles range, the GATV entered sunlight and appeared extremely bright. At this point, a 15 ft/sec braking maneuver was applied with the forward-firing thrusters. The line-of-sight rates were very low in both pitch and yaw. The pilot continued to call out range and range-rate information to the command pilot, and small line-of-sight corrections were made. The spacecraft was allowed to drift a little to the right of the GATV in the final phase of braking. The line-of-sight rates were brought to zero and the spacecraft drifted up a 105-degree line. The relative velocity was reduced to zero with the spacecraft at the same altitude, slightly to the right, and in front of the GATV. The spacecraft was then maneuvered from this point into a position for docking. The docking checklist was completed, the status display panel was checked, and the GO for docking was received from the ground controllers at the time the spacecraft was over the California coast. Docking was accomplished with the GATV in flight control mode 1. There were no problems associated with docking during any of the four dockings performed during the first day. The undock switch was used for the second undocking, and it was noted that the ready-to-dock light was not lit prior to redocking. Command 220 (unrigidize) was sent and the light illuminated. This command was used for all subsequent undockings.

7.1.2.10 Radar.- As previously reported, a radar problem was noted prior to the second midcourse correction. At no time when commands were sent to select either spiral antenna or dipole antenna was a MAP light received. During station keeping with the GATV and during the S026 experiment exercises, intermittent lock-on lights occurred and intermittent MAP lights were received when commands were sent to the GATV while undocked. Throughout the first day, MAP lights were always received when commands were sent to the GATV through the hardline connections. One hour prior to the firing for the high-altitude orbit, intermittent MAP lights were received when sending commands to the GATV through the hardline connections. The ground controllers, at this time, determined that all commands sent to the GATV by the flight crew, either through the radar or through the hardlines, were being received and executed by the GATV, and MAP's were being generated and transmitted over the GATV telemetry to the ground receiving stations. This problem continued throughout the flight, but, by turning the L-band transponder on at any point thereafter in the flight, MAP's could always be received in the spacecraft through the hardline connections.

7.1.2.11 High-altitude orbits.- Exacting, predetermined, written procedures were used by the flight crew to operate the GATV for the long-duration thrust required to achieve the high-altitude orbit. The GATV was commanded into flight control mode 2 approximately 10 minutes before the firing, and the platform was caged for the blunt end forward

(BEF) posigrade maneuver. Approximately five minutes before the firing, the platform was placed in orbit rate and the event timer was set up to read 57 minutes. Three minutes prior to the firing time, the event timer was started counting up toward 60 minutes (zero). At exactly 57 minutes on the event timer, the commands were sent to switch the GATV into flight control mode 7. At 59 minutes the computer START button was pushed. Also at this time, command 041 (record data) was sent to the GATV. At 59 minutes 30 seconds the velocity meter was enabled, the engine arm switch was armed, and the 16-mm sequence camera was turned on. At zero time on the event timer, which coincided with the planned time for firing, command 501 (primary propulsion system (PPS) on) was sent. At 50 seconds the $\Delta V_{X_{S/C}}$ was read out of the Manual Data Insertion Unit (MDIU) to check that the secondary propulsion system (SPS) of the GATV was providing the proper ullage orientation. At 1 minute 25 seconds, the PPS ignited. The pilot monitored the status display panel and his Flight Director Attitude Indicator (FDAI) for attitude excursions. The command pilot also monitored the status display panel, the event timer, and the rate indicators for rate excursions on his FDAI. The Δt of firing information was available, and one second on the event timer after termination of the firing, the command pilot gave a mark to the pilot to shut down the PPS. In all three PPS firings, velocity meter shutdown occurred prior to manual shutdown. In both the posigrade and the retrograde maneuvers, attitude excursions in yaw were noticed. In the posigrade maneuver, the attitude excursion was eight degrees in yaw, and during the retrograde maneuver the attitude excursion in yaw was seven degrees. At a time determined to be five degrees of central-angle travel after perigee on the posigrade maneuver, the platform was to be switched to FREE. The GATV was powered down and control was assumed by the spacecraft control system. Throughout the first high-apogee orbit and half of the second one, the spacecraft was maneuvered to obtain high-altitude photographs for the S005 and S006 experiments. The S026 experiment equipment was operated and spacecraft/GATV orientation was maintained to provide sensor orientation in the orbital plane in order to record data. After completing 1 1/2 revolutions in the elliptical orbit and at the time of second apogee, the spacecraft was aligned on the inertial ball in the proper attitude for the local horizontal. The GATV was powered up in flight control mode 2 with gyrocompassing ON in order to align for the retrograde firing. Several minutes prior to the retrograde firing and after having determined that the GATV was in the proper alignment, the platform in the spacecraft was caged SEF. Thirty seconds prior to the firing, the platform was uncaged to orbit rate in order to monitor the retrograde PPS maneuver. The same countdown procedure of using the event timer to count up from 57 minutes to 60 minutes (zero time), starting three minutes prior to the time of the retrograde maneuver, was used successfully.

7.1.2.12 <u>Extravehicular activities</u>.-

7.1.2.12.1 Umbilical EVA: The umbilical EVA preparation was started at 20 hours g.e.t. The equipment was unstowed and donned by the pilot in accordance with the planned procedures. Because the crew had practiced these procedures in the Gemini crew-station mock-up many times and at great length, EVA preparation was completed in approximately half of the allotted four hours. This, in itself, caused some difficulty because the ELSS was dumping oxygen into the cabin and the cabin relief valve was continually relieving the cabin pressure. Also, there was no cooling from the ELSS heat exchanger at the 5-psia cabin pressure. The crew decided to interrupt the umbilical EVA preparation, disconnect the ELSS hoses from the pilot's suit, return to the spacecraft system, and await the nominal time for egress which was approximately 24 hours g.e.t. This caused an interruption in the preplanned procedures and the crew had to sit idle for approximately two hours.

About 45 minutes prior to the scheduled hatch opening time, the pilot returned to the ELSS, pressurized his suit, and commenced the final EVA preparation. Difficulty was encountered in installing the extravehicular visor. The command pilot attached the clip on the left-hand side but was unable to aid the pilot in attaching the right-hand side of the EVA visor. Approximately 30 minutes was spent before the visor was properly installed. With no cooling from the ELSS at this time, the pilot became overheated, perspired, and experienced elevated heart rates which necessitated two or three rest periods during this time. The EVA visor was successfully attached, however, and the hatch was opened on time. For future flights, it is believed that the procedures should be changed to allow donning the EVA visor while the pilot's suit is unpressurized. This will permit an easy installation of the visor.

Immediately prior to hatch opening, the GATV was placed in an inertial control mode to maintain an attitude with respect to the sun so that the hatch could remain open throughout the entire period of the planned EVA without adverse thermal constraints.

The sequence of events performed by the pilot during the umbilical EVA were as follows:

(a) Raise the handrail

(b) Inspect the adapter assembly of the spacecraft

(c) Retrieve the S009 Nuclear Emulsion experiment package

(d) Install the 16-mm EVA sequence camera (5-mm lens)

(e) Proceed to the front end of the spacecraft and attach the 100-foot spacecraft/GATV tether

(f) Return to the spacecraft hatch area by having the command pilot slowly pull on the umbilical

(g) Remove the EVA sequence camera and hand to the command pilot for film change

(h) Install the EVA camera in the proper position for recording the D016 Power Tool Evaluation experiment

(i) Remove the EVA camera, ingress the spacecraft, and close the hatch.

When the hatch was opened, both pilots noted that a tremendous amount of initial out-gassing was indicated by the amount of debris that flowed directly out the open hatch. The pilot also had a tendency to float out of the spacecraft and the command pilot took hold of his foot to hold him in position. The command pilot opened the flap on the right leg of the pilot's suit where a strap had been previously attached so that the command pilot could hold the pilot in position while he was standing on the seat. The pilot was able to stand in the seat, face aft, and inspect the spacecraft adapter assembly. The aft handrail had been deployed, the umbilical guide in the adapter assembly was deployed and in position, and the adapter edge (spacecraft/launch vehicle separation plane) appeared to have been cut cleanly. The doors on the S009 and D016 experiments were properly deployed. The pilot manually deployed the forward handrail. The S009 experiment package was retrieved by first attaching a tether to the handle on the package. The pilot experienced some difficulty in retrieving the package, but this difficulty was attributed to the handle on the S009 package not being fully actuated. Once the handle was fully actuated, the package was easily extracted and handed to the command pilot. The command pilot tethered the package inside the spacecraft before he released the pilot's tether. The pilot then reinstalled the tether on the ELSS and proceeded to install the EVA sequence camera. The camera bracket was difficult to mount because it would not fully seat in the receptacle. The pilot had to partially egress and exert an impulsive force on the top of the camera to lock it in place.

The pilot then turned and faced forward, and, by leaning over the hatch closing device and grasping the RCS thrusters with his right hand, he proceeded toward the Rendezvous and Recovery (R and R) section of the spacecraft. In this manner he pulled himself forward and, by applying force on a thruster with his right hand, he propelled himself toward the GATV Target Docking Adapter (TDA) where the 100-foot tether was stowed. On the first attempt, the pilot floated above the TDA and to the left. The command pilot pulled on the umbilical so that the pilot could return to the area of the hatch. A second attempt was made, and this time the pilot was able to grasp the TDA and the left handhold and easily stop his forward motion. The pilot attempted to straddle the R and R section using his feet and legs to hold himself in position. This was very difficult to do and a great amount of energy was expended in trying to maintain body position. The pilot was able to extract the tether and the tether clamp from its stowage location and to slide the clamp and tether over the docking bar of the spacecraft. Once this was done, the pilot attempted to secure the clamp to the docking bar, but found the clamp extremely difficult to secure. He rested several times during this operation but became very fatigued from expending energy to hold his body in position so that he could use both hands to secure the clamp. After considerable effort, the clamp was locked in place and the command pilot once again pulled on the umbilical to pull the pilot toward the open hatch. When the pilot returned to the open hatch he stood in the seat facing aft and retrieved the EVA sequence camera. The camera was handed to the command pilot for a film change. During the second installation of the camera, the same difficulty was encountered, and, after the camera was placed into the adapter receptacle, the pilot found that he could not rotate the camera to the position required for the D016 experiment. Therefore, he had to remove the camera and insert it oriented in the proper position. At this time, it became apparent to both crewmen that the pilot had expended a tremendous amount of energy, was fatigued, and was being bothered by perspiration in his right eye. Because night was approaching, the decision was made that the umbilical EVA would be terminated. The pilot then retrieved the EVA sequence camera, inspected the hatch area to assure that it was clear, ingressed the spacecraft, and closed the hatch. The crew rested until the outflow from the ELSS had pressurized the cabin.

In general, three factors complicated the EVA sequence: (1) suit mobility, (2) the ELSS, and (3) body positioning of the pilot while extravehicular. Suit mobility was such that during the EVA, the pilot was required to exert a continual force on the suit when moving it to any position other than the normal inflated position. This meant that to extend an arm or to change the position of the legs required a continual force to hold the suit in that particular position. Over a period of time, that in itself would have become tiring. The ELSS complicated the EVA sequence from two viewpoints: (1) the ELSS did not have the capability to dissipate the heat loads generated by the pilot during high workload requirements, and this resulted in the pilot becoming hot and in perspiration accumulating during the EVA sequences when the pilot's workload exceeded the capability of the ELSS to dissipate heat; and (2) the position of the ELSS interfered with the ability of the pilot to grasp or see objects directly in front of him. The tasks required of the pilot while extravehicular generally required him to use both hands and to place the work tasks in front of him where he could naturally see it. Another problem is one of body positioning. It was found during this flight that a tremendous amount of energy was expended by the pilot to simply maintain his body position so that his work task could be kept in view and both hands could be used to operate equipment. It would appear that this requirement must be eliminated from a pilot's task so that he will not have to be concerned about his body position while doing useful work. If a restraint system of some type were provided so that the pilot would not have to expend energy to keep his body in position, it is believed that the EVA tasks encountered to date, and those anticipated for the future, could be done with relative ease.

7.1.2.12.2 Equipment jettison: After the umbilical EVA, the hatch was opened again to jettison all the gear that would not be required during the remainder of the flight. Major items jettisoned were the ELSS, the 30-foot umbilical, and all the EVA hoses, connectors, and associated straps. The pilot used a lap belt as the only restraint and pulled it down tight prior to suit pressurization. Both pilots performed a suit integrity check before the cabin was vented and the right-hand hatch opened. The pilot was able to jettison the ELSS and the duffle bag filled with miscellaneous equipment. Once these items were jettisoned, the hatch was closed, and normal cabin repressurization procedures were used.

7.1.2.12.3 Stand-up EVA: Standup EVA preparation was scheduled to begin 44 hours into the flight, immediately after the two high-altitude orbits. However, the crew had not had time to eat breakfast prior to the high-altitude portion of the flight, and they used one hour of the scheduled two-hour EVA preparation time to prepare and eat breakfast. The hour remaining was adequate for the standup EVA preparation. The only additional hardware items that were required for the standup EVA were the two ELSS inlet and outlet hoses, which were interconnected to the spacecraft ECS hoses, and one standup tether, which was attached to the left armrest of the pilot's seat. No difficulties were encountered during the preparations for the standup EVA.

The hatch was opened at approximately 46 hours g.e.t., about ten minutes prior to sunset. The standup EVA was used for photographing selected constellations for the S013 UV Astronomical Camera experiment. The 70-mm general-purpose camera and associated lens and grating were easily installed on the mounting bracket prior to the pilot standing up.

This equipment was tethered to the guard on the overhead circuit breaker panel. The command pilot handed the assembled camera and bracket to the pilot who had no difficulty in mounting the equipment. A manual shutter-release cable was used for all the S013 exposures. During this portion of the flight, the command pilot had some difficulty in seeing through his window, and orientation of the spacecraft was done with the assistance of the pilot. During the first nightside pass, three selected constellations were photographed. Once the command pilot had the spacecraft properly oriented, the pilot could easily lean over and turn on the GATV attitude control system (ACS). The GATV was controlling the docked combination inertially in flight control mode 2, thereby requiring no control tasks by the command pilot. At the end of the nightside pass, the pilot devoted the portion of the dayside pass over the continental United States to photographing the Gulf Coast for the S005 experiment.

During the dayside pass across the Atlantic, the pilot inadvertently turned off the suit-fan circuit breaker. This action was very evident to the crew because the cabin became extremely quiet, allowing them to recognize that the fan had been turned off. Once this was discovered, the command pilot easily reset the circuit breaker. The S013 experiment was concluded on the following nightside pass with the required exposures being taken once again of the three selected constellations. The experiment was completed well before the second dayside pass commenced.

After the standup EVA, ingress was accomplished with relative ease. The pilot sat down in the seat with his knees just under the instrument panel and pulled the hatch down onto his helmet. The command pilot used the hatch closing device to close the hatch to the last position and the pilot had no problem in locking the hatch. Cabin repressurization followed in the normal manner.

The workload encountered during the standup EVA, although very precise, was extremely easy when compared with the umbilical EVA. This is attributed to the pilot being very lightly tethered, with his feet resting on the floor of the spacecraft cabin. This gave him complete freedom to use both hands, and he remained virtually unconcerned about maintaining his body position.

7.1.2.13 Tether evaluation.- The tether evaluation started after completion of the standup EVA when the spacecraft was undocked from the GATV. The crew noticed that there was enough initial tension in the tether to cause the spacecraft to move slightly to the right and contact the TDA. Once the spacecraft started moving aft, approximately 50 feet of the tether came out very smoothly. It appeared that at the 50-foot point the tether hung up in the stowage container. A small amount of aft thrusting freed the tether and it deployed smoothly until it caught on the Velcro that was used to hold the GATV end of the tether firmly in place on the TDA. The command pilot had to maneuver the spacecraft well above the GATV to peel the tether off the Velcro. This consumed more time than had been anticipated and the period of 7 1/2 minutes allowed to fully extend the tether was exceeded. This meant that the GATV had gone through the local vertical; consequently, the gravity gradient portion of this evaluation had to be abandoned.

Prior to starting the rotational mode, some difficulty was encountered in pulling the tether taut. The tether rotated counterclockwise very similar to a skip rope. Five to ten minutes was spent in attempting to eliminate this skip-rope effect. The tether finally did become straight and taut, but neither pilot can describe the maneuvers required to eliminate the tether motion. Once the tether was taut, the command pilot rolled the spacecraft 180 degrees and fired aft and down with the maneuver thrusters for ten seconds. While this maneuver was being accomplished, the pilot turned off the GATV ACS. When the thrusting had been completed and the maneuver and attitude control systems were turned off, the elasticity or stretch in the tether had a slingshot effect on the spacecraft. This effect moved the spacecraft toward the GATV for several feet and caused a big loop to form in the tether. However, the centrifugal force took over immediately and the tether became taut again. There was a small amount of longitudinal oscillation during this time; however, the most pronounced effect noted was the large excursions of approximately ±45 degrees in spacecraft yaw. No control inputs were made at this time and the crew observed that the oscillations of both vehicles were slowly being damped. As the nightside approached, the crew realized that the entire system was stabilizing satisfactorily, and the tether evaluation was continued into the nightside pass. With the docking light on during this nightside pass, the crew could easily observe the tether and see that it was remaining taut. At the end of the nightside pass, it was apparent that the entire system had essentially stabilized. The rotational rate of the system was approximately 38 deg/min, and the inclination of the plane of rotation was approximately 30 degrees to the horizon. At the beginning of the daylight pass, the ground controllers requested the crew to increase the rotation rate. With the spacecraft still moving slightly in roll and with the plane of rotation inclined to the local horizontal, the crew decided to wait and apply the thrust when all the motion was exhibited on the pitch rate indicator. When the yaw rate indicator went to zero, and all the motion was in the pitch plane of the spacecraft, the command pilot fired aft and down for approximately three seconds. This resulted in making the thrust application along a single axis and in the plane of rotation. The same effects occurred as noted before, except that the spacecraft attitude excursions were much greater (approximately 60 degrees). This was more than the crew was willing to allow and the command pilot used the pulse mode to damp the spacecraft rates. The entire system was stabilized for the remainder of the dayside pass and the following nightside pass. During this period, the rotation rate of the system was estimated to be approximately 55 deg/min. The crew became so confident that this system was in a stable mode that during the next nightside pass they took time to eat a meal and paid very little attention to the rotating system. During the period of the 55 deg/min rotation, the crew investigated the gravity field by holding a camera against the instrument panel and carefully releasing it. The evidence of a gravity field was plainly visible in that the camera moved aft in the cockpit on a line parallel to the tether. The crew was not aware of any physiological cue of a gravity-field at any time during the period of rotational tethered flight.

At the completion of the tether evaluation, the crew prepared to jettison the spacecraft docking bar and to start station keeping with the GATV. The pilot turned on the GATV ACS, and the command pilot maneuvered the spacecraft toward the GATV, which slackened the tether, and then jettisoned the docking bar as the GATV passed through the horizon. Within ten seconds after the start of this maneuver, the command pilot was station keeping with the GATV.

In general, the crew believe that the gravity gradient method of station keeping is feasible; however, more time must be allowed to fully deploy the 100-foot tether before the GATV goes through the local-vertical position. This should assure that the command pilot will have adequate time to deploy the tether and station keep with the GATV in the local vertical with the GATV in orbit rate prior to turning off all control systems. The rotational maneuver proved to be a very feasible method of long-term station keeping in that little fuel was expended in starting or stopping the rotation, and the entire system became adequately stabilized in a very short period of time.

7.1.2.14 <u>Coincident-orbit rendezvous</u>.- The coincident-orbit (second) rendezvous, a real-time change to the flight plan, was begun at approximately 53 hours g.e.t. The platform was aligned SEF while station keeping behind the GATV in the platform mode. The platform was carefully aligned for at least 15 minutes. The separation maneuver from the GATV occurred at 53:24:58 g.e.t. Forward-firing thrusters were used to establish an 8.8 ft/sec retrograde separation velocity. Although forward-firing (reverse) thruster logic had been inserted into the computer in order to use the FDI for attitude control during this maneuver, the spacecraft had to be rolled heads down, or 180 degrees. The crew believed that this maneuver should have been made BEF, heads up, and using the aft-firing thrusters. The maneuver was made on time and all residuals were reduced to zero. An excellent platform alignment, and the ability to easily remove all residuals, eliminated any out-of-plane component during this maneuver. The next maneuver associated with the second rendezvous was a stand-off maneuver, which was also used as a calibration maneuver for the D003 Mass Determination experiment. This maneuver was executed at 54:37:28 g.e.t. The total ΔV was 9.8 ft/sec and the duration of the firing was 11 seconds. Once again, all residuals were reduced to zero for this maneuver; however, they were not nulled until the completion of the 11 seconds of firing so that necessary D003 experiment parameters could be recorded. The TPI maneuver was made at 65:27:22 g.e.t. and required approximately 23 seconds to accomplish. This maneuver was computed to place the start of the TPI maneuver at a trailing distance of approximately 23 miles, for a rendezvous with an ωt of 292 degrees. The S030 Dim Sky Photographs experiment was conducted during the initial period of the second rendezvous. After visual acquisition of the GATV, visual tracking was maintained throughout the second rendezvous. Computer angles were read out and a correction, computed from onboard data, was made at approximately 66:30:36 g.e.t. Ground controllers had transmitted a correction at this point of 6 ft/sec forward, zero ft/sec up/down, and 2.4 ft/sec right. It was obvious to the command pilot that the out-of-plane error at this time was zero, and the 2.4 ft/sec right was not applied; however, the 6 ft/sec forward was applied on time. A backup calculation was made by the pilot and the zero up/down component was verified. During this rendezvous, the crew was ready for the extreme target brightness that had been encountered during the initial rendezvous. Both pilots had their sunglasses on as the GATV came into daylight. This rendezvous was made without the use of radar and was done by visually tracking the GATV. As the range was reduced, the crew could see that the 100-foot tether was completely extended and was standing straight up from the TDA in relation to the earth. The pilot used the sextant to call out range and range rate. The range was called out at 4000, 2000, and 1000 feet, with a range rate of 15 ft/sec calculated between 2000 and 1000 feet. This information was used for the braking maneuver to complete the rendezvous.

After the final correction was made, no line-of-sight rate was observed. Inertial indicator data were put into the computer and the command pilot nulled the extremely small line-of-sight rates. At the end of braking, the command pilot was station keeping with the GATV at a range of 20 to 40 feet. It was noted that the forward-firing thrusters had disturbed the tether during station keeping, and the tether had begun to slowly oscillate around the GATV. In general, the second rendezvous was easily accomplished with onboard information and charts because line-of-sight rates were virtually nonexistent. Both the excellent platform alignment and the ability to null all residuals to zero probably accounted for these minimum out-of-plane and line-of-sight rates during the terminal phase of the rendezvous. Although the sextant was used to determine range and range-rate to aid in the braking maneuver, this type of device normally should not be used to measure these parameters. Instead, a ranging telescope or a telescope with a calibrated reticle would have been easier to use and better suited for this type of measurement.

7.1.2.15 Reentry.- After a platform alignment, a 3 ft/sec retrograde maneuver was made for final separation from the GATV. The spacecraft was aligned BEF and in platform mode for three revolutions prior to retrofire. During this time, Module IV was loaded into the computer and verified. The preretrofire checklist was completed well ahead of schedule. The checklist for time-of-retrofire (T_r) minus 256 seconds was initiated approximately seven minutes prior to retrofire and was also completed well ahead of schedule. All Digital Command System quantities were loaded into the computer and were verified by using the MDIU. Check-off lists presented no problem and each item was physically checked off at its completion. The T_r minus 1-minute checklist was started at two minutes, which allowed time for emergency procedures in case the adapter had failed to separate. At T_r minus 30 seconds, the squibs were armed, and at T_r minus 10 seconds the automatic retrofire circuit was armed. Retrofire was on time. The pilot verified the COMP light, started the elapsed timer, and actuated the manual retrofire switch one second after the automatic retrofire. The periods between successive retrorocket firings were equally spaced, and there was good alignment for the first three with no hesitations noted between successive firings. Retrorocket no. 4 was slightly misaligned in yaw; single-ring rate command mode was more than adequate for controlling the attitudes. The nominal IVI readings for retrofire were 305 ft/sec aft, and 115 ft/sec down. The actual IVI readings were 303 ft/sec aft, 1 ft/sec left, and 118 ft/sec down. The adapter retrograde section was jettisoned on time at T_r + 45 seconds. After the retrograde section was jettisoned, changes in velocity read from the MDRU were 303.1 ft/sec aft, 1.1 ft/sec left and 118.3 ft/sec down. The post-retrofire checklist was completed on schedule. At this time, the D-rings were unstowed and held in place by the clip on the microphone push-to-talk button cord. They were held neatly in place in this position throughout the reentry. After retrofire, the spacecraft attitude was controlled blunt end forward (BEF) heads-down with a 10-degree left bank. The onboard indication of 400K feet occurred at 20 minutes 14 seconds after retrofire. When 400K feet was reached, the command pilot rolled the spacecraft to the backup bank angle of 44 degrees left. The computer then commanded a bank angle for full lift, and the roll-command indicator was on full right indicating a right roll to recover from the backup bank angle.

The command pilot selected the reentry rate-command mode and rolled the spacecraft to full lift, matching the indicators. At this time, fairly large spacecraft oscillations began to occur, and the command pilot damped the rates. Both pilots agreed that the computer was operating properly and a decision was made to switch to the reentry control mode. The spacecraft was then controlled by the automatic system. The computer called for full lift which indicated a fairly nominal reentry. As the spacecraft approached one-g, the downrange indicator indicated zero error and the automatic system commanded a left roll. As the spacecraft was rolling to the left, some crossrange error did develop and the computer commanded the specified bank angle at approximately the 130-degree point in the roll. The "short-way-home" logic caused the spacecraft to hesitate at the 180-degree position, or lift-vector full down. However, it recovered very shortly and commanded full lift. The logic oscillated at full lift for a few seconds, began to pull out downrange error, and began commanding a roll to the right. Once again, the same procedure was encountered. The crossrange indicator was indicating an error of less than two nautical miles during the entire reentry. A roll reversal was again commanded at the 130-degree point; and once again, the "short-way-home" logic caused the spacecraft to hesitate for a few seconds with lift-vector full down. The spacecraft then rolled to full-lift to cancel the downrange error. As the spacecraft came out of maximum-g, the computer commanded one more roll, a complete 360 degrees, and then went to full lift as the altimeter started to indicate below 100K feet.

At approximately 125K feet, Air Boss (recovery aircraft) began calling for a short count. This procedure should definitely be discontinued, as this is a very critical time concerning reentry. The crew had read out address 86 (predict touchdown latitude) and 87 (predict touchdown longitude), which were 02481 (24.66 degrees N geodetic latitude) and 29002 (69.98 degrees W longitude), respectively, at 80K feet, and this should have been sufficient for direction-finding purposes. The remainder of the reentry was nominal in all respects. The control system was switched to dual-ring rate command at approximately 90K feet, and the spacecraft was very stable all the way through drogue deployment, which occurred at 50K feet. Drogue deployment was completely normal and only very slight spacecraft oscillations were noticed with respect to the drogue-line attach points. The 27K-foot checklist was completed to go to oxygen high rate and to verify that the cabin air recirculation valve had opened. The main parachute was deployed at 10.6K feet, and was disreefing six to eight seconds after deployment.

After ensuring that the main parachute was good, the crew actuated single-point release between 7500 and 7000 feet. The 2000-foot checklist was completed, consisting of water seal closed and repressurization valve open, to assure positive pressure within the cabin. The repressurization valve was closed at approximately 500 feet altitude so that spacecraft overpressurization would not occur. During descent on the main parachute, the crew observed the R and R section going by the right window, less than 40 feet away.

7.1.2.16 Landing.- The landing was nominal and very mild. The spacecraft momentarily submerged and rolled to the left because the main parachute was still attached and was pulling the spacecraft in that direction. The parachute was released, and the spacecraft rolled upright and exhibited no internal leaks. The spacecraft interior was warm and fumes were noted, but the environment was completely tolerable. The postlanding checklist was completed; however, the crew experienced some difficulty in accomplishing this because of the great amount of interference on the radio. The recovery helicopter was broadcasting the entire recovery sequence on 296.8 mc, and the crew had to turn off the UHF radio to complete the postlanding checklist. The recovery helicopter, in broadcasting the recovery sequence, should use a different frequency and avoid interfering with the ability of the crew to expeditiously power down the spacecraft and complete the postlanding checklist. The crew elected to egress the spacecraft and to be picked up by helicopter, although the ship was only about 2 1/2 miles away.

Egress was slightly delayed because the left side of the flotation collar did not fully inflate, but was completely normal otherwise. Both crewmen boarded a liferaft attached to the side of the spacecraft. Helicopter pickup and return to the ship were normal.

7.1.2.17 Experiments.- A general statement concerning all experiments on the flight is that they were accomplished in accordance with the flight plan, except for the D016 Power Tool Evaluation experiment.

7.1.2.17.1 Experiment D003, Mass Determination: The mass determination translation was performed at 1:55:29 g.e.t. At the end of 25 seconds, $\Delta V_{X_{S/C}}$ read -0029, $\Delta V_{Y_{S/C}}$ read 00001, and $\Delta V_{Z_{S/C}}$ read 00005. The propellant quantity remaining at the end of the experiment was 53 percent. The calibration firing was conducted at 54:37:28 g.e.t. At the start of the firing, $\Delta V_{X_{S/C}}$ was 8.9 and at the end of 11 seconds was -0.9. Attitude control during this experiment was in rate command and aft-firing thrusters were used. No problems were encountered in conducting this experiment.

7.1.2.17.2 Experiment D015, Night Image Intensification: The D015 Night Image Intensification experiment was conducted at the end of revolution 34, during all of revolution 35, and at the beginning of revolution 36. The experiment was conducted in accordance with the flight plan. Objects seen on the TV monitor and the command pilot's view out the window were described on onboard tapes. In addition, photographic coverage was obtained for most of the objects. In general, it can be said that only gross features were determined. These included clouds, thunderstorms, breaks in the overcast, coast lines, cities, jungle fires, and lightning. Two meteorites were also observed on the monitor during the course of the experiments. The only anomaly was one of alignment, in that the ground, as seen on the monitor, was passing from the upper right-hand corner to the lower left-hand corner indicating that there was a 45-degree skew in the field of view. To aid in interpreting the scenes viewed, the pilot held the monitor between his knees and turned it 45 degrees so that it could be viewed in a more normal fashion. Also, the night airglow under the conditions of the flight, such as no moon, was of such a brightness that it had a tendency to wash out small ground features or details of ground features that might otherwise have been observed. In addition, the brightness of the TV monitor was such that the command pilot could not become night adapted.

7.1.2.17.3 Experiment D016, Power Tool Evaluation: The D016 experiment was not performed during the flight; however, it was observed that the door to the D016 stowage area had been properly deployed. The pilot wore the D016 knee tether during the EVA but it caused no problem.

7.1.2.17.4 Experiment S004, Radiation and Zero-g Effects on Blood and Neurospora: The S004 experiment equipment worked properly. The experiment was conducted in real time with each package being activated and deactivated with ground coordination.

7.1.2.17.5 Experiment S005, Synoptic Terrain Photography, and Experiment S006, Synoptic Weather Photography: Photographs of land areas and ocean areas were taken for the S005 and S006 experiments during the high-altitude portions of revolutions 26 and 27. The areas photographed with the 70-mm EVA still camera and the 70-mm general-purpose camera were North Africa, Saudia Arabia, the Indian Ocean, India, the Bay of Bengal, Southeast Asia, and Australia. In addition, during the 161-nautical-mile circular orbit, several photographs were obtained of Baja California in Mexico, the U.S. Gulf Coast, and the Andes Mountains on the coast of Chile. During the flight, no problems were observed with any of the camera equipment associated with these two experiments.

7.1.2.17.6 Experiment S009, Nuclear Emulsion: The Mode 1 operation of the S009 Nuclear Emulsion experiment was selected in accordance with the flight plan at approximately 1 hour 45 minutes g.e.t. The experiment remained in this mode of operation until retrieval during the umbilical EVA at approximately 24 hours g.e.t. During the major portion of the flight, the equipment was stowed in the command pilot's footwell, with the exposed plate facing aft. Prior to reentry, the package was placed on the camera box stowage frame, and a cloth cover was used to protect the exposed surface. No difficulty was encountered during the stowage of the package.

7.1.2.17.7 Experiment S011, Airglow Horizon Photography: The S011 experiment was conducted in accordance with the flight plan with the north/south airglow photography being conducted at 17 hours 15 minutes g.e.t. Sequence 2 was accomplished in accordance with the established procedures and no problems were encountered. The next two sequences were to photograph the eastern airglow at approximately 29 hours 20 minutes g.e.t. and to take three sunrise photographs during the same night pass at 29 hours 45 minutes g.e.t. The final S011 sequence was conducted during the high-orbit portion of the flight at approximately 41 hours 35 minutes g.e.t. and consisted of photographing the western horizon, beginning when the spacecraft reached approximately 800 statute miles in altitude. The S011 experiment consisted of the 70-mm general-purpose camera with a special film pack and lens and a special bracket mounted in the right-hand window. The bracket was modified prior to flight so that a more comfortable head position could be maintained during this experiment. The bracket was modified to reduce some of the yaw and pitch angles so that the sight was closer to the normal head position during flight. However, the crew was unable to obtain pointing commands for this bracket orientation. During flight, a trial-and-error method was used to obtain pointing commands so that the command pilot could fly the spacecraft to the approximate attitude before turning over the controls to the pilot for precise control by visual observation. For future flights using this equipment, or any equipment not aligned with the spacecraft axes, the crew should be provided with the offset, or with the angles at which the equipment is offset from the X-axis of the spacecraft, so that more accurate pointing can be obtained. In addition, extreme difficulty was encountered during the assembly of the S011 camera equipment. The f/0.95 lens was difficult to install on the camera because the procedures for assembling the camera were reversed; in other words, the camera back had to be put on before the lens could be installed on the camera. This is a reversal of normal procedures. The existing equipment should be modified to assure easy installation of the S011 lens.

7.1.2.17.8 Experiment S013, UV Astronomical Camera: The S013 experiment was conducted during the standup EVA and two night passes were devoted to the experiment. The experiment was conducted in accordance with preflight planning and procedures, with no difficulty being encountered with the equipment. The constellation Scorpius, the star Achernar, and the constellation Orion were used for performing this experiment. The command pilot first flew the spacecraft in rate command to the proper orientation with respect to the star and each of the constellations; then the pilot turned on the GATV ACS to hold the spacecraft in an inertial mode during the sequence of exposures. This experiment could not have been conducted without using the GATV in the inertial mode for stabilization purposes. Flight control mode 2 was used throughout. The GATV should be used during the conduct of this experiment. In addition, all pieces of equipment associated with the S013 experiment should be tethered. The camera installation was removed during the dayside pass so that the grating could be replaced with a prism. Because the prism is a very small piece of equipment, it was not tethered and the command pilot dropped it in the confines of the spacecraft during this change; fortunately, it was recovered.

7.1.2.17.9 Experiment S026, Ion-Wake Measurement: The S026 experiment was conducted with the TDA south during the first night pass after the initial docking. The out-of-plane maneuver was performed in accordance with the flight plan at approximately 2 hours 10 minutes g.e.t. Because of the relative ease with which this experiment was conducted, a GATV tape dump was not required over the Carnarvon tracking station and the in-plane maneuver was conducted at the completion of the out-of-plane maneuver. At the completion of this nightside pass, the GATV tape was dumped at Hawaii, and the spacecraft was positioned for the out-of-plane sequence. The linear portion of the experiment was conducted during the following nightside pass. This experiment was easily performed and no anomalies were encountered. Sequence photographs were taken of all maneuvers with the nightside pictures being taken on black-and-white film at one frame per second, f/4, and at a speed of 1/200 of a second. The only dayside sequence photographs were taken with color film, photographed at one frame per second, f/16, and at a speed of 1/200 of a second. In addition, the S026 experiment was conducted during the high-altitude portion of the flight for an ambient ion density measurement at an apogee of 850 statute miles by performing a 360-degree roll maneuver with the spacecraft pointed at the nadir. It was later discovered that the GATV tape recorder was inadvertently left off. However, real-time data of this maneuver should have been received by the Carnarvon station, which had acquisition of spacecraft telemetry during this period.

7.1.2.17.10 Experiment S029, Libration Region Photography: Experiment S029 was cancelled from the flight plan due to the libration point being obscured by the Milky Way as a result of the launch delay from September 9 to September 12, 1966. General celestial photography was accomplished, however, using the S029 equipment. The S029 photographs were to have been taken at approximately 5 hours 20 minutes g.e.t. with a 60-second exposure. Comet photography was taken with the S029 magazine using pointing commands from the ground of 143 degrees yaw left and 16 degrees pitch up. The S029 camera equipment utilized the S011 window bracket for this experiment.

7.1.2.17.11 Experiment S030, Dim Sky Photographs: Dim sky photographs utilizing the D015 equipment were taken during the second rendezvous in accordance with the flight plan procedures. Data were recorded during the conduct of this experiment by utilizing the D015 experiment equipment. The photography included a 360-degree sweep of the horizon airglow, the Magellanic Clouds (15 degrees south of Canopus), and the eastern horizon ten minutes before sunrise. No difficulty was encountered during the conduct of this experiment.

7.1.2.18 Anomalies.-

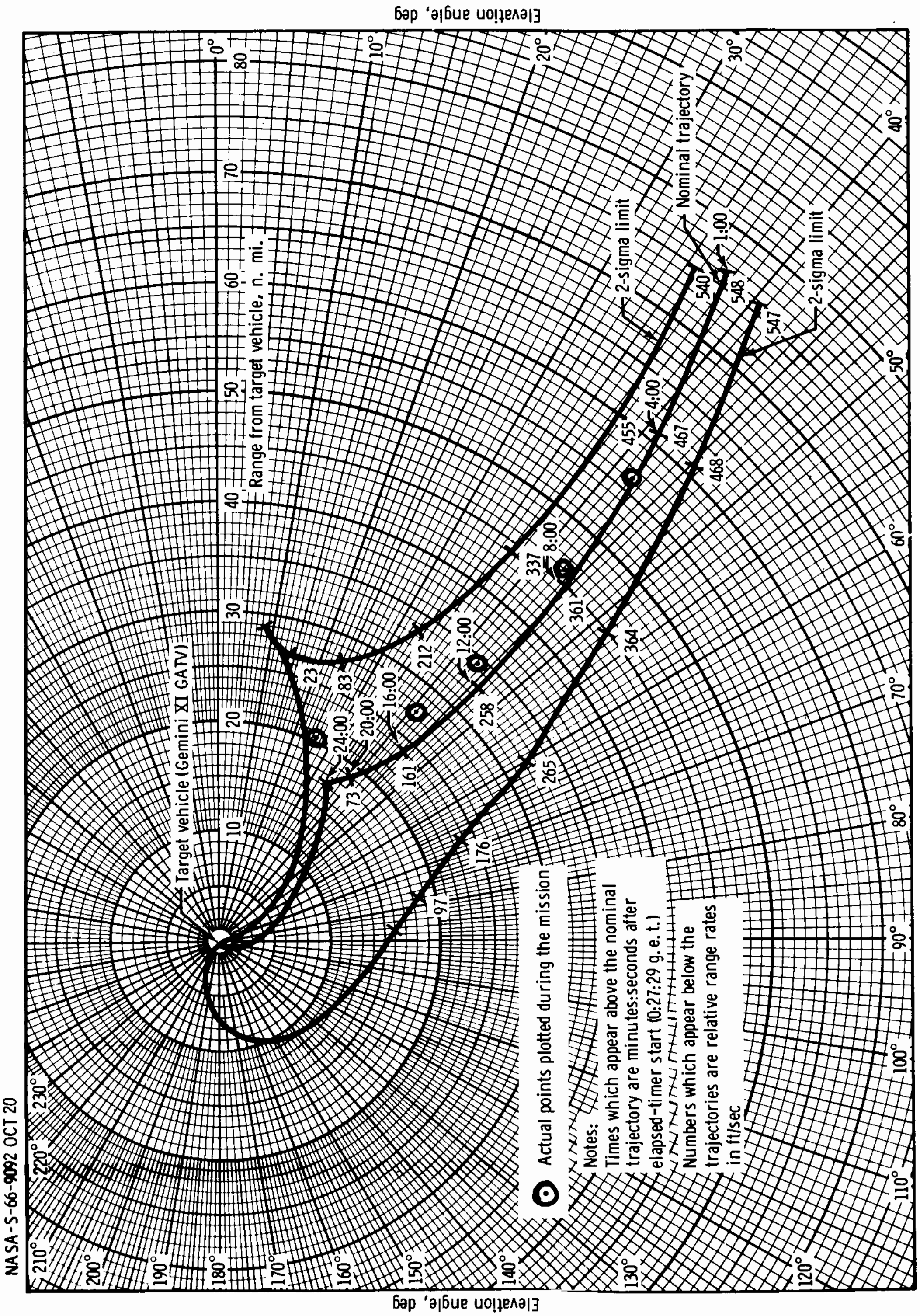
7.1.2.18.1 Windows: Although window covers were used during the launch phase of flight, it was observed that when the window covers were jettisoned, both the command pilot's and the pilot's windows were covered with a very thin film on the outside of the outer pane. This phenomenon alone caused no difficulty and presented no problem during the flight or during photographic experiments. However, the inside of the outer window pane on the command pilot's side exhibited a thin oily film that obscured his vision. This film had the appearance of petroleum jelly in that it was clear but appeared to diffuse the light. The film covered a small area approximately 4 by 6 inches directly in the center of the window. The effect of the film became more pronounced throughout the flight, and, during the conduct of the S013 experiment, the command pilot had great difficulty in seeing a first-magnitude star. Because this condition is totally intolerable for flight, the cause of this substance should be identified and eliminated before the Gemini XII mission.

7.1.2.18.2 Voice tape recorder: An anomaly with the voice tape recorder was experienced during flight. All of the tape cartridges were used; however, an end-of-tape light was exhibited for only two cartridges. This failure is discussed in section 5.1.2.

7.1.2.18.3 Inadvertent circuit breaker actuation: Two instances of inadvertent circuit breaker actuation occurred during the flight: (1) during the standup EVA, the pilot inadvertently opened the suit fan circuit breaker, and (2) while the command pilot was turning around in his suit to gain access to the aft food box, he inadvertently opened the electronic timer circuit breaker.

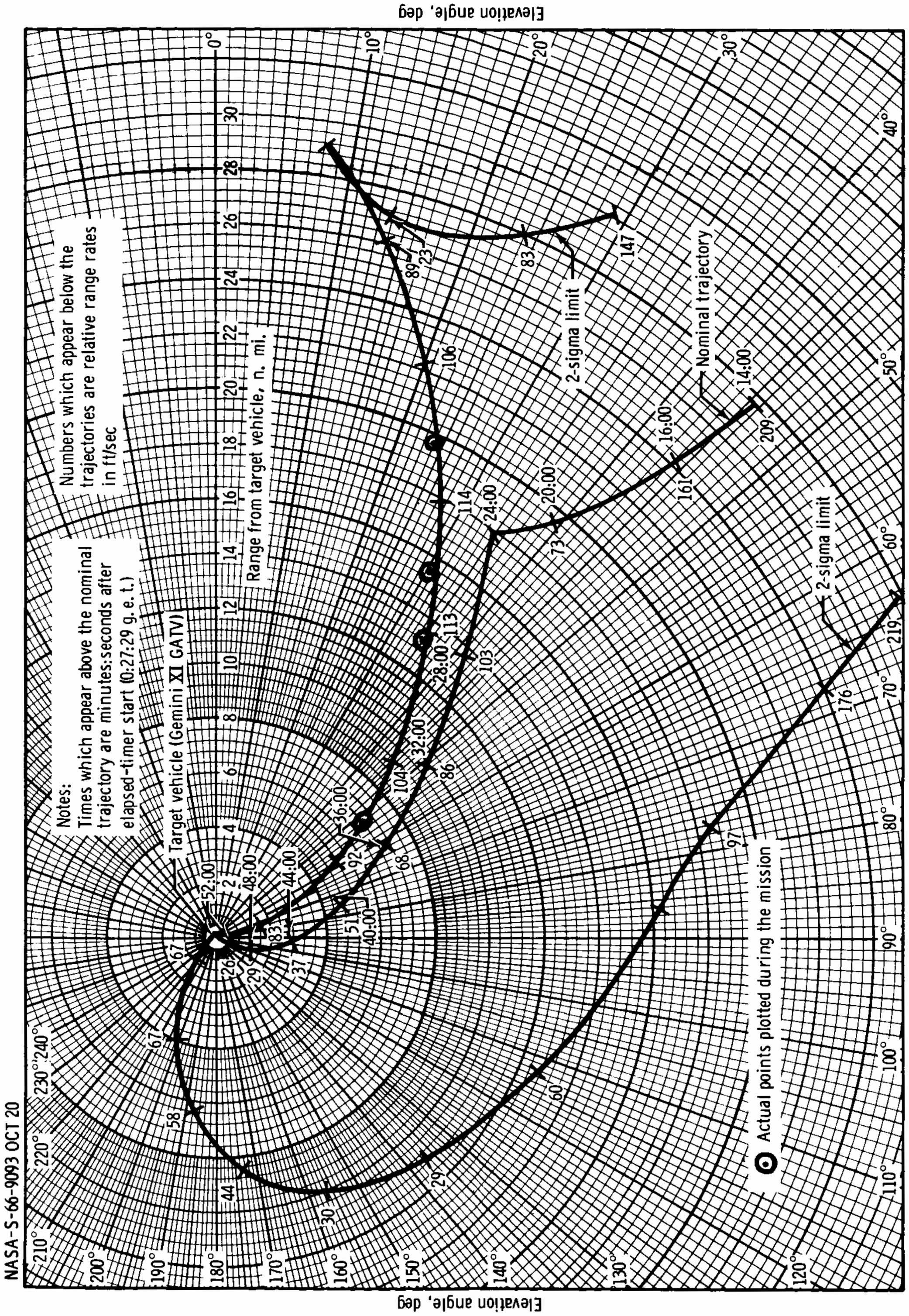
7.1.2.18.4 Systems failures during flight: During the flight, as previously mentioned, the radar became inoperative. It was later discovered that the spacecraft radar had not failed but that the GATV transponder had failed, thereby eliminating the use of the onboard radar.

Fuel cell stack 2C failed during flight. This was not noticed by the crew, but the low voltage was recorded on the ground. The crew was immediately notified and turned off the stack for the remainder of the flight.



(a) Pre TPI.

Figure 7.1.2-1. - Onboard target-centered coordinate plot of rendezvous.



(b) Post TPI.

Figure 7.1.2-1. - Concluded.

7.2 AEROMEDICAL

Gemini XI was a three-day mission which included rendezvous, docking, a docked maneuver to a high-apogee orbit, and two major periods of extravehicular activity (EVA). The only medical problem which occurred during this flight was related to pilot fatigue during the umbilical EVA. This fatigue was severe enough to cause premature termination of this period of EVA. An evaluation of the factors considered to be important contributors to this degree of fatigue is presented in paragraph 7.2.2.2.2.

7.2.1 Preflight

7.2.1.1 General preparations.- A review of the medical records of the prime and backup crews revealed no contraindications for this flight, nor were there any sensitivities to onboard medication or biosensoring materials found in the course of sensitivity testing.

7.2.1.2 Specific preflight preparations.- Throughout the preflight preparation, the crew attempted to reserve two hours during the middle of the day for exercise and relaxation. They spent this time engaged in a self-designed exercise program which consisted primarily of running on the beach or swimming. The crew began a modified low-residue diet on September 5, 1966, and remained on this diet during the entire preflight period. An attempt was made to recycle their work day during the last ten days of preflight activity so that the day would more nearly correspond to that planned for the mission. The mission flight plan called for both crewmen to retire at a time corresponding to approximately 5:00 p.m. e.s.t. and to arise for their second-day activities shortly after 1:00 a.m. e.s.t. It has been found that most individuals can readjust to an altered time schedule within approximately two weeks. The crew found it difficult to adjust to the hours indicated in the flight plan; however, they did retire at approximately eight or nine o'clock at night and arose between the hours of four and five in the morning. This schedule was broken to a degree by the Labor Day holiday weekend, when the crew returned to Houston for the day, and during the weekend following the launch delay. On the night prior to launch, the crew retired at approximately 10:00 p.m. and arose at 5:00 a.m.

Before retiring on September 7, 1966, the pilot took two bisacodyl tablets orally, and the command pilot took one. When the launch was delayed, the pilot repeated a bisacodyl suppository on September 10, 1966, with the desired effect. Due to the nature of his initial response, the command pilot elected not to repeat this type of medication.

7.2.1.3 Medical examinations.- On August 30, 1966, the crewmen were examined by the internist and the crew flight surgeons. The remainder of the medical specialty team, consisting of a neuropsychiatrist, an opthalmologist, and an otolaryngologist, conducted their examinations of the crew on September 6, 1966. Crew flight surgeons conducted the preflight examinations on September 10, 1966, and repeated this examination on the morning of September 12, 1966. Neither crewman was found to have any history, symptoms, or signs of significant illness during the 30 days prior to flight. Laboratory determinations (table 7.2-I) were considered to be within normal limits.

7.2.1.4 Special data collection.- Two tilt table studies were carried out on each crewman prior to the flight. The data from these studies are shown in figure 7.2-1. A bicycle ergometer test of the pilot's exercise capacity was performed on September 6, 1966. The results of these studies are seen in figures 7.2-2 and 7.2-3.

7.2.1.5 Spacecraft drinking water contamination.- On August 27, 1966, during the routine microbiological testing of the drinking water supply aboard Spacecraft 11, two separate laboratories found an unacceptable level of gram-negative bacilli present in the water samples. Because the contamination appeared to be primarily in the drinking gun (water metering device), this portion of the system was disinfected with 1200 ppm of benzalkonium chloride solution and the system was reserviced. The drinking gun was found to be mechanically defective and was also replaced. On September 3, 1966, the examination of water samples again revealed an unacceptable level of microbial contamination. The entire spacecraft water system was then drained and reserviced in the routine manner. On September 5, 1966, additional samples were taken from the water-servicing-equipment fittings 643 and 675, as well as three samples from the drinking gun. Although the 12-hour growth on each sample was essentially negative, the 24-hour data demonstrated viable microbial population of 2.5×10^5 organisms per milliliter in the drinking gun samples. This was again considered unsatisfactory for flight. At this time, it was decided to reservice the water system with distilled water to which chlorine had been added in an attempt to attain 6 ppm free chlorine. Examination of the water immediately after reservicing revealed available chlorine to the level of 8 ppm and no viable organisms. This was considered satisfactory to proceed with the launch. A sample taken at T minus 360 minutes on September 10, 1966, failed to show any available chlorine in the water supply. However, this was not considered sufficient reason to delay the flight. The initial report from this sample, as well as the samples taken at T minus 360 minutes on September 12, 1966, were unremarkable; however, after the full incubation period, the samples from the drinking gun showed microbial contamination in the magnitude of 9.1×10^3 organisms per milliliter, and samples from the drinking water line contained 5.5×10^4 organisms per milliliter.

The third sample, which presumably came from the spacecraft water storage tank, contained no viable organisms.

Postflight samples from the drinking-gun hose and storage tank contained viable microorganisms to the magnitude of 2.5×10^5 organisms per milliliter. Samples of the condensate water were examined on September 21, 1966, and were found to be contaminated by the same microbiological organisms which had been present in the spacecraft drinking water. All data collected to date indicate that the suit condensate was the source of the microbial contamination of drinking water. Although the condensate valve is not opened during flight, it is quite feasible that microbial contamination might easily find its way around such a valving arrangement.

7.2.1.6 Precount medical activities.- During the suiting procedure, the pilot suffered a small punctate laceration of his chin. This injury was caused by a small metal catch on the inside of his neck ring. This laceration was cleaned and closed with a small piece of surgical tape. Both crewmen were considered to be well prepared and completely ready for the flight.

7.2.2 Inflight

7.2.2.1 Physiological monitoring.- The bioinstrumentation system was similar to that used on previous Gemini flights. During the umbilical EVA, only the sternal electrocardiogram and the pneumogram tracing were available through the 30-foot electrical umbilical. The oral temperature probes were deleted from the bioinstrumentation system; however, one probe was stowed so that the oral temperature could be taken if necessary. No oral temperature measurements were programmed during flight and none were taken.

7.2.2.1.1 Electrocardiogram: Heart rate data plotted from real-time records and biomedical tape recorders may be found in figure 7.2-4. The pilot's heart rates during the umbilical and standup EVA periods are shown in figures 7.2-5 and 7.2-6. Figure 7.2-6 is a plot of the pilot's heart rate compared with Btu output and is based on data obtained during preflight and postflight ergometry studies. Following the umbilical EVA, at approximately 26 hours of elapsed time, it was noted that the pilot's sternal electrocardiogram signal, as received on the ground, was of poor quality. At the time it was believed that this was caused by a loose sensor, as it was possible for the pilot to restore the quality of this trace by pressing on the sensors. During the desuiting process, however, it was found that the sensors were still firmly stuck to the skin. The rate data indicate that the workload experienced during the umbilical EVA was much higher than had been expected and during the standup EVA was as low as had been observed on previous flights.

7.2.2.1.2 Respiration: Respiration rates are included in figures 7.2-4 through 7.2-6. With the exception of a high respiration rate observed during the umbilical EVA, the rates for the remainder of the flight were within the normal expected limits.

7.2.2.2 Medical observations.- Immediately prior to lift-off, at lift-off, and during powered flight, there were no unusual medical observations to report. The crew experienced no unusual sensations during these periods nor during transition into weightless flight.

7.2.2.2.1 Orbital phase: With the exception of the two periods of EVA and the tether evaluation, which are reported separately, there were no unusual or unexpected medical observations to report. The crew responses, as reflected in heart and respiration rates, were appropriate to the various phases of the flight. Expected increases in rates were seen during dynamic phases of flight, such as the primary-propulsion-system (PPS) maneuvers, and low rates were associated with sedentary activity or rest.

7.2.2.2.2 Umbilical EVA: In addition to the considerable activity normally associated with the umbilical EVA preparation period, there were two periods of excessive activity. The first of these resulted from the need for the pilot to disconnect from the Extravehicular Life Support System (ELSS) and return to the normal spacecraft Environmental Control System (ECS) oxygen supply approximately 1-1/2 hours before egress and subsequently reconnect to the ELSS. The second period of increased activity was associated with the difficulty in donning the EVA visor. This period lasted approximately 30 minutes, and was characterized by heart rates in excess of 100 beats per minute and as high as 150 beats per minute (fig. 7.2-6). Based on the preflight and postflight ergometry data, it is apparent that, during the EVA period, the pilot was working near or at his peak level of performance in trying to carry out the tasks assigned. Apparently the majority of the pilot's work output was expended in trying to position his body and in working against the suit, leaving very little energy to carry out the assigned tasks. The rest periods which the pilot took before and after attaching the tether were too brief to be of any consequence in allowing recovery. The rest period taken after his return to the hatch area, however, did allow for substantial recovery. The pilot stated that, subjectively, he never felt excessively hot. For this crewman, a heart rate of 180 beats per minute occurs at a measured workload of 230 watts with a calculated heat production of 3600 Btu/hr. However, this workload was measured by bicycle ergometry, and the degree of correlation between ergometry workloads and the workloads actually encountered by the pilot during extravehicular activity has not been determined. Subjectively, the pilot was sweating moderately profusely during this period, and it appears that, prior to egress, he had accumulated a fair amount of moisture in his suit as a result of the pre-EVA preparation activities. Because the pilot was fatigued and also because perspiration was interfering with vision in his right eye, the command pilot terminated the EVA early. The pilot ingressed the spacecraft and closed the hatch approximately 33 minutes after opening it.

7.2.2.2.3 Standup EVA: From the medical viewpoint, the standup EVA was relatively uneventful. Heart rates on the command pilot varied from values in the low 70's to 120 but for the majority of the time were below 100 beats per minute (fig. 7.2-4). The pilot's heart rate varied between 80 and 160 beats per minute, but most of the time it was observed to be between 85 and 110 beats per minute (fig. 7.2-5). These observations are, of course, in marked contrast to the umbilical EVA and support the contention that standup EVA is considerably easier than umbilical EVA. The respiration rates for both crewmen during standup EVA were quite unremarkable.

7.2.2.2.4 Tether evaluation: On those occasions when the command pilot was maneuvering to produce the rotation for the tethered vehicles evaluation, moderate increases in heart rate were observed. Neither the initial or final rates of rotation were sufficient to produce a subjective sensation of centrifugal force for the crewmen. Neither crewman detected a subjective sense of disorientation during this period.

7.2.2.2.5 Cabin environment: The thermal and gaseous control of the cabin environment was relatively constant, as has been the case on previous missions. The pilot reported feeling warm during most of the flight. He attributed this to the thermal layer on his pressure garment.

During revolution 3, from 4 hours 9 minutes through 4 hours 15 minutes g.e.t., some difficulty was experienced in receiving good telemetry data from the Coastal Sentry Quebec tracking ship. It was observed that carbon dioxide, cabin temperature, and some other environmental parameters were reading low. Over Hawaii on the same revolution, at the time of the PPS calibration maneuver at 4 hours 28 minutes, a slow rise in carbon dioxide partial pressure to 3.4 mm Hg was noted. This rise was not associated with a tape playback. By 4 hours 42 minutes g.e.t., over the Texas station during revolution 3, the carbon dioxide partial pressure was back down to 0.6 mm Hg. The cause of these observations is unexplained at this time. No further perturbation in carbon dioxide pressure was noted for the remainder of the flight. (Editor's note:

these apparent deviations from normal were the result of spurious resets in the telemetry system.)

7.2.2.2.6 Food, water, sleep, and waste: Nine meals of flight food for each crewman were carried aboard the spacecraft. The water intake was reported in such a way that it is not possible to differentiate the separate intake for each crewman and it is reported as though they both consumed the same amount of water. There is no doubt that during the second 24-hour period, which included the umbilical EVA, the pilot drank considerably more water than the command pilot. It is not possible, however, to tell how much. Based on the reports given by the crew and on the postflight analysis, the caloric intake and water consumption for the crewmen were as follows:

Period	Command pilot		Pilot	
	Food, calories	Water, pounds	Food, calories	Water, pounds
First 24 hours	1218	5.5	1497	5.5
Second 24 hours	2071	5.7	2214	5.7
Third 24 hours	1110	6.3	1110	6.3

During the first planned sleep period, the command pilot was quite restless and got very little sleep other than a few periods of dozing and perhaps one to two hours of moderate sleep. During the same period, the pilot appeared to have managed two to three hours of light sleep, but was otherwise restless. It appears that during the second planned sleep period the command pilot had a much more satisfactory sleep, probably four to five hours of moderate sleep. The pilot, on the other hand, slept somewhat restlessly during this same four to five hours. In the third and last programmed sleep period, both crewmen appeared to have had three to four hours of light to moderate sleep. Generally, this crew did not do as well in sleeping as have some other crews, and it appears that the deprivation of sleep endured by the pilot the first night may have contributed to some degree to his difficulties during EVA the next day. Neither crewman found it necessary to use the defecation device during the flight, and they reported no particular difficulties with the urine collection and disposal system.

7.2.2.2.7 Medications: The command pilot used two tablets of diphenoxylate hydrochloride to suppress the urge to defecate on three occasions, at 30 hours 45 minutes, and 44 hours 10 minutes g.e.t. and at approximately an hour and a half before retrofire. No other medications were taken by either crewman.

7.2.2.2.8 Vision: During this flight, the crew had the opportunity to observe ground targets from a higher altitude than had been attained by any previous crew. Two revolutions were flown with the spacecraft orbital apogee at 741.5 nautical miles. The crew reported that the curvature of the earth was far more pronounced than expected, and that detailed ground features became increasingly difficult to find as altitude was gained. The only visual difficulty reported was the one noted by the pilot as being caused by perspiration during the umbilical EVA.

7.2.2.2.9 Orientation: No abnormalities of orientation were experienced. During the PPS maneuver for the high-apogee excursion, the crewmen were subjected to approximately 1.1g in an eyeballs-out vector, but this caused them no difficulties. During the rotation of the tethered vehicles, they could sense no centrifugal force nor were they able to sense the angular velocity, except visually. Initially, the spacecraft was rotating at 38 deg/min, and this rate was maintained for approximately 1 hour 27 minutes. During this period, the crew were on the end of a 50-foot arm of rotation. The rate of rotation was increased to about 55 deg/min and maintained at that level for about 1 hour 15 minutes. During this period, the crew were similarly unable to sense any angular velocities or any centrifugal acceleration. No disorientation was experienced during the period of rotation.

7.2.2.2.10 Radiation: The two high-apogee revolutions were chosen specifically to avoid exposure of the S009 Nuclear Emulsion experiment package to ionizing radiation. Neither the crew nor the S009 experiment package was exposed to any radiation during these two high-apogee revolutions that exceeded that to which they would have been exposed had they remained in a 161-nautical-mile orbit. The integrated dose indicated on the Gemini Radiation Monitoring System (GRMS), due to the radiation environment, was 30 millirads. This number is corrected for leakage before flight and inflight. The following radiation doses were recorded by the thermoluminescent dosimetry system (passive).

Location of measurement	Radiation dose, millirads	
	Command pilot	Pilot
Helmet	39 ±1	34 ±2
Thigh	28 ±3	25 ±1
Left chest	27 ±1	23 ±1
Right chest	26 ±3	25 ±1

Trained radiation monitoring personnel at MSC reported that the difference in doses indicated by the GRMS and the passive radiation dosimeters can be attributed to the difference in the solid angle with which each was exposed to the radiation field.

7.2.2.2.11 Retrofire and reentry: The crew reported nothing remarkable from the point of view of their sensations at retrofire, during controlled reentry, upon deployment of the drogue or main parachutes, going to two-point suspension, or landing in the water. It is notable that this reentry was completely automatic and that the crew spent a minimum amount of time on the water because of the accuracy of the landing.

7.2.3 Postflight

This portion of the report includes aeromedical observations during the time from spacecraft landing to final medical evaluation of the crew at Kennedy Space Center, Florida. The medical information presented is derived from the postflight ergometry studies on the pilot, postflight medical examination, tilt-table studies on each crewmember, and routine laboratory studies. With the exception of the following findings, the postflight examination was entirely within expected limits:

(a) Slight asymptomic postural hypotension

(b) Slight erythema at sensor sites

(c) Macular rash on the pilot's neck

(d) Minor dehydration

(e) Minimal bilateral conjunctivitis.

7.2.3.1 Recovery medical activities.- The planned recovery medical procedures were essentially unchanged from those of the Gemini X mission and were completed approximately two hours after the crew entered the sick bay. The crew returned to the hospital area of the ship approximately eight hours later for their second tilt study.

7.2.3.1.2 Recovery procedures: The U.S.S. Guam, an LPH-type helicopter carrier, was stationed in the primary recovery area. Personnel aboard the ship were able to observe the spacecraft from the point it passed through the 70 000-foot level until landing. At approximately 70 000 feet, a vapor trail appeared and continued to be visible down to about 50 000 feet. The spacecraft was next seen when the drogue parachute deployed, and the spacecraft was easily visible throughout the remainder of the recovery operation.

Although moderate oscillation was experienced by the crew while on the main parachute, this motion did not cause any significant discomfort. The landing was no more severe than that which the command pilot had previously experienced during the Gemini V mission. The seas were calm, with waves of two to three feet. This, with the immediate availability of the recovery helicopters and expeditious retrieval of the crew, precluded any difficulty with postlanding motion sickness. Although portable cooling and ventilating units were available to the crewmembers while in the helicopter, both declined to use them. Consequently, when the crew were first seen on deck, they were perspiring profusely but otherwise showed no obvious adverse effects. At the time of the second postflight tilt, about 12 hours after landing, both crewmen showed signs of considerable fatigue. The command pilot retired shortly thereafter and the pilot retired at 3:00 G.m.t. Both men slept well, awoke without residual ill effects, and prepared to leave the ship at 13:00 G.m.t., September 16, 1966.

7.2.3.2 Examinations.- After desuiting, it was evident that a significant heat load had been sustained by the crew. Their undergarments were saturated and the inner portion of their pressure garments was wet. The skin of each crewman was in excellent condition except for some minor erythema and vesiculation around the sensor sites. The pilot had a small area of erythema on the right anterior aspect of his neck. Although the crew stated that they felt fatigued, they did not manifest this on the postflight physical examination. The remainder of the examination was within normal limits. Laboratory findings are presented in tables 7.2-I(a) and (b).

7.2.3.3 Special data collection.- Three postflight tilt studies were performed at the times indicated in figure 7.2-1. The postflight bicycle ergometry test of the pilot's exercise capacity was performed after return to Cape Kennedy. The results are presented in figures 7.2-2 and 7.2-6.

TABLE 7.2-I.- HEMATOLOGY

(a) Command pilot

Determination / Date	Preflight		Postflight
	August 30, 1966	September 6, 1966	September 15, 1966
Red blood cells/mm^3	5 473 762	5 506 654	5 920 000
Hematocrit, percent	48	47.4	51.5
Hemoglobin, grams percent	14.2	14.4	15.8
Reticulocyte, percent	0.8		
Indices:			
Mean corpuscular volume, μ^3	86	86.1	86.9
Mean corpuscular hemoglobin, $\gamma\gamma$	27	26.2	26.7
Mean corpuscular hematocrit, percent	31.5	30.4	30.7
White blood cells/mm^3	6 950	7 600	6 150
Neutrophiles			
Segmented, percent	47	35	72
Stab, percent		1	
Lymphocytes, percent	47	57	27
Monocytes, percent	2	5	1
Eosinophiles, percent	2		
Basophiles, percent	2	2	
Sodium, mEq/l	152	146	140
Potassium, mEq/l	4.6	5.0	[a]6.2
Calcium, mEq/l	9.2	9.0	9.4

[a]Hemolysed specimen.

TABLE 7.2-I.- HEMATOLOGY - Concluded

(a) Command pilot

Determination / Date	Preflight		Postflight
	August 30, 1966	September 6, 1966	September 15, 1966
Calcium, mgm percent	4.6	4.5	4.7
Chloride, mEq/l	106	105	99
Blood urea nitrogen, mgm percent	20.1	24.2	17.1
Protein, total, gm percent	7.8	7.3	7.9
Albumin, gm percent	5.5	4.9	5.4
Uric acid, mgm percent	5.5	5.9	4.5
Cholesterol, mgm percent	200	213	
Osmolality, mOs/kg	297	288	287
Electrophoresis			
α1, gm percent	0.27	0.36	0.31
α2, gm percent	0.64	0.61	0.73
β, gm percent	0.58	0.66	0.68
γ, gm percent	0.55	0.54	0.61
Fibrinogen, gm percent	0.33	0.27	0.17

TABLE 7.2-I.- HEMATOLOGY

(b) Pilot

Determination / Date	Preflight		Postflight
	August 30, 1966	September 6, 1966	September 15, 1966
Red blood cells/mm^3	5 283 997	5 049 963	5 300 000
Hematocrit, percent	49	48	48
Hemoglobin, grams percent	15.9	15	16.6
Reticulocytes, percent	.9		
Indices:			
Mean corpuscular volume, μ^3	92.6	95.1	89.9
Mean corpuscular hemoglobin, $\gamma\gamma$	30.1	30.0	31.1
Mean corpuscular hematocrit, percent	32.4	31.6	34.6
White blood cells/mm^3	10 900	8 400	5 200
Neutrophiles			
Segmented, percent	69	55	71
Stab, percent			
Lymphocytes, percent	25	37	28
Monocytes, percent	3	2	
Eosinophiles, percent	3	5	1
Basophiles, percent		1	
Sodium, mEq/l	158	148	137
Potassium, mEq/l	4.3	4.3	[a]5.4
Calcium, mEq/l		4.1	4.6

[a]Hemolysed specimen.

TABLE 7.2-I.- HEMATOLOGY - Concluded

(b) Pilot

Determination / Date	Preflight		Postflight
	August 30, 1966	September 6, 1966	September 15, 1966
Calcium, mgm percent		8.2	9.2
Chloride, mEq/l		107	100
Blood urea nitrogen, mgm percent	13.1	17.5	10.7
Protein, total, gm percent		7.6	7.7
Albumin, gm percent		4.6	4.8
Uric acid, mgm percent		6.4	5.0
Cholesterol, mgm percent	146		
Osmolality, mOs/kg	293	285	282
Electrophoresis			
α1, gm percent		0.34	0.31
α2, gm percent		0.65	0.71
β, gm percent		0.67	0.66
γ, gm percent		0.91	0.92
Fibrinogen, gm percent		0.42	0.35

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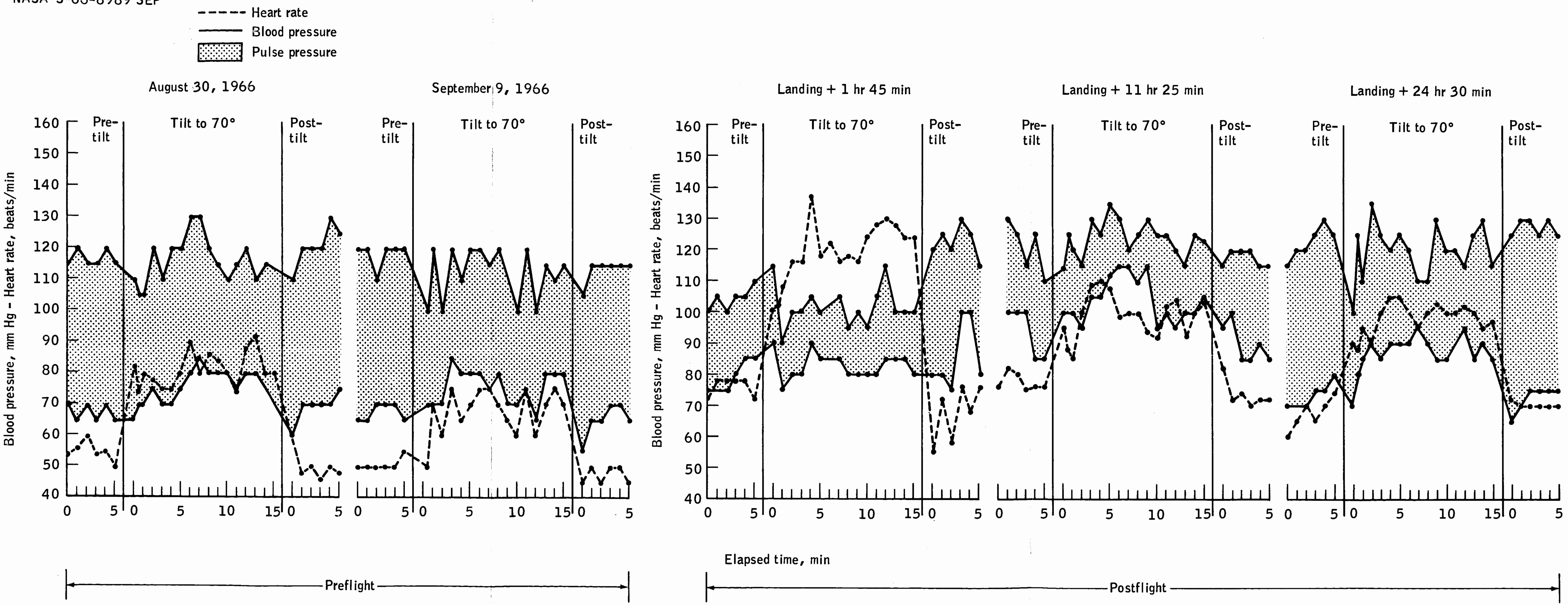

(a) Command pilot.

Figure 7.2-1. - Tilt table studies.

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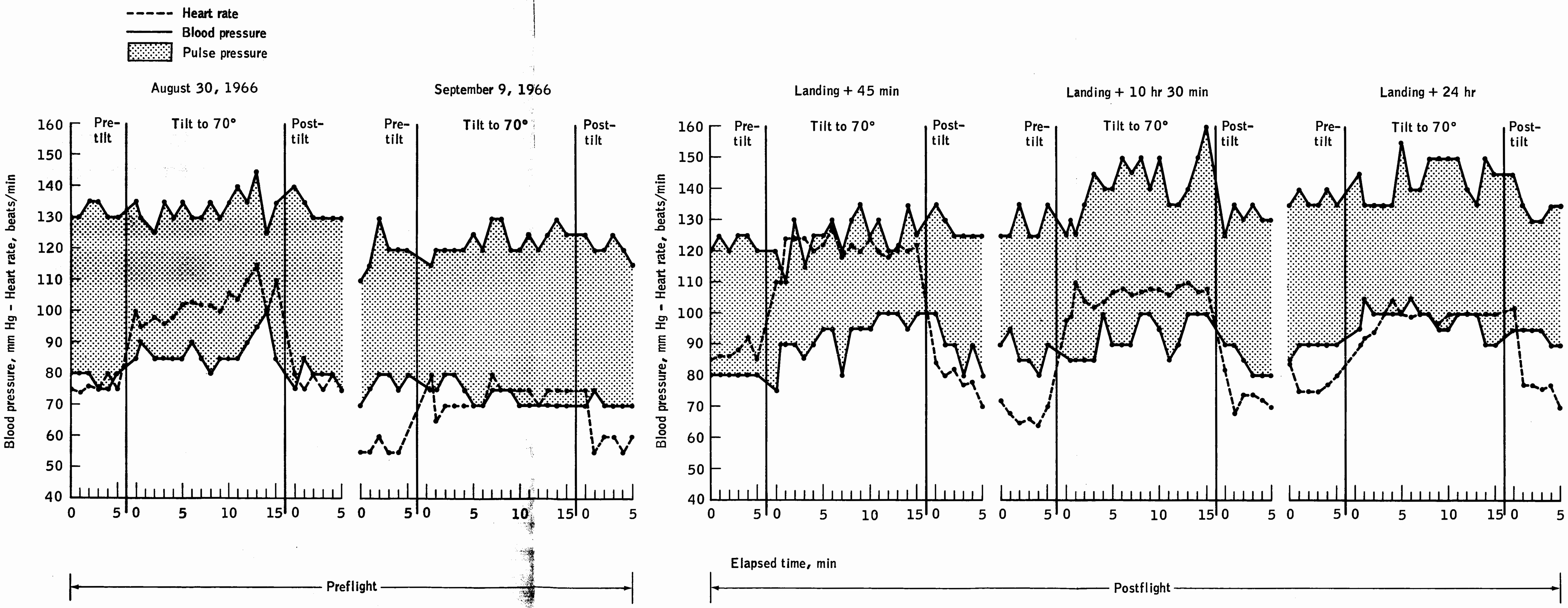

(b) Pilot.

Figure 7.2-1. - Concluded.

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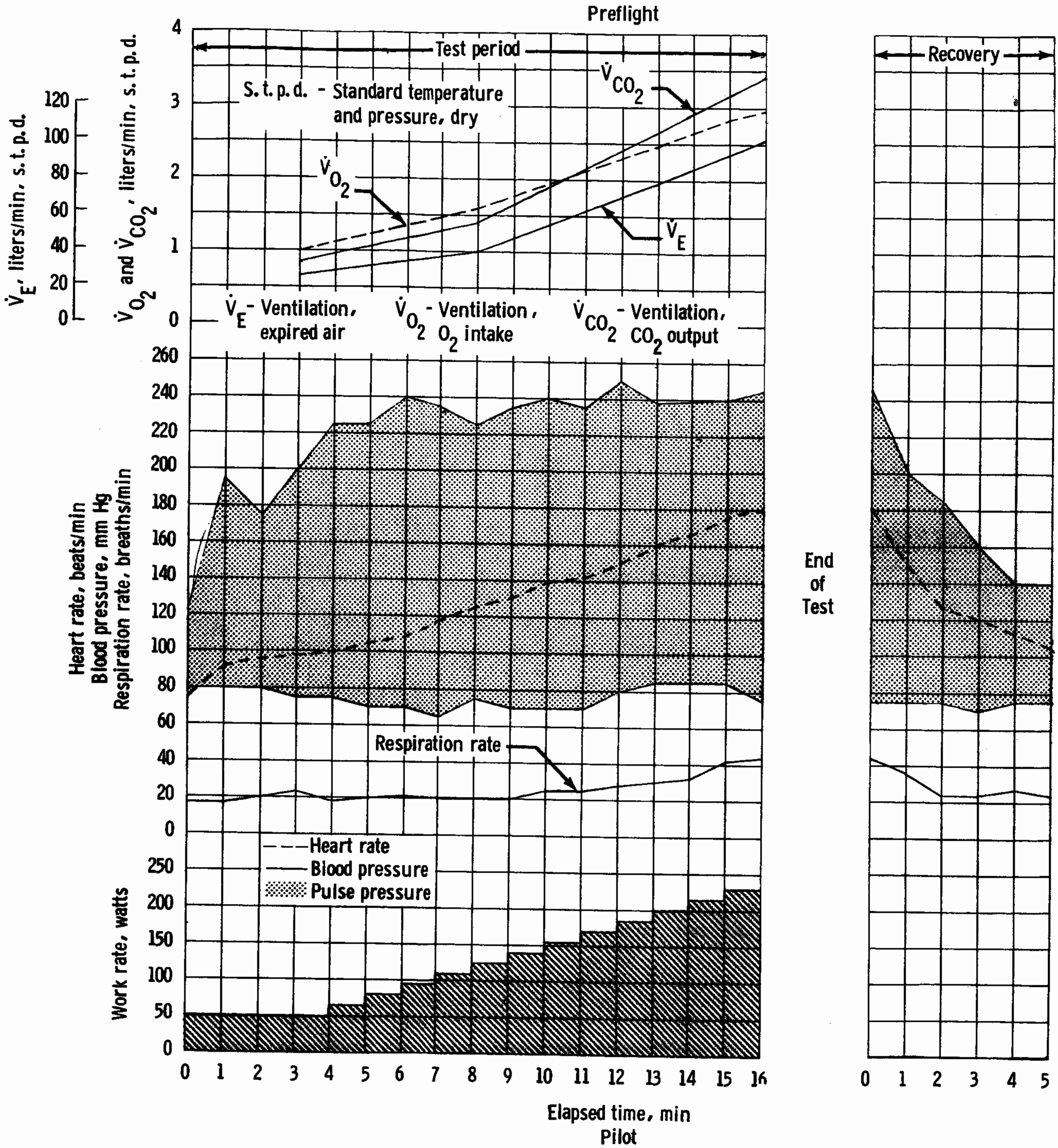

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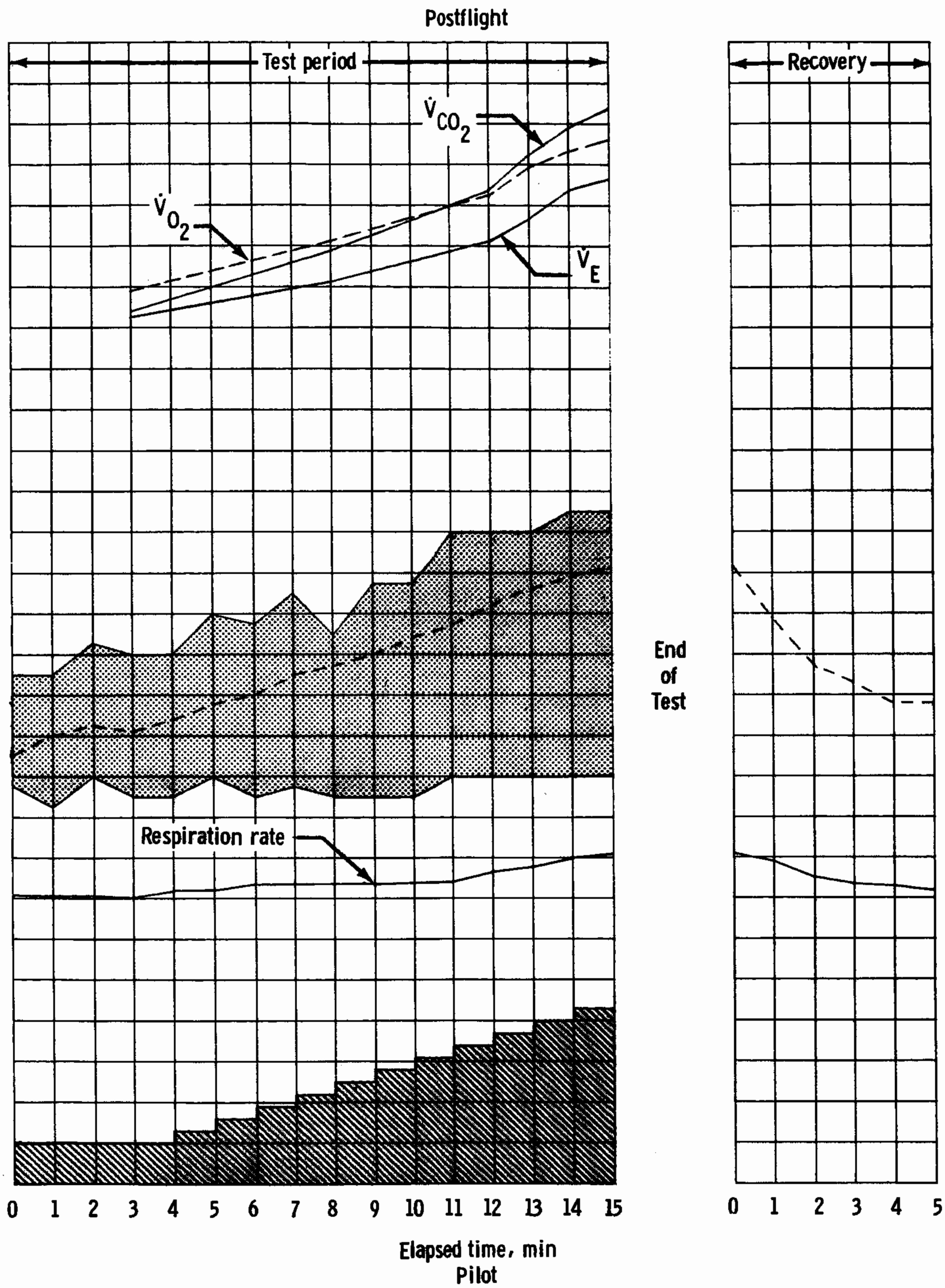

Figure 7.2-2. - Exercise capacity test result.

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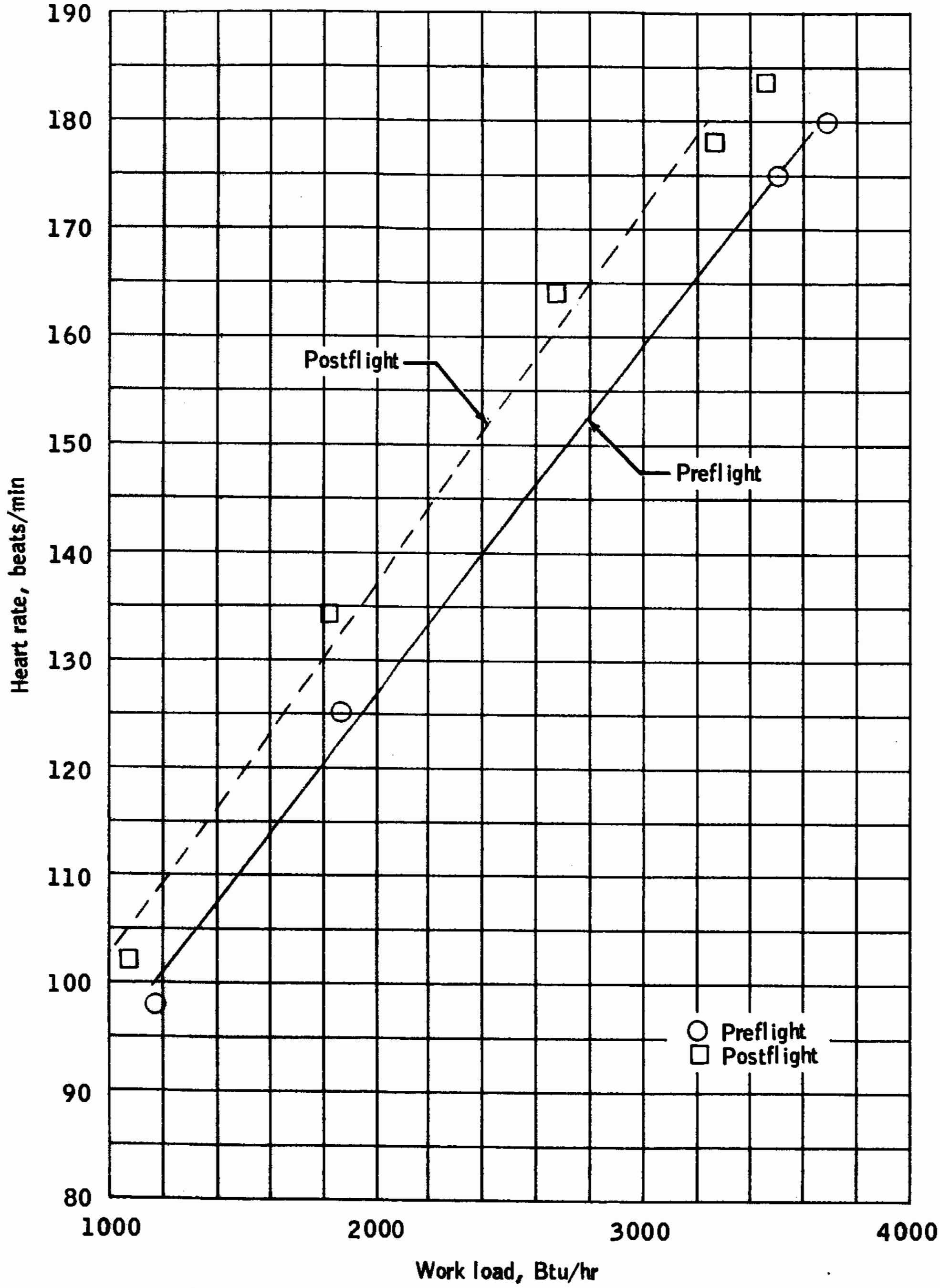

Figure 7.2-3.- Exercise studies on the Gemini XI pilot.

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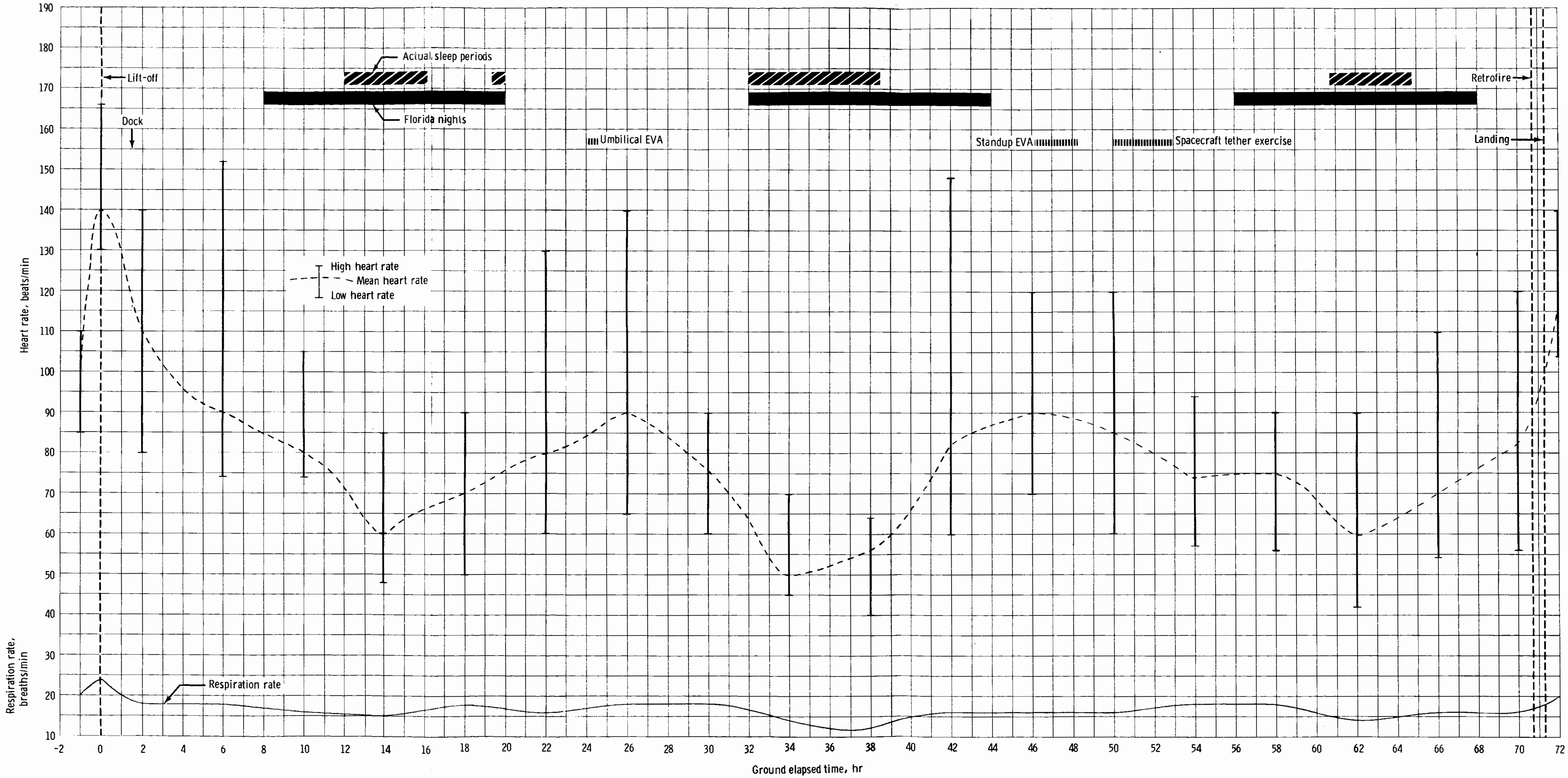

(a) Command pilot

Figure 7.2-4. - Physiological measurements.

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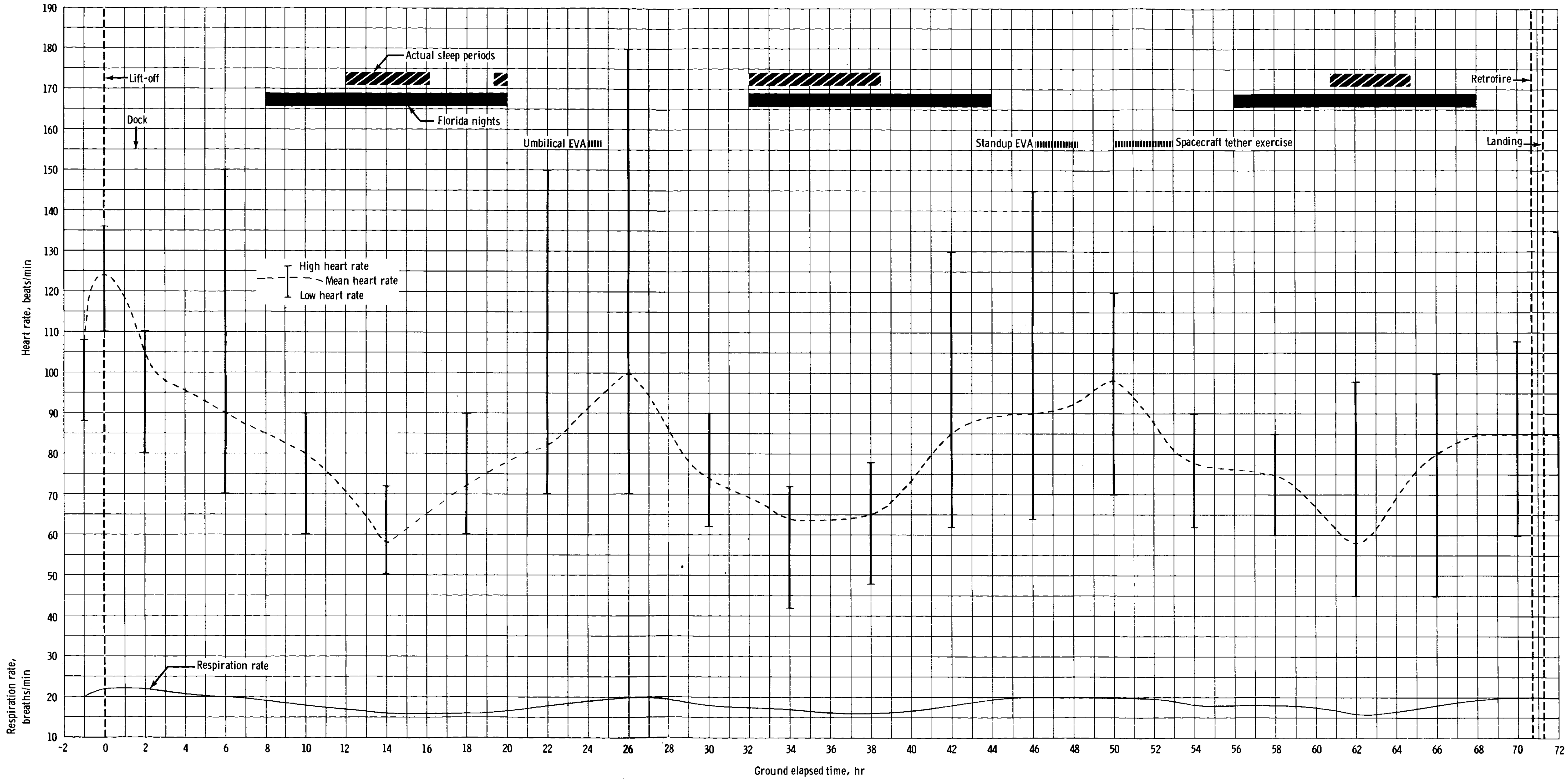

(b) Pilot

Figure 7.2-4. - Concluded.

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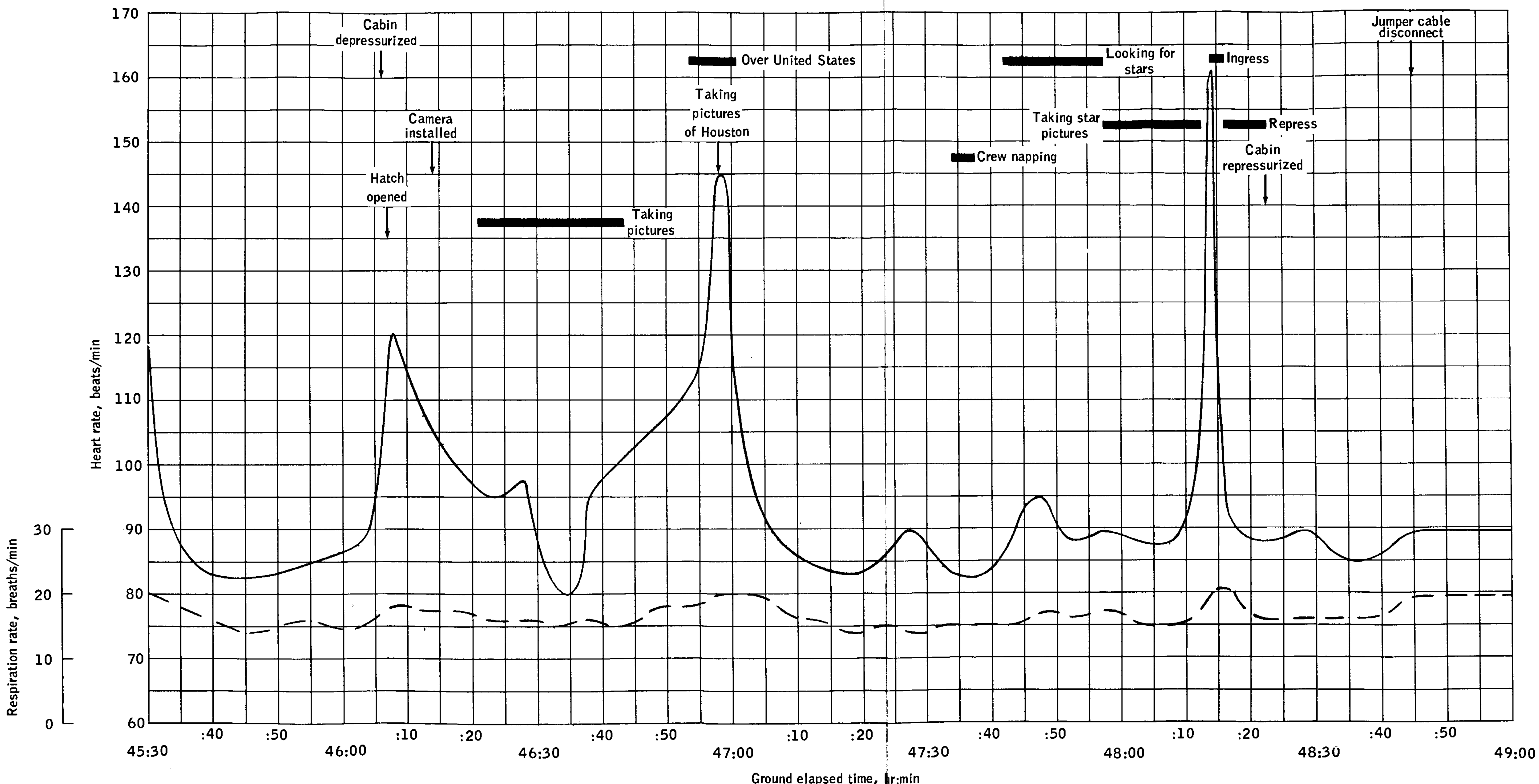

Figure 7.2-5. - Physiological data during standup EVA, pilot.

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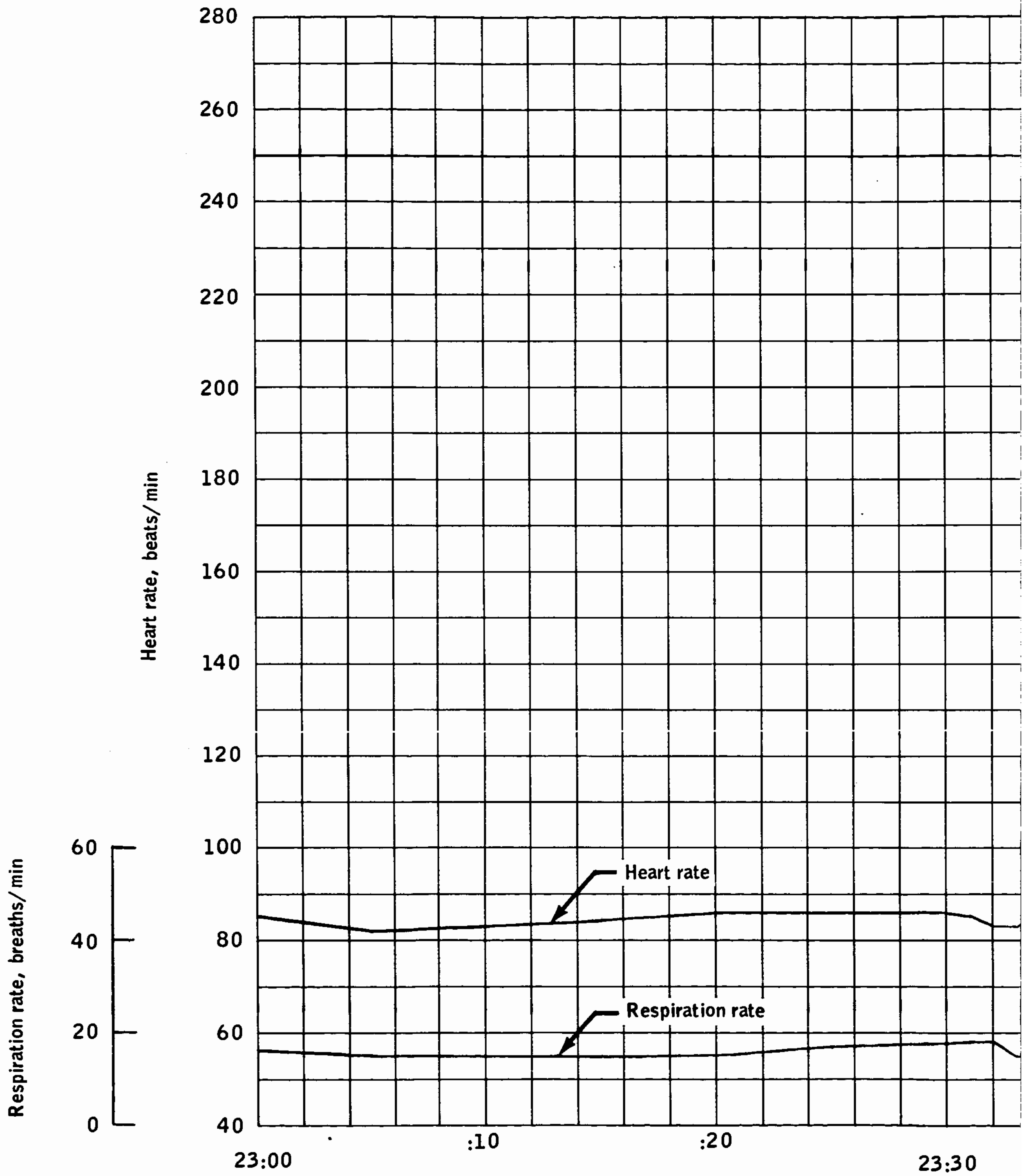

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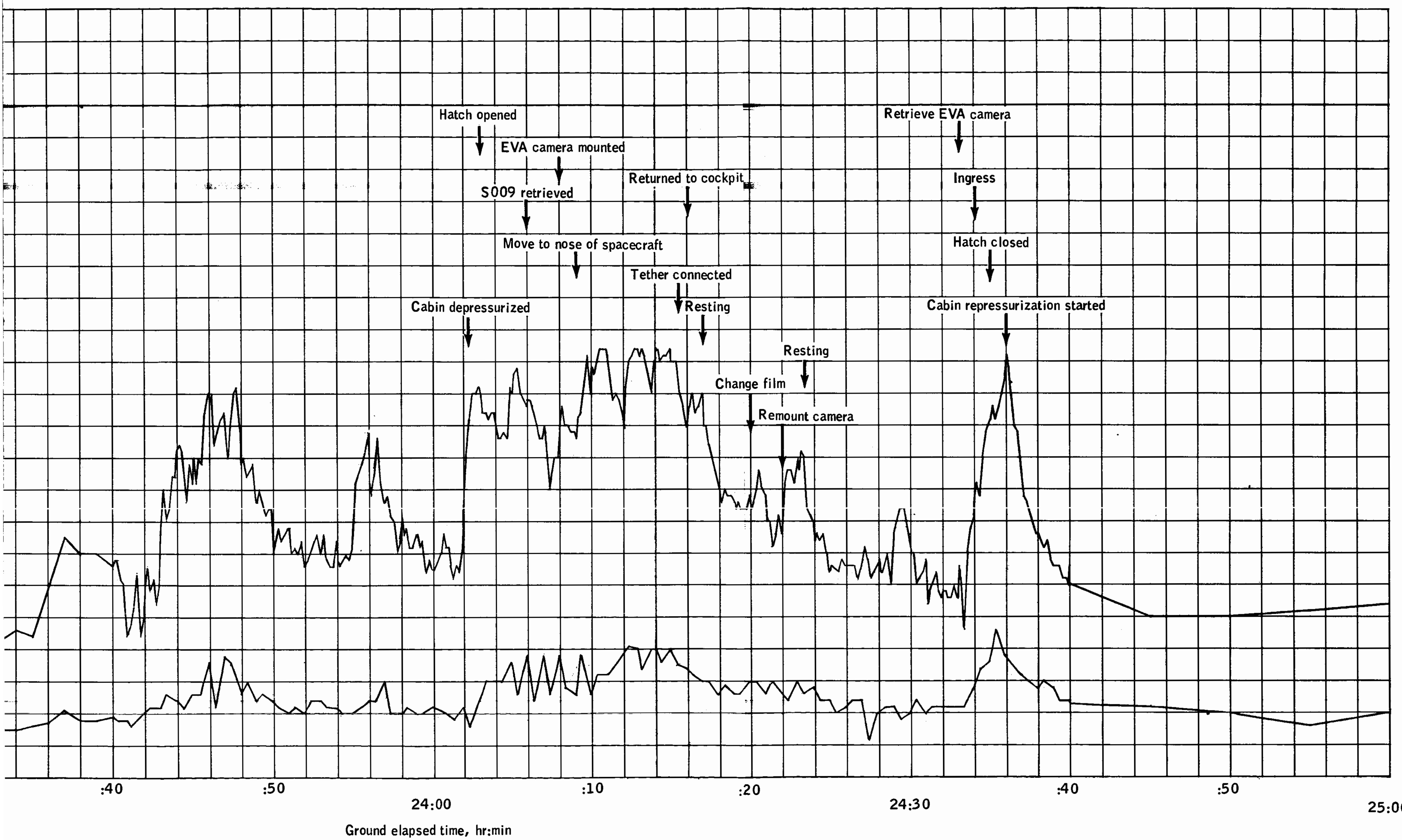

Figure 7.2-6.- Physiological data during umbilical EVA, pilot.

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8.0 EXPERIMENTS

Twelve scientific or technological experiments were originally planned for the Gemini XI mission. The 3-day delayed launch resulted in cancellation of the S029 Libration Regions Photography experiment because the earth-moon libration regions became obscured by the Milky Way star background, preventing the experiment from meeting its basic objectives. Table 8.0-I lists in alphanumeric order the 11 scheduled experiments, and shows the experiment title, sponsoring agency, principal investigator, and qualitative success on this mission. The actual schedule of experiment activities shown in table 8.0-II, was reconstructed from the preflight plan, onboard voice tapes, mission notes, crew flight logs, and scientific debriefings.

Preliminary analyses of available photographic and telemetry data indicate that the fundamental objectives were obtained for 9 of the 11 scheduled experiments. The D016 Power Tool Evaluation experiment was not attempted because of premature termination of the umbilical extravehicular activities (EVA). The S030 Dim Sky Photographs/Orthicon experiment was successfully performed; however, only one of the several scheduled activities was photographically recorded.

Each experiment is described in the sections that follow, and the success or failure of the experiment is indicated. For most experiments, detailed evaluation of the data will require several months of analysis and correlation; therefore, only preliminary results are reported for those experiments. Specific scientific or technological reports will be published as appropriate when the analyses are completed.

TABLE 8.0-I.- EXPERIMENTS ON GEMINI XI

Experiment number	Experiment title	Principal investigator	Sponsor	Data obtained	Completion of planned objectives
D003	Mass Determination	Department of the Air Force Detachment 2, NASA, MSC Houston, Texas	Department of the Air Force, Detachment 2, Space Systems Division (AFSC)	Two periods of useful data	Completed
D015	Night Image Intensification	Naval Air Development Center, Johnsville, Warminster, Pennsylvania	Department of the Navy	Five periods of useful data	Completed
D016	Power Tool Evaluation	Air Force Avionics Laboratory, Wright-Patterson AFB, Ohio	Department of the Air Force Detachment 2, Space Systems Division (AFSC)	No useful data obtained	Not attempted
S004	Radiation and Zero-G Effects on Blood and Neurospora	Atomic Energy Commission, Oakridge National Laboratory, Oakridge, Tennessee	NASA Office of Space Science and Applications (OSSA)	Several periods of useful data	Completed
S005	Synoptic Terrain Photography	NASA, Goddard Space Flight Center, Greenbelt, Maryland	NASA/OSSA	145 photographs	Completed
S006	Synoptic Weather Photography	U. S. Weather Bureau National Weather Satellite Center Suitland, Maryland	NASA/OSSA	180 photographs	Completed

TABLE 8.0-I.- EXPERIMENTS ON GEMINI XI - Concluded

Experiment number	Experiment title	Principal investigator	Sponsor	Data obtained	Completion of planned objectives
S009	Nuclear Emulsion	U. S. Naval Research Laboratory; NASA and Goddard Space Flight Center	NASA/OSSA	All data obtained	Completed
S011	Airglow Horizon	U. S. Naval Research Washington, D. C.	NASA/OSSA	25 frames of photographic data	Substantial
S013	Ultraviolet Astronomical Camera	Dearborn Observatory, Northwestern University, Evanston, Illinois	NASA/OSSA	21 frames of photographic data	Substantial
S026	Ion-Wake Measurement	Electro-Optical Systems, Inc., Pasadena, California	NASA/OSSA	Seven periods of useful data	Completed
S030	Dim Sky Photographs/ Orthicon	Dudley Observatory Albany, New York; University of Minnesota, Minneapolis, Minnesota	NASA/OSSA	One sequence of useful data	Partial

TABLE 8.0-II.- FINAL EXPERIMENT FLIGHT PLAN FOR GEMINI XI

Experiment title	Priority	Activation time, g.e.t., hr:min	Revolution	Condition	Remarks
D003 Mass Determination	3	1:55:29.3	2	Mass acceleration phase	25-second translation in a docked configuration
		54:37:28.1	34	Thruster calibration phase	11-second translation in an undocked configuration
D015 Night Image Intensification	1	54:32	34	System check	Checkout test over Hawaii
		55:04	34	Search and track, scan modes	West coast of South America
		55:28	35	Scan and track modes	South Africa area
		55:35	35	Scan mode	India area
		56:40	36	Scan mode	South America area
		57:02	36	Search and track, scan, track modes	Sea features, Africa, and Saudi Arabia areas
		66:15	41	Scan mode	Thruster 15 fired to check D015 optical fogging
		67:30	42	GATV observation	GATV at 4 miles distance
D016 Power Tool Evaluation	2	24:40	16	EVA	Not attempted

TABLE 8.0-II.- FINAL EXPERIMENT FLIGHT PLAN FOR GEMINI XI - Continued

Experiment title	Priority	Activation time, g.e.t., hr:min	Revolution	Condition	Remarks
S004 Radiation and Zero-G Effects on Blood and Neurospora	5	30:09	19	Activate Neurospora	Over Hawaii
		65:38	42	Temperature	Switch turned off to increase temperature
		66:43	43	Blood package activation	
		67:53	44	Blood and Neurospora deactivated	KSC ground test also deactivated
S005 Synoptic Terrain Photography	10	40:42 to 41:14	26	200 to 600 n. mi. altitudes	Egypt, Saudi Arabia, India, and Australia areas
		42:08 to 42:46	27		
S006 Synoptic Weather Photography	11	46:15 to 47:06	29	160 n. mi. altitudes	Mexico, U. S. Gulf Coast, and Florida areas
S009 Nuclear Emulsion	4	1:42	2	Mode 1 - activation	Spacecraft is attitude controlled
		24:06	15	EVA	S009 package was retrieved and stowed
S011 Airglow Horizon Photography	8	17:14	11	Sequence 2	Northern and southern horizons photographed
		29:15	19	Sequences 1 and 3	Eastern airglow photographed
		41:35	26	Mode A, sequence 4	Western horizon photographed during high-apogee orbit

TABLE 8.0-II.- FINAL EXPERIMENT FLIGHT PLAN FOR GEMINI XI - Concluded

Experiment title	Priority	Activation time, g.e.t., hr:min	Revolution	Condition	Remarks
S013 UV Astronomical Camera	7	46:12 to 46:49	29	Mode A	Diffraction grating used for stars Shaula, Canopus, and Alnilam
		47:45 to 48:20	30	Mode B	Prism used
S026 Ion-Wake Measurement	6	1:35	1	Docking	
		2:10 to 3:50	2	Mode B: Sequences 1 through 3 Mode A: linear	Consists of two out-of-plane, one in-plane, and one linear maneuver
		41:10	26	High-apogee orbit	Ambient data recorded
S030 Dim Sky Photographs/ Orthicon	9	65:46 to 66:25	41	Sequences 1 through 6	Photographically record airglow and Canopus

8.1 EXPERIMENT D003, MASS DETERMINATION

8.1.1 Objective

The objective of the D003 Mass Determination experiment was to evaluate the accuracy of using a direct contact method with a spacecraft to determine the mass of an orbiting object. The method consisted of accelerating the Gemini Agena Target Vehicle (GATV) using the spacecraft propulsion system. The mass of the GATV was calculated from the resultant acceleration, updated spacecraft mass, and calibrated thrust levels of the vehicles.

8.1.2 Equipment

No special equipment was required for this experiment; however, the following spacecraft equipment was used.

(a) Computer: Computed velocity change (ΔV) during the thrusting periods

(b) Manual Data Insertion Unit: Displayed ΔV

(c) Time Reference System: Indicated to the crew and recorded through telemetry the event time in ground elapsed time

(d) Orbital Attitude and Maneuver System (OAMS): Used to perform required spacecraft maneuvers

(e) Instrumentation System: Provided standard telemetry measurements

(f) Voice tape recorder: Used by flight crew to record experiment data.

8.1.3 Procedures

This experiment was performed using standard spacecraft procedures; therefore, additional training was not required by the crew. A calibration acceleration of the spacecraft was first required so that the thrust of the aft-firing thrusters could be accurately determined. A mass-determination acceleration with the spacecraft/GATV in the docked configuration was then required to complete the experiment. Because of operational considerations, the mass determination was performed early in the mission (1:55:29.3 g.e.t.) after the first docking. The calibration maneuver was accomplished later (54:37:28.1 g.e.t.) after the spacecraft had been separated from the GATV.

The planned procedure was that, after docking, the spacecraft/GATV combination was to be thrusted for 25 seconds with the aft-firing OAMS thrusters. The first 18 seconds of the thrusting assured that a minimum GATV fuel motion would occur during the subsequent 7-second measurement period. The average acceleration was to be determined over this 7-second period and is derived by measuring incremental velocity (ΔV) and thrusting time (ΔT) intervals.

The mass of the GATV was to be computed from

$$M_{A_c} = \frac{F_c\,(\Delta t)}{\Delta V} - M_{G_c}$$

where

M_{A_c} = GATV mass, slugs

F_c = maneuvering thrust of the spacecraft, lb

Δt = measured thrusting time interval, sec

ΔV = measured incremental velocity, ft/sec

M_{G_c} = spacecraft mass, slugs

The greatest error in the evaluation would normally arise from variable or unknown thruster output; therefore, inflight crew evaluation of the spacecraft OAMS thrust was required prior to docking. This value for F_c was used in the GATV mass computations.

Two methods for calculating the mass of the GATV were to be employed. The Astronaut Method was to be accomplished by the flight crew in real time using data collected onboard. The Telemetry Method was to be accomplished after the flight, using telemetry data. The results of both methods of calculation were to be compared with the iterated mass of the GATV determined from the known insertion weight and the consumption of expendables. Due to time constraints on the flight crew during the mission, calculations for both methods were actually accomplished postflight.

(a) Astronaut Method: The Manual Data Insertion Unit (MDIU) in the spacecraft was used for the ΔV determination and the event timer was used for the Δt measurement. The ΔV was available with 0.1 ft/sec resolution and Δt had errors of less than 0.2 of a second. The crew computed the thrust, mass, and updated mass using these inflight data. The crew performed the predocking part of the experiment by thrusting the spacecraft for seven seconds with the aft-firing thrusters, measuring the ΔV and Δt, and then computing the maneuvering thrust based on updated spacecraft mass and the measured parameters. After docking and rigidizing the spacecraft/GATV combination, the crew thrusted with the OAMS and activated the event timer to commence the mass determination phase of the experiment. The crew monitored a countdown to seven seconds, then activated the computer for the ΔV calculation over the 7-second period. When the timer reached zero, the crew stopped thrusting. The crew then computed an updated spacecraft mass and used this value, with the computed predocking value of the maneuvering thrust and the measured ΔV and Δt, for calculating the GATV vehicle mass.

(b) Telemetry Method: An independent analysis was accomplished after the mission, using telemetry data as shown in figure 8.1-1. This method employed the same equation as the Astronaut Method, but the ΔV was obtained from computer telemetry data and Δt through the Time Reference System (TRS). The values of ΔV and Δt were available with resolutions of 0.1 ft/sec and 0.125 of a second, respectively. Using these data systems, the values of ΔV and Δt were obtained for the undocked and the docked phases of the experiment. Mass updating data, including propellant consumption and environmental oxygen consumption, were used in updating the mass of the spacecraft at the midpoint of both maneuvers and in updating the GATV mass at the midpoint of the mass determination maneuver. Postflight comparisons were then made with the data obtained from the Astronaut Method of mass determination.

8.1.4 Results

During the calibration maneuver, the assumed spacecraft weight, based on prelaunch conditions and consumables expended prior to the maneuver, was 7402 pounds. For the calibration maneuver, using the Astronaut Method, forward translation with the OAMS aft-firing thrusters lasted 11 seconds and resulted in a velocity change of 9.8 ft/sec. The thrust calculated from these values, assuming acceleration of gravity to be 32.17 ft/sec/sec, was 205.0 pounds. Using the Telemetry Method, the firing time was actually 11.2 seconds and the actual velocity change was

9.71 ft/sec. The thrust calculated from the telemetry values was 200.4 pounds. These values compare favorably with the nominal value of 189 pounds thrust cited in reference 20.

During the mass determination maneuver in the docked configuration, the OAMS aft-firing thrusters were fired for 25 seconds. The first 18 seconds were used only to minimize the effects of propellant slosh in the GATV. The three-axis velocity changes during the subsequent 7-second period were then recorded. The resultant velocity change obtained was 2.9 ft/sec. Using the calibrated thrust of 205.0 pounds, assuming a spacecraft weight of 7881 pounds, the acceleration of gravity, and the measured values of ΔV and Δt, the weight of the GATV was calculated by the Astronaut Method to be 7820 pounds.

For the Telemetry Method, a thrusting time of seven seconds actually resulted in a velocity change of 3.05 ft/sec. Using the spacecraft weight of 7881 pounds, the mass of the GATV was calculated to be 214.9 slugs, corresponding to a weight of 6912 pounds.

For the time of the mass determination translation maneuver, the weight of the GATV was estimated as 7268 pounds. Using this value as a standard, the relative error in determining mass by the Astronaut Method is 7.6 percent and the error using telemetry data is approximately 4.9 percent.

While these preliminary results are encouraging, it should be noted that some of the vehicle weight values used in the calculations are subject to adjustment. Calculations are very sensitive to precise measurements of velocity changes and duration of thrusting, especially over very short periods such as those employed. Both of the mass determination methods appear to be feasible; however, neither should be adopted until confirmation by additional statistical samples is accomplished.

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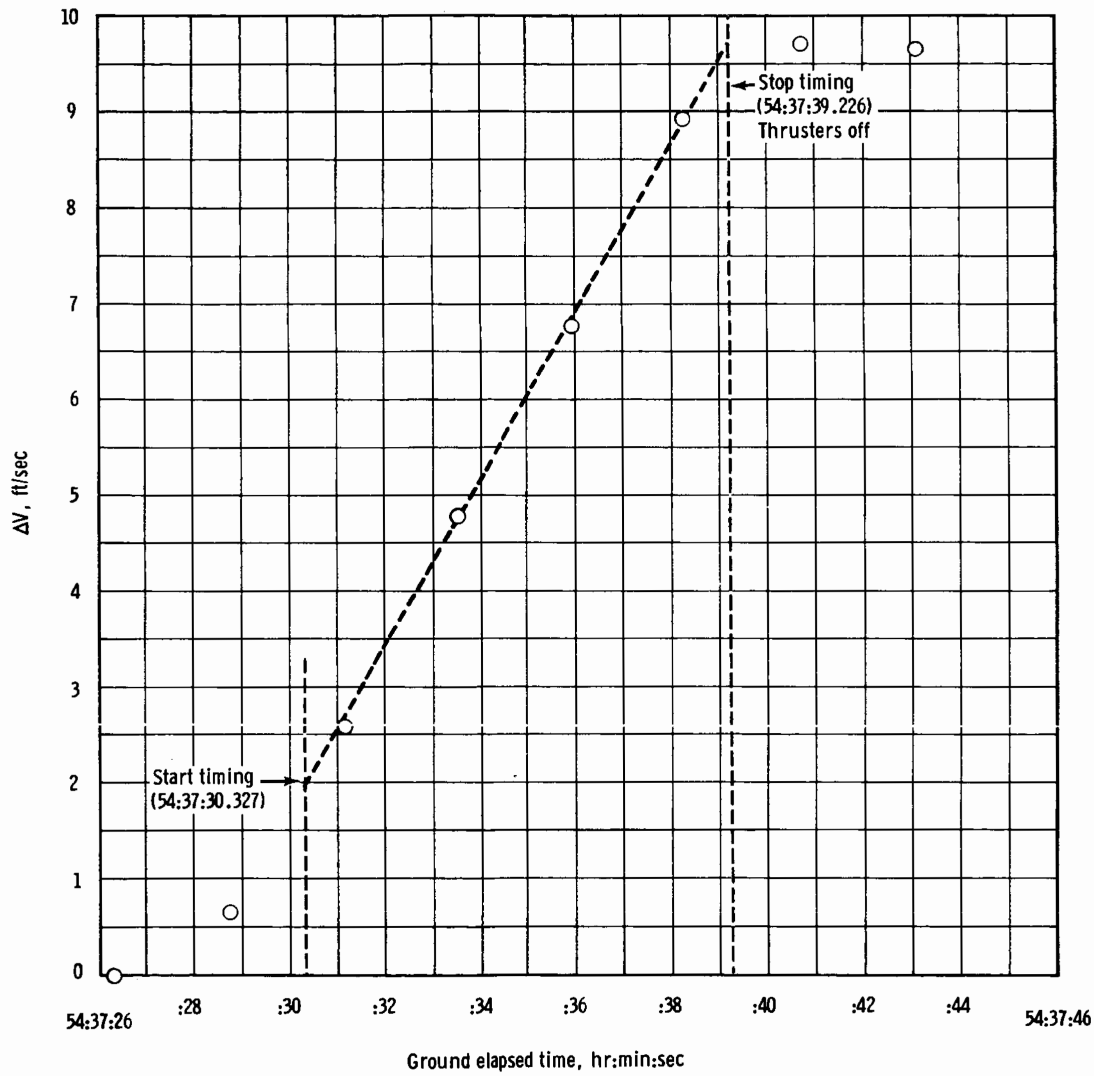

(a) Calibration maneuver.

Figure 8.1-1. - Experiment D003, mass determination (telemetry method).

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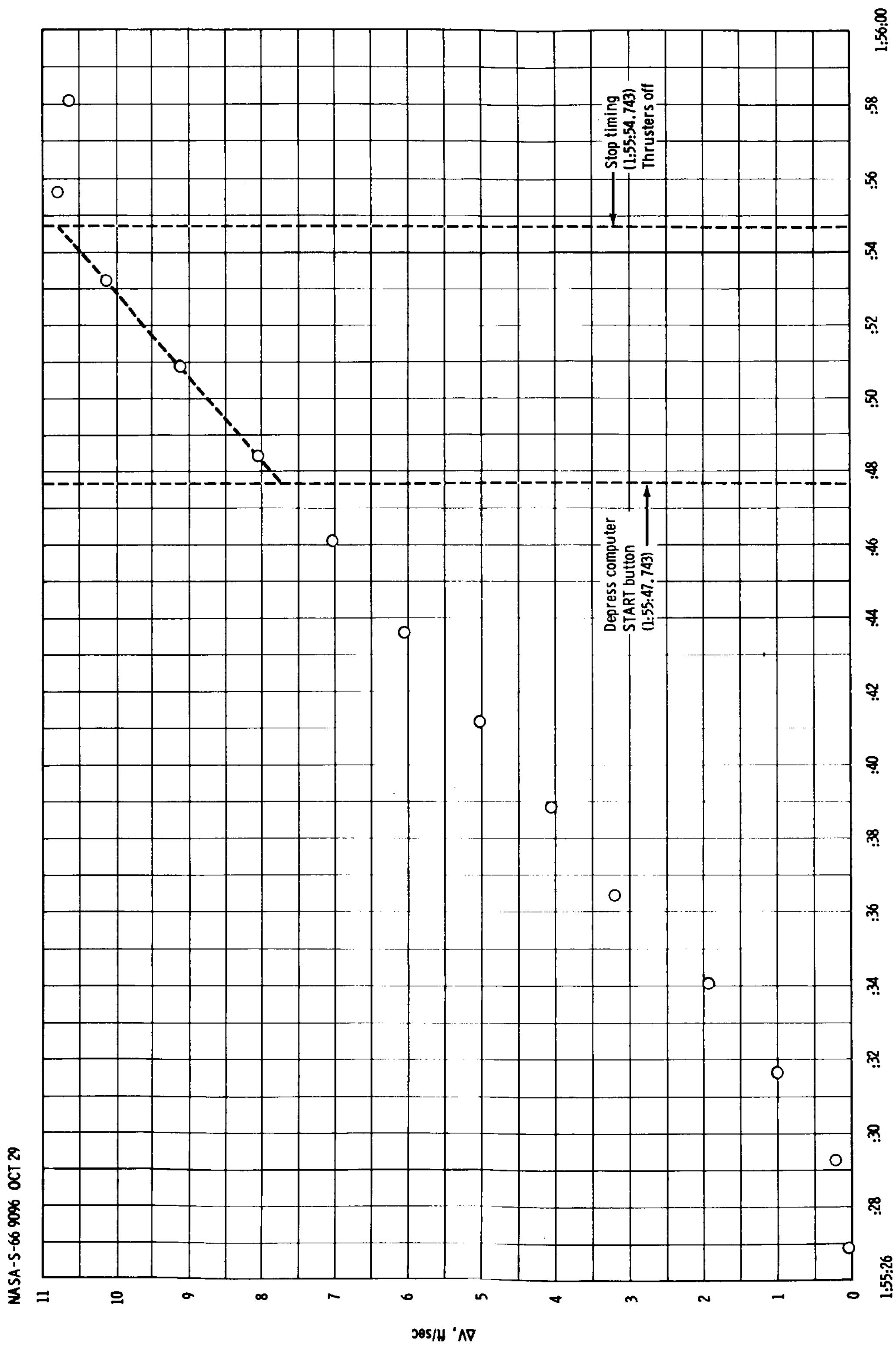

(b) Mass determination maneuver.

Figure 8.1-1. Concluded.

8.2 EXPERIMENT D015, NIGHT IMAGE INTENSIFICATION

8.2.1 Objective

The D015 Night Image Intensification experiment was designed to test the performance of a Low Light Level Television System as a supplement to unaided flight crew vision in the observations of surface features under conditions of darkness and a non-dark-adapted crew. The Low Light Level Television System was designed to be more sensitive than the dark-adapted eye when object illumination was less than full moonlight.

8.2.2 Equipment

The Low Light Level Television System consisted of five basic units (figs. 8.2-1 and 8.2-2). Physical characteristics and operating procedures are described in references 21 and 22.

The camera optical system would view an earth scene, then focus the image on a sensor that converted it to electronic signals for optical conversion in the viewing and recording monitors. The camera was installed so that the line-of-sight was parallel to the centerline of the spacecraft. The TV camera scene was displayed to the pilot on the viewing monitor tube. The command pilot viewed the same earth scene directly through the left window of the spacecraft.

Photographic film was exposed to the recording monitor scene when the pilot actuated a pushbutton located on the viewing monitor. A permanent photographic record was thus obtained for postflight analysis.

8.2.3 Procedures

The flight plan scheduled this experiment for the nightside portions of revolutions 35 and 36. Both pilots were to record their observations on the onboard voice tape recorder. The experiment flight plan used for this period is shown in table 8.2-I.

8.2.4 Results

The system was initially activated over Hawaii during revolution 34. Telemetry information and crew reports verified that the system was functioning properly. The experiment was performed during revolutions 35 and 36 in the time periods specified by the flight plan. In general, the areas listed in the flight plan within the spacecraft ground track were observed, but the crew made no attempt to perform the tracking tasks for those areas which were off the ground track. Most observations and recordings were made in the scanning mode and only those features which appeared prominent were tracked. Tracking was generally accomplished using spacecraft pitch control. Night viewing was without moon illumination and with medium to heavy cloud cover over most areas.

During the night periods, the pilot was able to observe, on the TV monitor, earth scenes such as coastlines and peninsulas, and the same scenes were not visible to the command pilot; however, the command pilot's window was dirty and the comparison was not completely valid. Coastlines and peninsulas were recorded on the photographic film. The pilot stated that the quality of the monitor presentation was superior to that shown on the photographic film. This degradation had been observed also during laboratory tests and was expected.

The D015 equipment functioned properly, except for the following anomalies:

(a) During the experiment activation, the field of view appeared tilted by an angle of approximately 45 degrees on the viewing monitor. Photographs from the recording monitor show a similar misalignment, indicating that the anomaly originated in the television camera or mirror. The television camera was mounted 20 degrees from the Y-axis of the spacecraft. Provisions were made during the integration of the equipment into the spacecraft for an upright display on the viewing monitor. The pilot corrected the display orientation by removing the viewing monitor from its bracket, rotating the monitor until the scene was corrected, then holding the unit between his legs. An analysis is being performed to determine the cause of the misorientation of the scene.

(b) The field of view of the television camera did not appear to be properly aligned with the optical sight on the command pilot's window. After installation, the television camera was optically aligned at the spacecraft contractor's facility to an accuracy of 1/2 of a degree of the spacecraft centerline. The television camera was removed from the spacecraft for shipment to the Kennedy Space Center (KSC). Tolerances on the camera mounting base and the spacecraft mounting fixture were sufficient to retain the desired alignment accuracy during camera removal and replacement. A comparison of test results from the contractor and from KSC indicate that the camera was reinstalled properly at KSC. No explanation for the misalignment is apparent at this time; however, the effect may be related to the tilted field of view previously discussed.

(c) A bright area near the center of the television display persisted throughout the experiment. Adjustment of the TV beam control reduced the spot but could not entirely eliminate this condition. Figure 8.2-3 shows two selected frames from the 3-frame-per-second, 1/30-second exposure, 16-mm film illustrating this condition. The lower frame in the figure shows a prominent bright spot, and the upper frame is one in which the spot is of minimum brightness. The bright area was probably caused by an ion spot beginning to develop in either the image intensifier or image orthicon tube sections of the television camera.

(d) Several photographic sequences taken during the S030 experiment operations were not on the flight film. A failure analysis on the recording monitor and photographic camera will be conducted.

(e) Stowage and handling of the viewing monitor within the cabin were performed without difficulty. Stowage of the viewing monitor in the footwell, however, was a cause of crew discomfort during the mission.

8.2.5 Conclusions

The experiment demonstrated that geographic features on the surface of the earth can be observed under starlight illumination as low as 5×10^{-5} foot-candles.

The airglow was very prominent under a new-moon condition, resulting in an apparent reduction in scene contrast, a washed-out presentation, and reduced television resolution. Due to this airglow, usable pictures were obtained only when the spacecraft was pitched down at an angle greater than 75 degrees from the horizontal.

Objects observed on the television monitor could be tracked by the pilot, using the monitor as a reference.

Clouds at night were quite prominent on the display because of their high reflectivity. The results of the experiment photography and the crew comments indicate that it is possible to map night cloud patterns over large areas.

Light areas on the surface of the earth, such as cities, appeared as extremely bright spots on the monitors. Many of the light areas viewed over Africa were reported by the crew to be fires. Lights under cloud cover were also readily distinguishable from the background.

Stars were quite apparent on the monitor. During revolution 41 at 65:27:21 g.e.t., the GATV was sighted on the viewing monitor while in total darkness at a distance of approximately 15 miles. The acquisition light was easily distinguished in the starfield background.

Successful operation of the experiment equipment proved that fragile electronic components, such as image orthicon tubes, can be packaged and installed to withstand a launch environment.

Following the completion of the S030 experiment, a supplemental experiment was performed to determine whether or not thruster operation would fog the viewing mirror. The spacecraft OAMS thruster no. 15 was located approximately 18 inches from a mirror used for directing the D015 experiment field of view forward along the longitudinal axis of the spacecraft. Following operation of the thruster, the crew reported no noticeable degradation on the television presentation.

TABLE 8.2-I.- FLIGHT PLAN FOR EXPERIMENT D015

Task	Area to be observed[a]	Mode of operation	Film recording time, sec
Revolution 35			
1	West coast of South America	Search and track[b]	30
2	South America	Scan[c]	30
3	Sea features	Scan	60
	Africa		120
4	East coast of Africa	Search and track	30
5	India	Scan	60
6	Calcutta	Track[d]	30
Revolution 36			
7	San Felix Island	Track	30
8	South America	Scan	50
9	Sea features	Search and track	60
10	St. Helena Island	Track	30
11	Africa	Scan	120
	Saudi Arabia coast		60
12	Gulf of Kutch	Track	30
Total			740

[a]Features of interest: Coast lines, islands, peninsulas, rivers, lakes, deserts, snow-capped mountains, cities, clouds, and ships.

[b]The search-and-track mode required the spacecraft to be oriented to a specific feature ahead of the spacecraft ground track. Upon acquisition, tracking was performed until 20 degrees past the nadir. Photographic features were recorded until 20 degrees past the nadir.

[c]The scan mode required the spacecraft longitudinal axis to be aligned normal to the surface of the earth as the spacecraft passed over the ground track area to be observed. Photographic features of interest were recorded as long as they remained in view.

[d]The track mode required the spacecraft to be oriented to an attitude which would facilitate acquisition of a specific feature as the spacecraft approached the feature. Upon acquisition, the feature was tracked until 20 degrees past the nadir. Photographic features were recorded from time of acquisition until 20 degrees past nadir.

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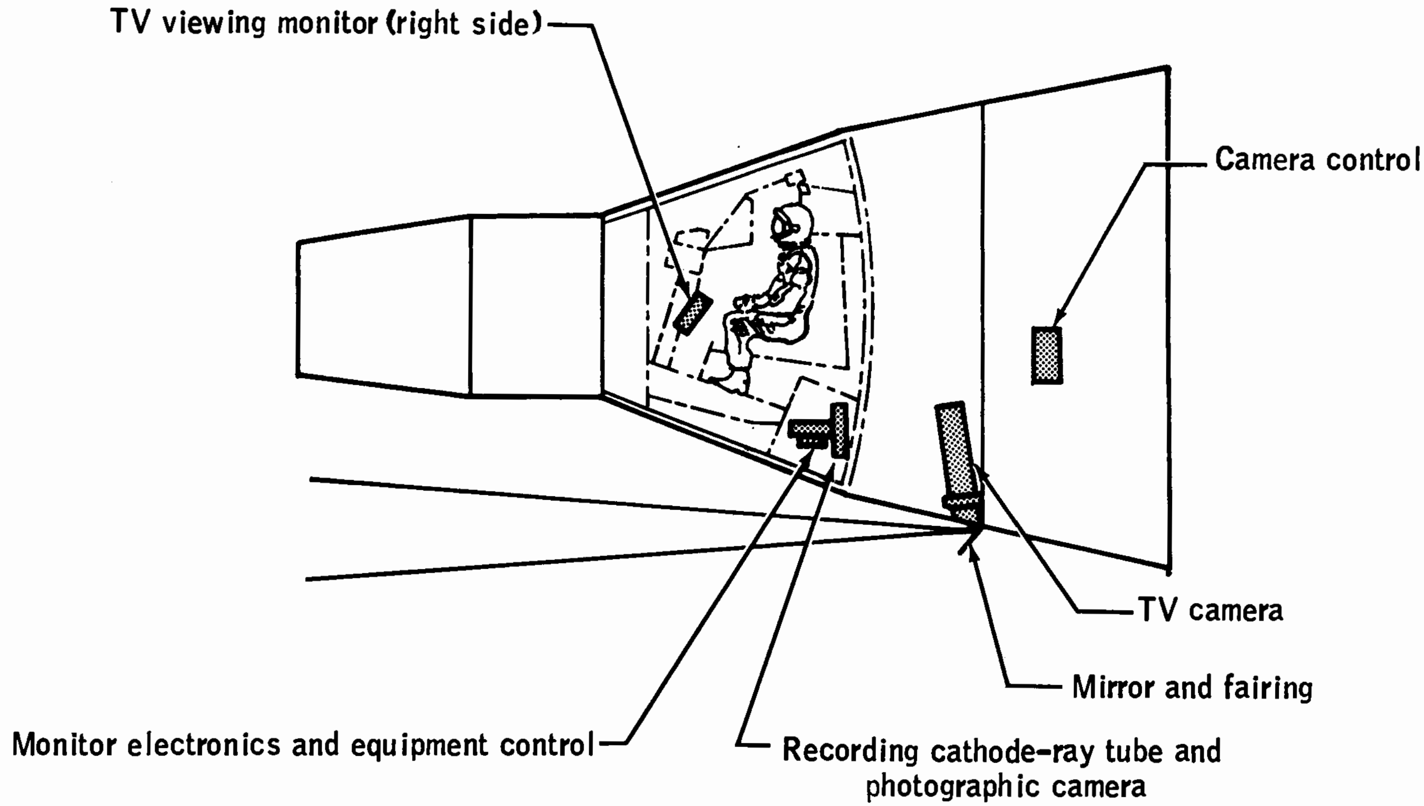

Figure 8.2-1. - Experiment D015, equipment location.

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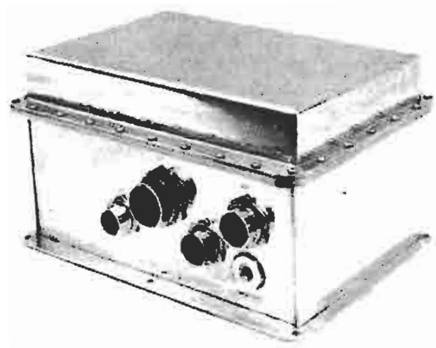
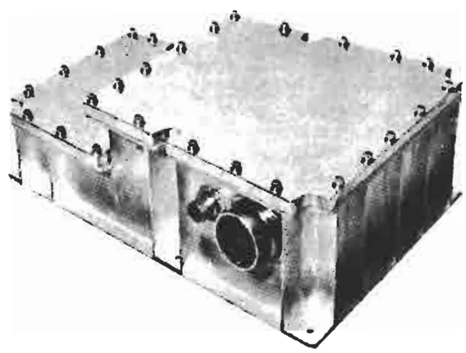
TV camera

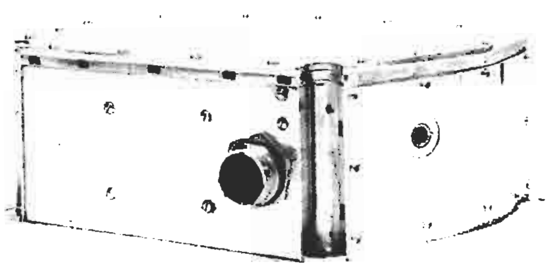


Camera control

TV viewing monitor



Monitor electronics and equipment control



Recording cathode-ray tube photographic camera

Figure 8.2-2. - Experiment D015, equipment.

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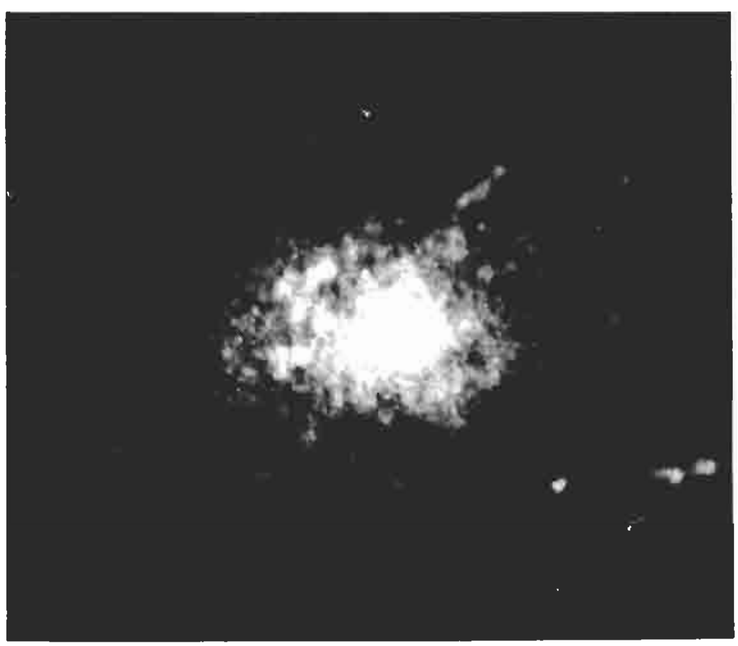
Night view of the earth horizon and star background.
Taken at 55:41:18 g.e.t.



Cloud covered eastern Coast of Africa taken at 55:19:27 g.e.t. (The bright spot in the picture is caused by probable ion contamination within the TV recording cathode ray tube.)

Figure 8.2-3. - Experiment D015, recorded image.

8.3 EXPERIMENT D016, POWER TOOL EVALUATION

8.3.1 Objective

The primary objective of the D016 Power Tool Evaluation experiment was to evaluate the capability of man to perform work in the space environment. Encompassing this objective were the following specific objectives:

(a) To determine the ability of an astronaut to perform a controlled work task

(b) To compare the ability of an astronaut to perform work under tethered and untethered conditions

(c) To determine the performance of the minimum reaction power tool relative to output and reactive torques.

8.3.2 Equipment

The equipment and its interrelationships are illustrated in figure 8.3-1. The operational concept of this experiment is shown in figure 8.3-2. A description of the equipment and the experiment procedures is included in reference 9.

8.3.3 Results

This experiment was not attempted during the mission because of premature termination of the umbilical EVA.

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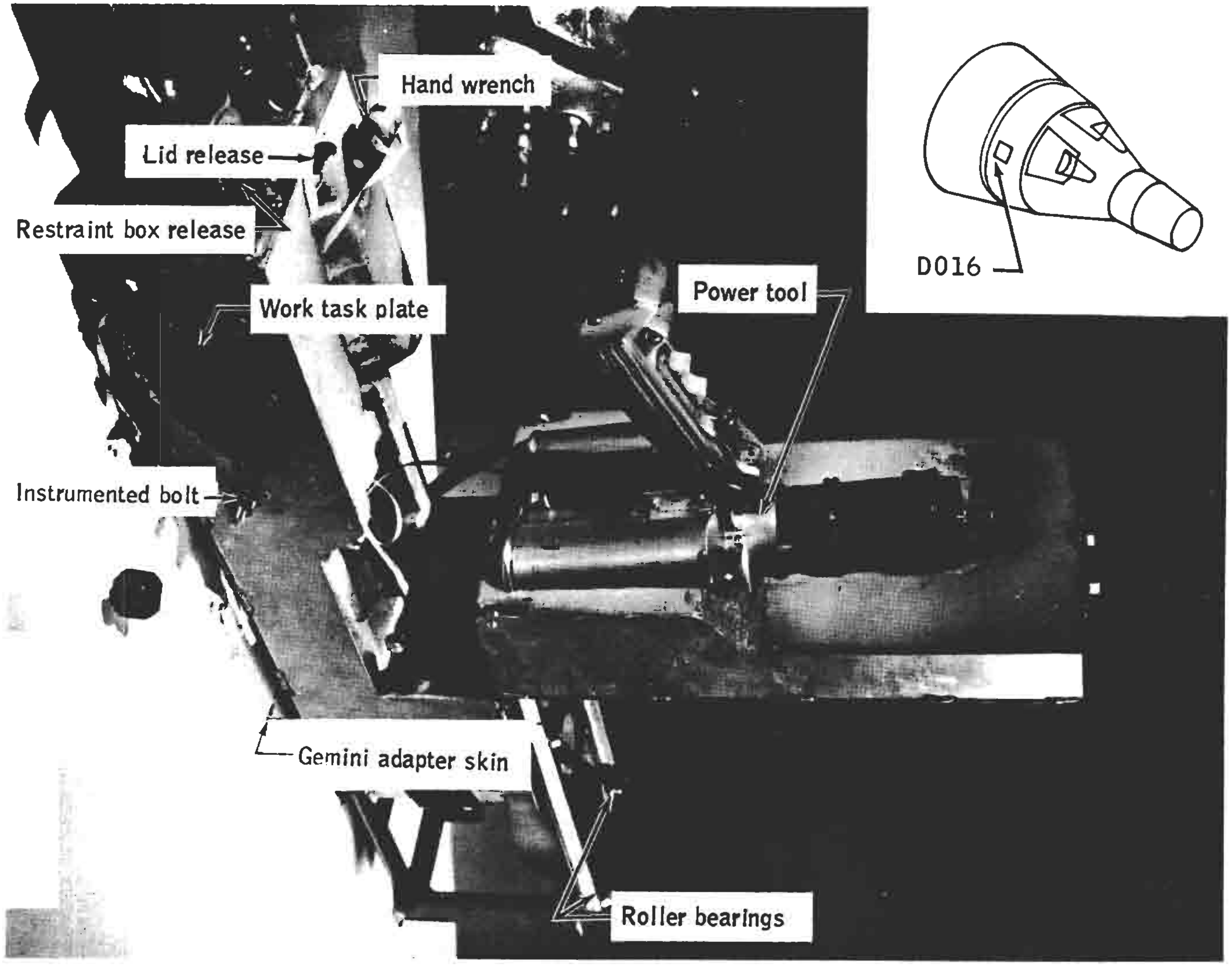

Figure 8.3-1. - Experiment D016, equipment.

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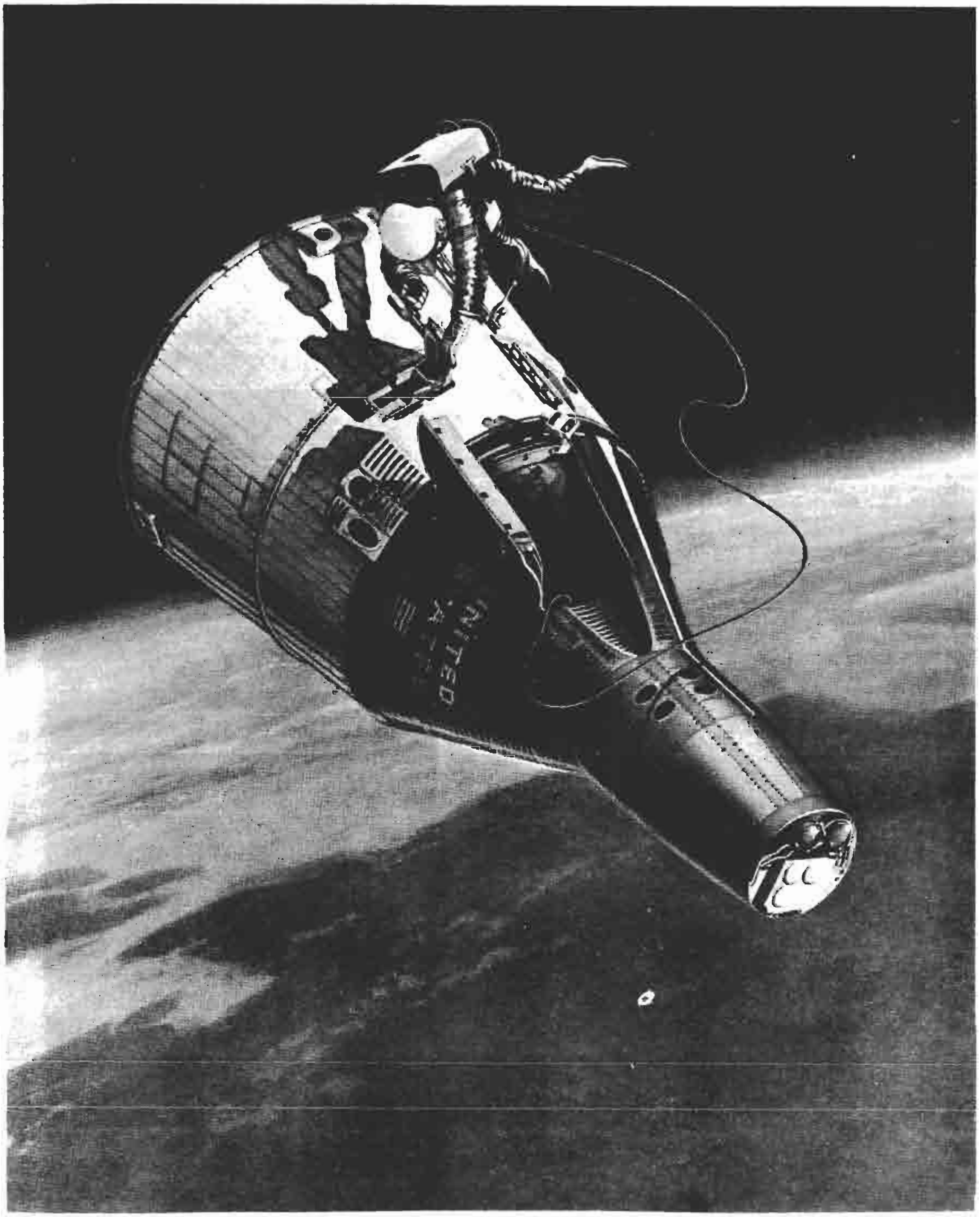

Figure 8.3-2. - Experiment D016, operational concept.

8.4 EXPERIMENT S004, RADIATION AND ZERO-G EFFECTS ON BLOOD AND NEUROSPORA

8.4.1 Objectives

The objective of the S004 Radiation and Zero-G Effects on Blood and Neurospora experiment was to determine whether a biological synergism exists between radiation and some space flight phenomena, such as weightlessness. The human-blood portion of this experiment had been conducted successfully during the Gemini III mission. A significant increase in one of the radiation effects studies—chromosome deletion production—was found when the radiation was studied after the orbital phase of that flight. This portion of the experiment was repeated on the Gemini XI mission in an attempt to confirm the previous results. The Neurospora portion of the S004 experiment was included in this mission to extend the investigation to a well-studied biological material and to determine survival and gene mutation data as biological endpoints. Preflight and postflight blood samples were obtained from the flight crew to provide baseline information.

8.4.2 Equipment

The same basic equipment configuration as was used during the Gemini III mission was used for the blood and the Neurospora portions of the S004 experiment on the Gemini XI mission. The equipment consisted of two hermetically sealed aluminum boxes, each containing a series of sterile samples of biological material and a series of phosphorous-32 beta-particle sources. The specimens were moved in and out of the radiation fields for control of radiation exposure. Dosimetric, temperature, and other recording instrumentation was included within the units for postflight analysis.

Because of the duration of the mission and of the perishable nature of the living white blood cells used for the experiment, the blood package was refrigerated during most of the mission. A thermoelectric refrigerator, using spacecraft power, provided the cooling. The refrigerator was mounted on a bracket on the inner surface of the left-hand spacecraft hatch. Figure 8.4-1 shows the refrigerator and the experiment package. A telemetry channel supplied information on the blood temperature to the experimenters. The Neurospora package was mounted with web straps on the inboard side of the right-hand footwell. Figure 8.4-2 shows the placement of the experiment equipment within the spacecraft.

8.4.3 Procedures

The Neurospora and the blood packages were assembled, tested, and installed in the spacecraft just prior to launch. Duplicate ground-control packages were also fabricated and retained at the launch site for activities during and after the flight.

The experiment equipment was in the non-irradiating and blood refrigerated condition at lift-off. At 30 hours 9 minutes g.e.t., the pilot activated the irradiation sequence of the Neurospora samples by operating the equipment handle. At 65 hours 38 minutes g.e.t., the pilot switched off the refrigerator, allowing the blood to stabilize at cabin ambient temperature. At 66 hours 43 minutes g.e.t., the command pilot started irradiation of the blood samples. At 67 hours 53 minutes g.e.t., the command pilot and pilot terminated the irradiation of the blood and the Neurospora samples. These operations were accomplished by real-time countdowns from the Mission Control Center-Houston, thus enabling experiment operations at Kennedy Space Center to be performed simultaneously on the ground-control blood and Neurospora packages.

8.4.4 Results

The experiment was conducted without difficulty. The biological samples were recovered in satisfactory condition. All the blood samples yielded countable cytological preparations and all the Neurospora samples yielded good cultures.

A minor anomaly was noted in the blood refrigerator temperature about 15 minutes after lift-off. The temperature increased gradually to 10° F above the control point, then stayed at this level until cabin depressurization prior to the first extravehicular activity period. The refrigerator operated in the design range thereafter, except for one other minor interval. Analysis shows that the difficulty was caused by high cabin temperature and a lower-than-expected heat-sink capacity of the spacecraft hatch structure. This problem did not affect the experiment activities or results.

Preliminary evaluation of the instrumentation packages has been completed. No physical abnormalities were noted, and good film records were obtained. The preliminary film and X-ray data compare favorably. The time-temperature and time-activation (irradiation) records show good agreement with the telemetry and voice transcript data.

Dosimetric analysis has been virtually completed, and there was good agreement between the inflight and postflight dosimetric measurements and the theoretical expectations.

The Neurospora samples have been cultured and yielded satisfactory preliminary survival and forward mutation measurements. Detailed analysis of the results from these parameters is in progress. Genetic analysis of the mutants recovered will be initiated when the other analyses are completed.

Cytogenetic analysis has been completed for a few blood samples and these results are summarized in table 8.4-I. This table shows a small increase in aberration frequency in the postflight samples from both crewmembers. The significance of this is not clear. At this time, the results from the Gemini XI experiment samples are too incomplete to permit drawing any conclusions for confirming the effect observed for the Gemini III mission. The blood and the Neurospora phases of the experiment appear to have been completely successful.

TABLE 8.4-I.- PRELIMINARY RESULTS OF CHROMOSOME ANALYSIS

Sample	Dose, rads	Cells scored	2n ≠ 46*	Chromatid deletions	Chromosome-type aberrations			
					Deletions	Dicentrics	Rings	Exchanges
Crew preflight:								
Command pilot	--	150	32	1	0	0	0	0
Pilot	--	150	27	1	1	0	0	0
Postflight:								
Command pilot	--	150	12	5	5	0	0	3
Pilot	--	150	21	9	4	0	0	2
Experiment equipment ground control:								
Female	8	150	8	1	3	1	0	0
Male	207	150	33	4	32	30	6	3
Female		150	17	1	38	†26	3	4
Flight:								
Male	8	150	12	4	2	4	0	0
Female		150	26	4	1	2	0	0
Male	207	150	17	1	36	20	9	6
Female		150	24	7	28	26	5	11

*n = haploid number of chromosomes in a germ cell.
†Includes one tricentric counted as two dicentrics.

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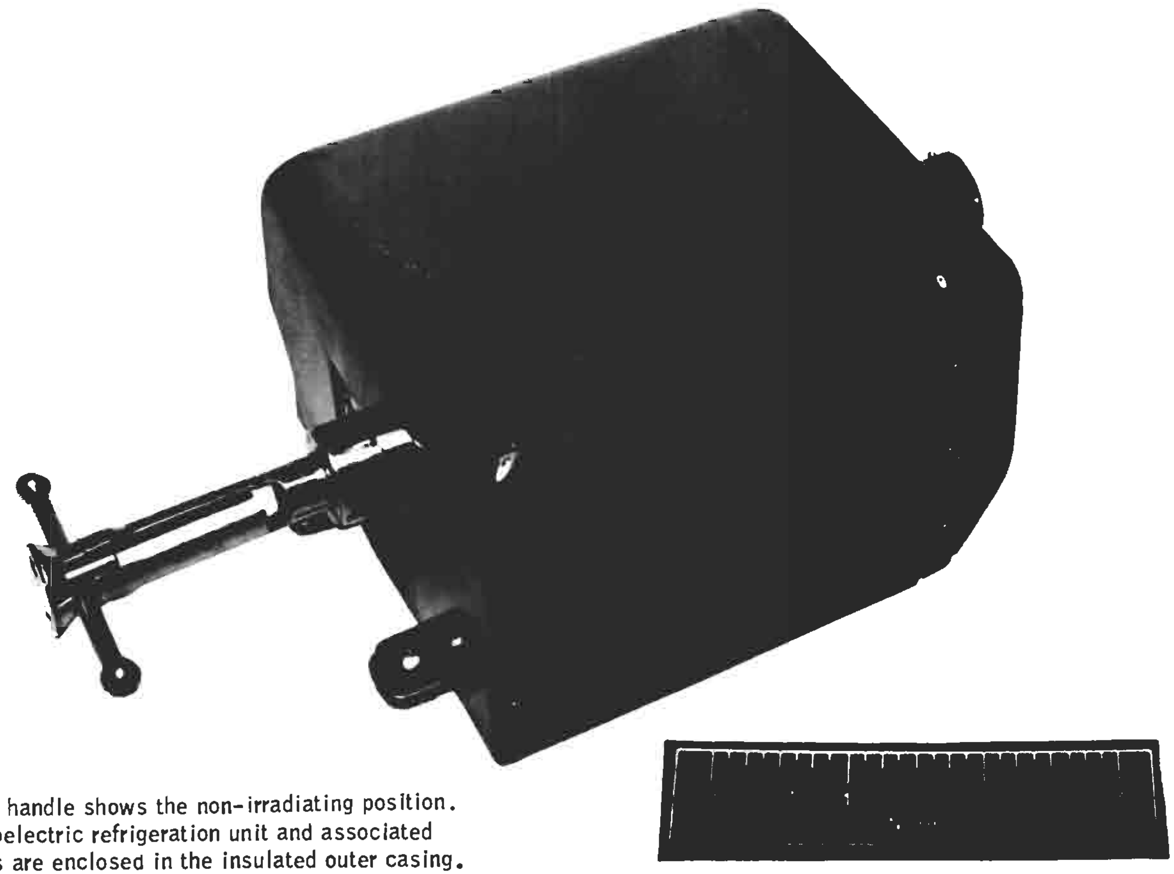

Note:
The operating handle shows the non-irradiating position. The thermoelectric refrigeration unit and associated electronics are enclosed in the insulated outer casing. Heat transfer to the spacecraft structure is through the bottom surface.

Figure 8.4-1. - Experiment S004, refrigerated unit with installed blood package.

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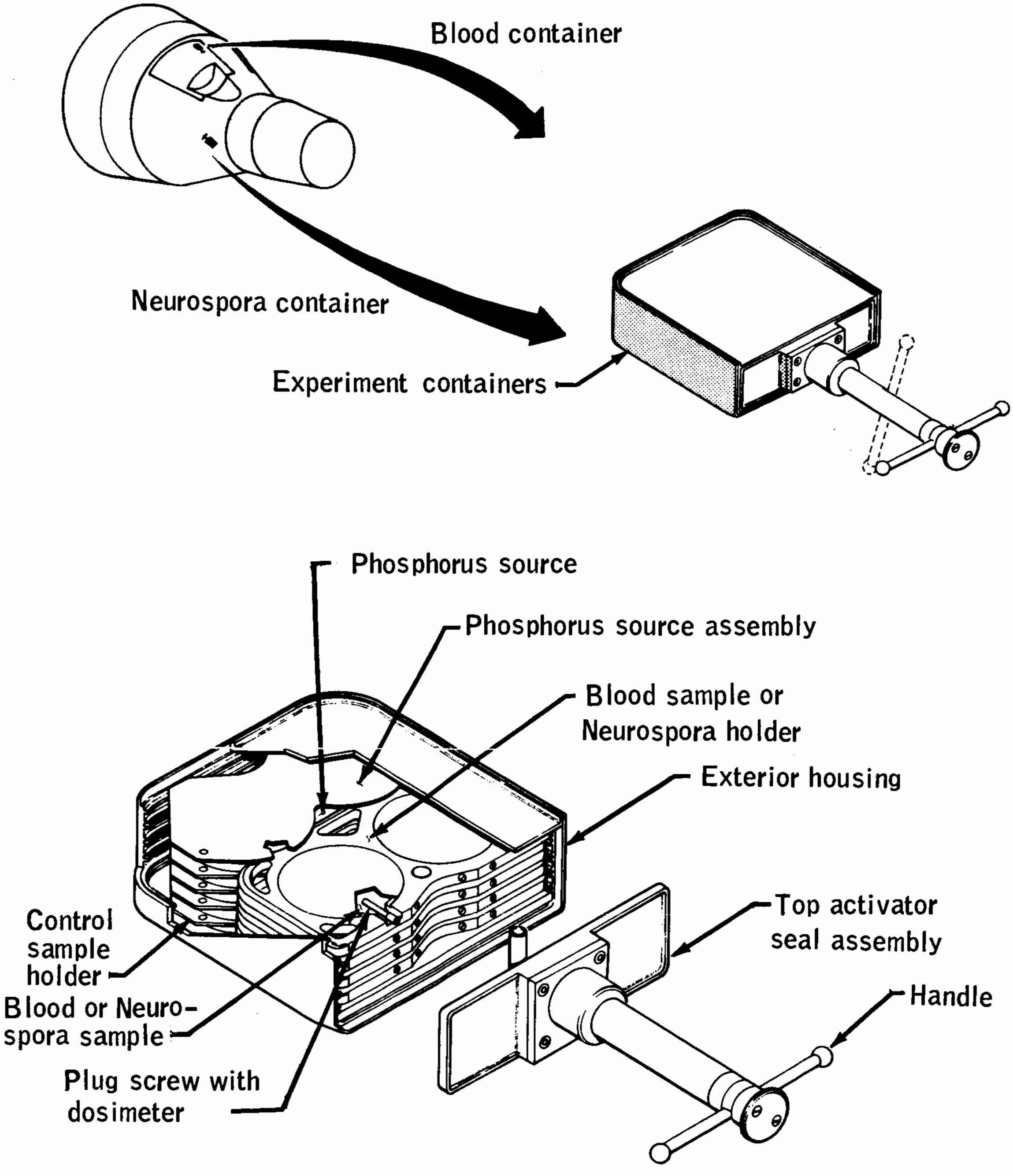


Figure 8.4-2 - Experiment S004, blood cell and neurospora experiment equipment.

8.5 EXPERIMENT S005, SYNOPTIC TERRAIN PHOTOGRAPHY

8.5.1 Objective

The objective of the S005 Synoptic Terrain Photography experiment was to obtain high-quality color photographs of selected terrain and oceanic areas for geodetic, geographic, and oceanographic research. In particular, photographs taken from very high altitudes were desired of the following areas, listed in order of priority: northwestern Australia, the Egypt/Red Sea/Arabian Peninsula area, southern India, and southern Mexico.

8.5.2 Equipment

Two cameras suitable for terrain photography were carried in the spacecraft, and both cameras were similar to those used during previous Gemini missions. Many of the pictures were taken with the 70-mm EVA still camera using a 38-mm focal length lens and a 90-degree prism assembly. The 70-mm general-purpose camera, with the 80-mm f/2.8 lens, was also used. Standard film magazines were used, and both cameras contained medium-speed color-reversal film (2.5 mil polyester base), a type not used on previous missions. A haze filter was used on both cameras.

8.5.3 Procedures

The crew was instructed to take vertically oriented, systematic, overlapping, or isolated photographs during the high-apogee and other revolutions over the desired areas. As in previous flights, it was stressed that photographs of any cloud-free land areas would be useful.

8.5.4 Results

The experiment was highly successful. About 145 photographs of good to excellent quality were obtained and included all the desired areas plus a number of additional ones.

The command pilot's window was obscured, as on previous flights, while the pilot's window was relatively clear. Consequently, the pilot took most of the terrain photographs, alternating between the 70-mm EVA still camera and the 70-mm general-purpose camera. This technique, which had not been planned as part of this experiment, provided not only stereoscopic coverage but also an excellent comparison of the two camera lenses. In general, pictures from both cameras were of good quality, but those from the general purpose camera were not as clear.

The majority of the terrain photographs were taken during the two high-apogee revolutions. During this period, most land areas, except Indonesia and Ceylon, were clear of cloud cover. Picture quality is good to excellent for most of the photographs. Reds and blues are somewhat exaggerated in several photographs taken with the 70-mm EVA still camera. The pictures taken through the command pilot's window were seriously degraded by deposits on the window.

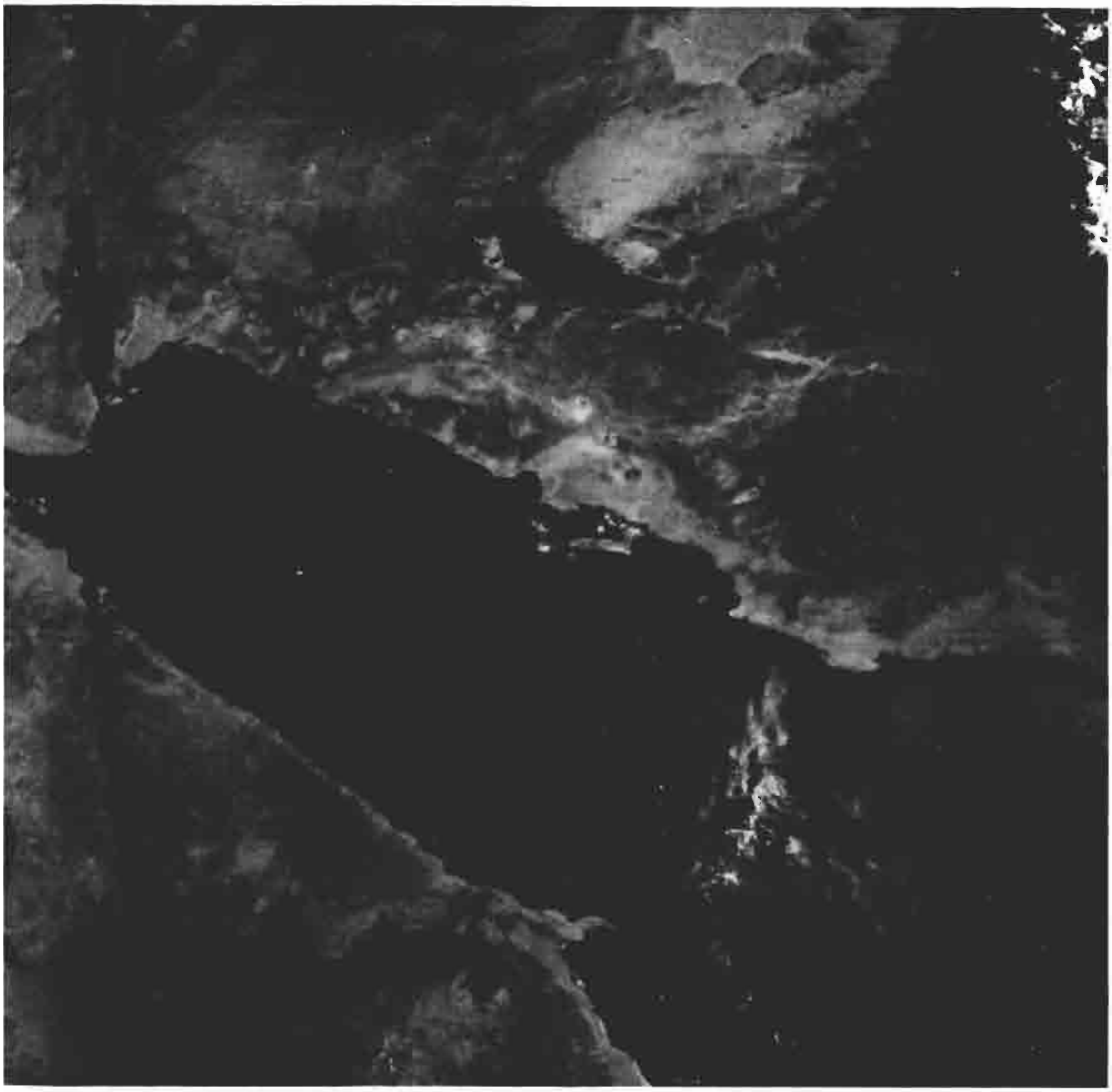
A preliminary examination of the pictures indicates they will be of great value for research purposes and, because of the wide coverage obtained, for locating areas photographed on earlier flights. Representative photographs are presented in figures 8.5-1(a) through (e).

NASA-S-66-9005 OCT 5

(a) Egypt, Jordan, Saudi Arabia, Lebanon, Syria, Iraq, Turkey, and Israel. The water areas include The Red Sea, Dead Sea, Sea of Galilee, Mediterranean Sea, Suez Canal and Euphrates River. Taken at an altitude of 220 nautical miles, looking north. (7:25 G.m.t., September 14, 1966)

Figure 8.5-1. - Experiment S005, typical synoptic terrain photography.

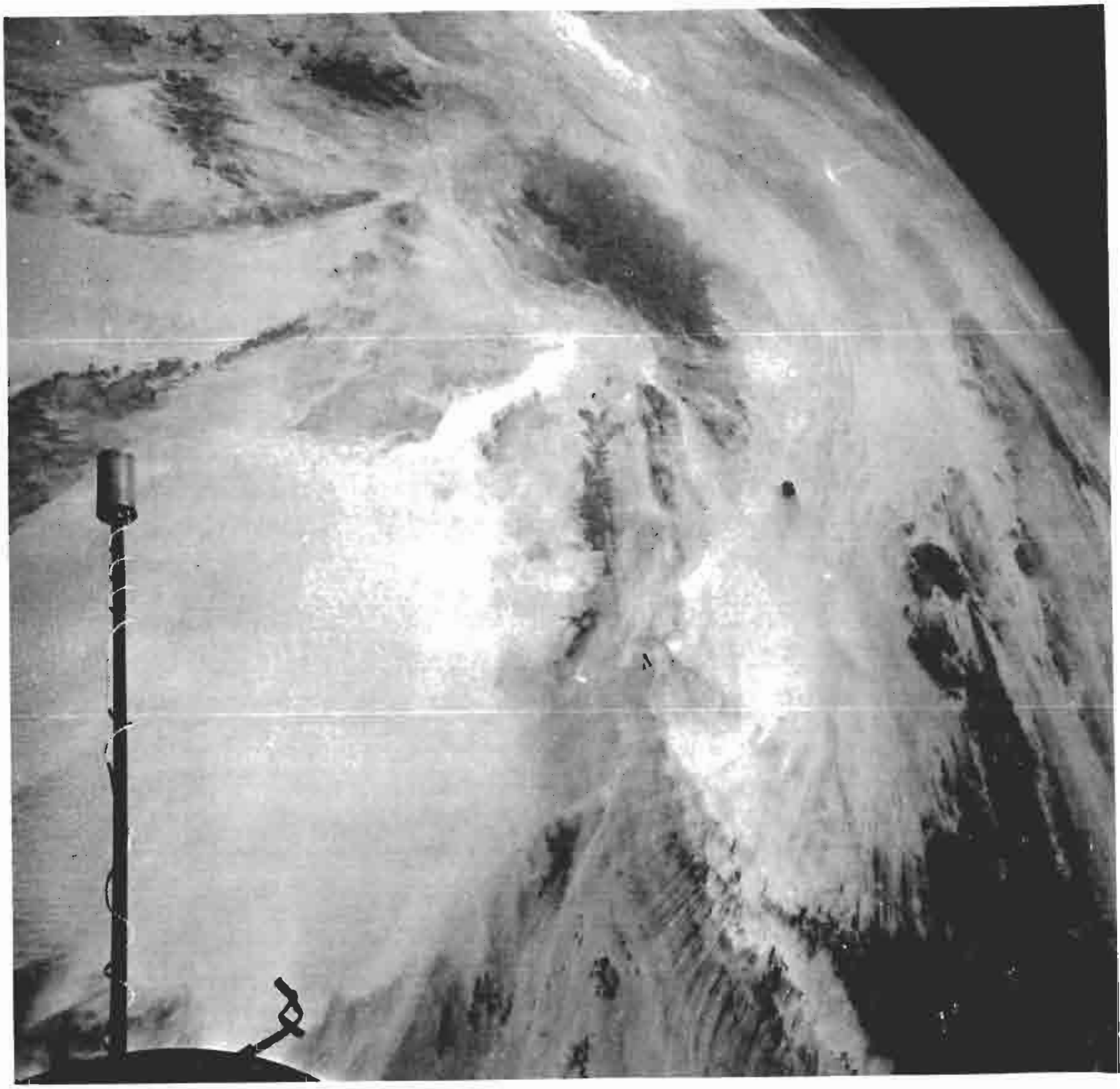
NASA-S-66-9002 OCT 5



(b) Egypt/Saudi Arabia area. Coverage includes Jordan/Israel, Sinai, Nile River, Red Sea, Dead Sea, and Al Hijaz. Taken at an altitude of 220 nautical miles looking down with North at the top of the page. (7:26 G.m.t., September 14, 1966).

Figure 8.5-1. - Continued.

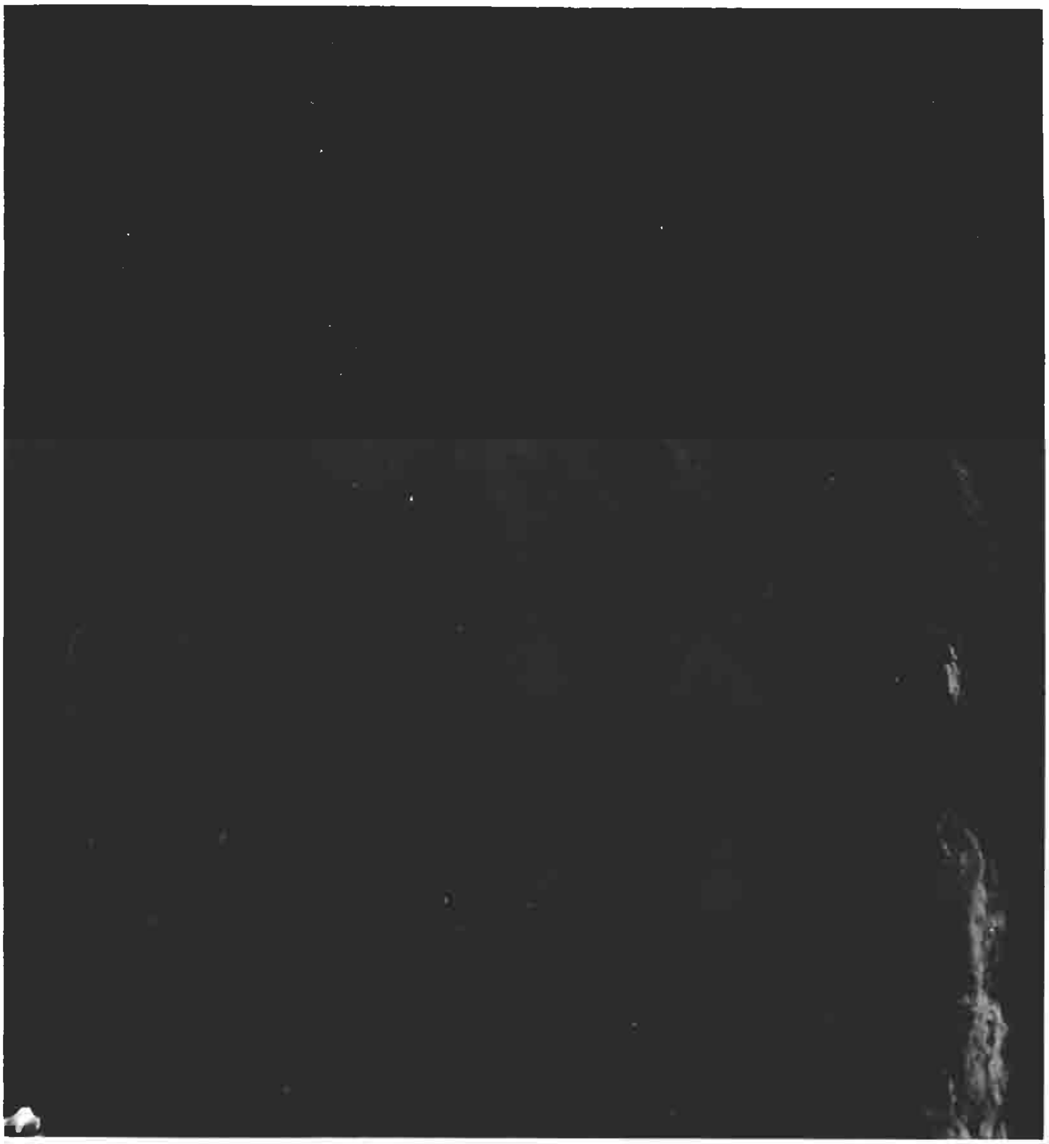
NASA-S-66-9010 OCT 5



(c) Libya, Chad, Sudan, Egypt, and Niger. The Tibesti Mountains, Al Harj Al Swad, Mediterranean Sea, and Great Libyan Land Sea are shown in background. Taken at an altitude of 240 nautical miles, looking northeast. (8:55 G.m.t., September 14, 1966).

Figure 8.5-1. - Continued.

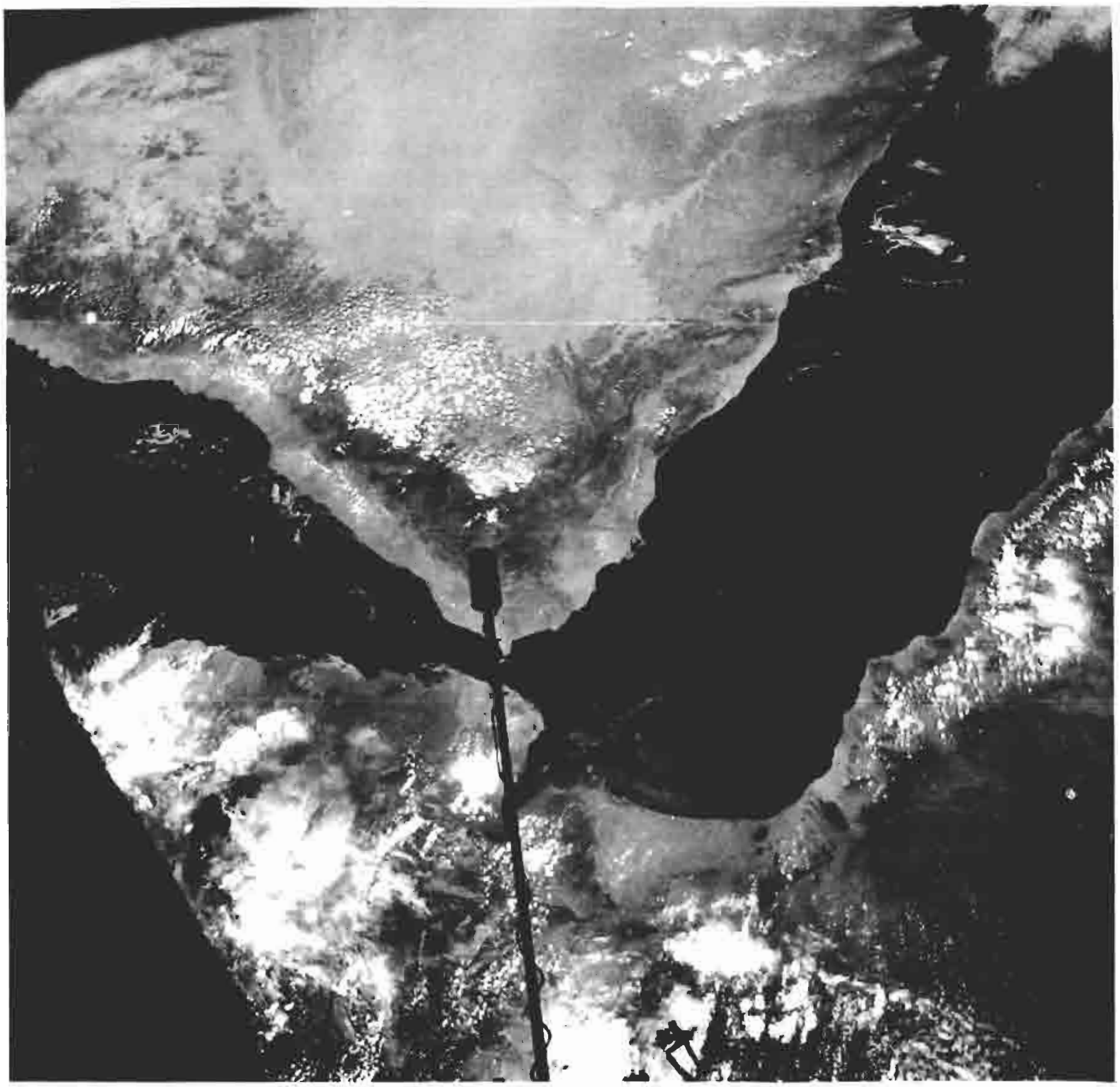
NASA-S-66-9006 OCT 5



(d) Egypt, Libya, and Sudan. Red Sea, Tibesti Mountains, Gulf El Kebir, and Great Land Sea are also shown. Taken at an altitude of 260 nautical miles, looking east northeast (8:56 G.m.t., September 14, 1966).

Figure 8.5-1. - Continued.

NASA-S-66-9003 OCT 5



(e) Ethiopia, Somali, French Somaliland, Saudi Arabia, Yemen, and South Arabia. The Red Sea and Gulf of Aden are directly below. Taken at an altitude of 350 nautical miles, looking down, with southeast at the top of the page (9:01 G.m.t., September 14, 1966).

Figure 8.5-1. - Concluded.

8.6 EXPERIMENT S006, SYNOPTIC WEATHER PHOTOGRAPHY

8.6.1 Objectives

The primary objective of the S006 Synoptic Weather Photography experiment was to obtain a selection of cloud photographs for use in studies of weather and for interpretation of weather satellite photographs. Specific objectives were to obtain color photographs of cloud systems from higher altitudes than in previous Gemini flights, comparable to altitudes where weather satellite observations are made. Secondary objectives were to obtain views of the same cloud areas on successive revolutions of the Gemini spacecraft.

8.6.2 Equipment

The equipment consisted of the 70-mm general-purpose camera using an 80-mm focal length lens and the 70-mm EVA still camera using a superwide-angle 38-mm focal length lens. Five magazines containing medium-speed color-reversal film on a 2.5 mil polyester base were used for the combined purpose of this experiment and general documentary photography.

8.6.3 Procedures

Prior to the flight, the crew was briefed on the various types of weather systems of interest for this experiment. On the day before flight and again on launch day, the crew were shown areas of meteorological interest. Specific emphasis was placed on revolutions 26 and 27 when the spacecraft was scheduled for a high-apogee orbit of about 750 nautical miles.

8.6.4 Results

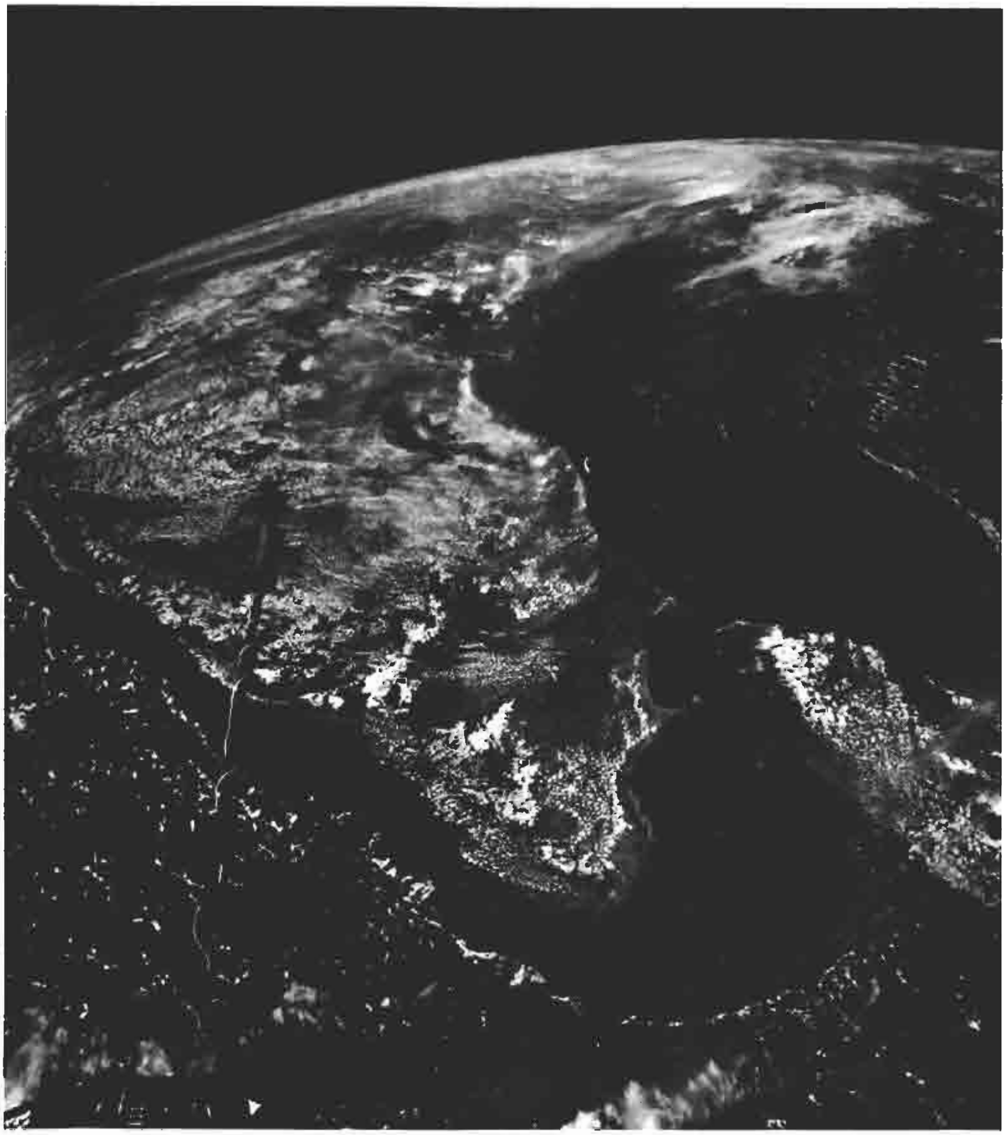
Approximately 180 photographs taken during the mission show clouds of various structures. Most of these were taken on September 14, 1966, over Africa, Arabia, the Indian Ocean, and Australia during revolutions 26 and 27. During these passes, photographs were taken with both of the 70-mm cameras. There was especially good photographic coverage of India and the adjacent ocean areas. The ESSA I meteorological satellite passed over the India area about midway in time between spacecraft revolutions 26 and 27. The pictures taken from the spacecraft of this area permit (1) a comparison of the aerial coverage and detail obtainable with the two onboard cameras, (2) a comparison of actual color photographs with concurrent operational weather satellite pictures, and (3) a study of the cloud movement and changes which occurred between the times of the two passes.

Figure 8.6-1(a) shows India, Ceylon, and the adjacent oceans as viewed with the wide angle 70-mm EVA still camera during revolution 26 at 41 hours g.e.t. Of particular interest is the cloud-free band off the west coast of India. Figure 8.6-1(b) shows part of this area photographed at the same time with the narrower angle lens of the 70-mm general-purpose camera. There was some gain in detail with the narrower lens angle. In general, meteorological features are adequately resolved with the wider angle lens which has the advantage of greater aerial coverage. During the next pass, in revolution 27, considerable changes were noticed in some areas. In particular, the photograph shown in figure 8.6-1(c), taken with the general-purpose camera at 42 hours 36 minutes g.e.t., shows rapid cumulus development over Ceylon. In only 96 minutes, these clouds changed from the towering cumulus stage to well-formed cumulonimbus (thunderstorm) clouds with anvils spreading westward to approximately 85 nautical miles.

For comparison purposes, figure 8.6-1(d) shows a view of this area photographed at 41 hours 41 minutes g.e.t. and obtained from the ESSA I weather satellite. The principal cloud systems are visible on this televised view, but much greater detail was obtained on the photographs made from the spacecraft.

Other photographs which will be examined critically include the extensive cloud mass associated with tropical storm Grace in the western Pacific Ocean, a view of the large vortex in stratocumulus clouds south of Cape Rhir off Northwest Africa, a variety of organized patterns of convective clouds, and extensive areas of cumulonimbus activity in the tropics.

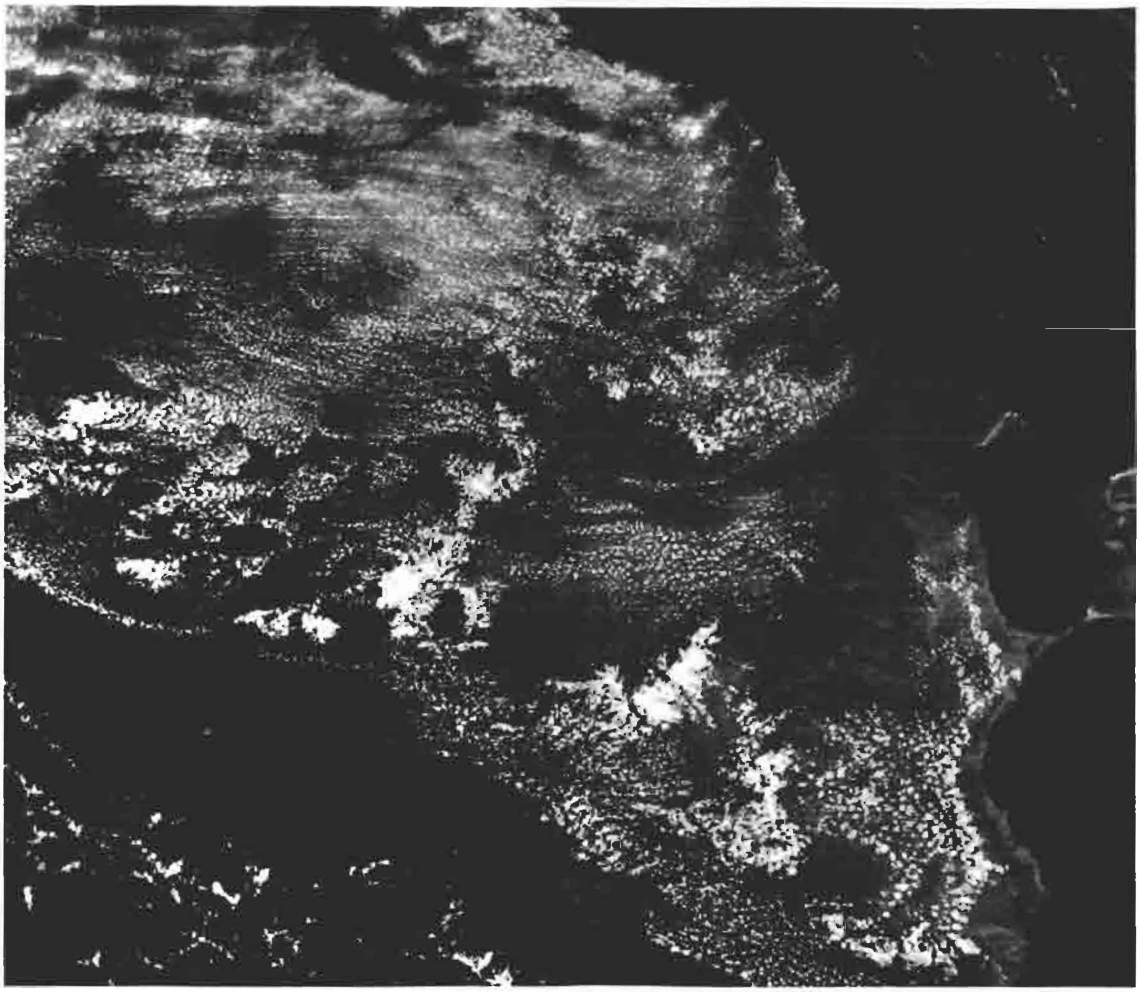
NASA-S-66-9011 OCT 5



(a) View of India and the surrounding area through wide-angle lens, looking north northeast (7:35 G.m.t., September 14, 1966).

Figure 8.6-1. - Experiment S006, a series of four typical synoptic weather photographs.

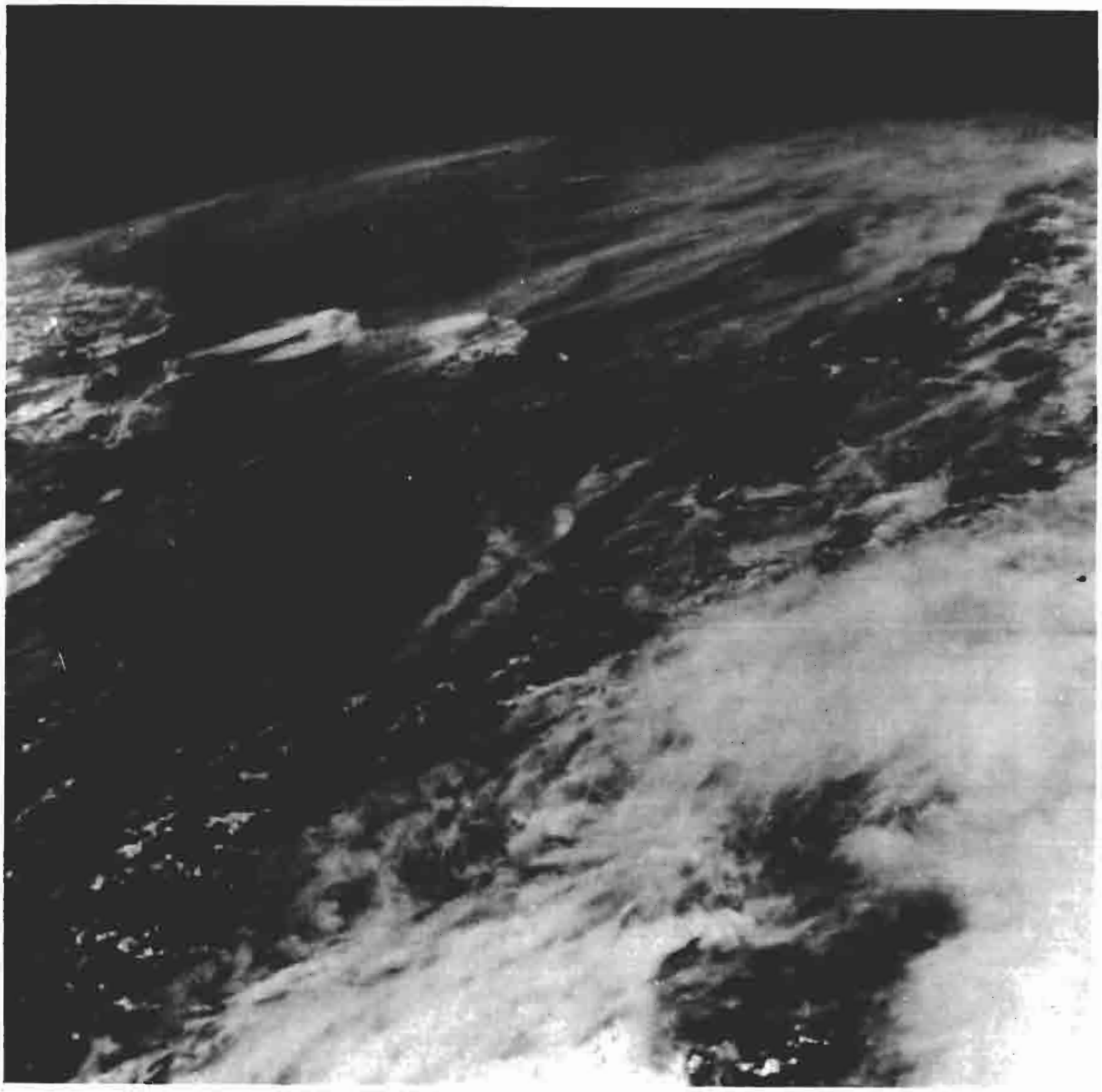
NASA-S-66-9009 OCT 5



(b) View of India through narrow-angle lens, looking north northeast (7:35 G.m.t., September 14, 1966).

Figure 8.6-1. - Continued.

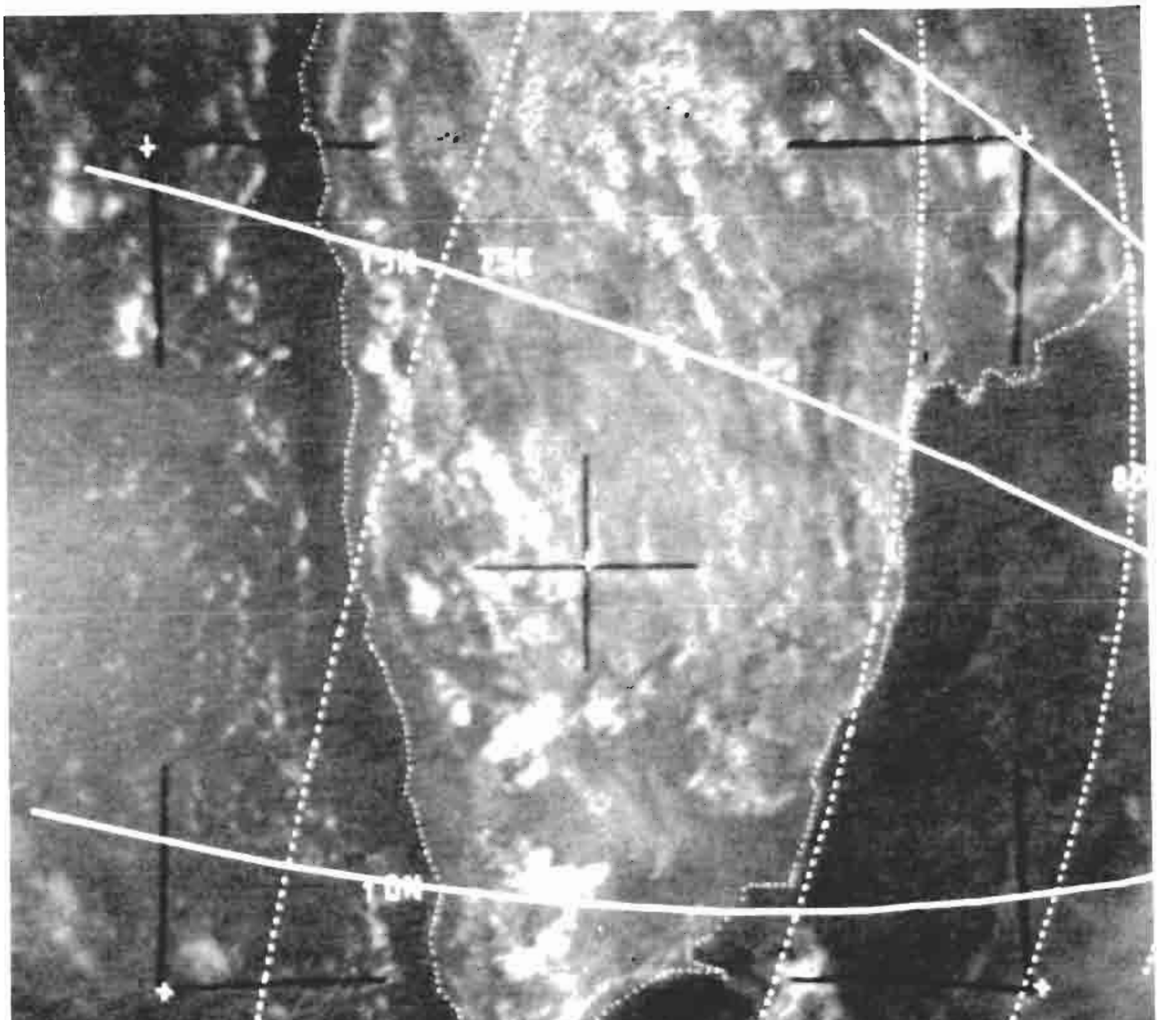
NASA-S-66-9012 OCT 5



(c) View of the Indian Ocean, India, and Ceylon taken during revolution 27, looking northeast (9:11 G.m.t., September 14, 1966). Of particular interest is the extensive cumulonimbus cloud development over Ceylon.

Figure 8.6-1. - Continued.

NASA-S-66-9015 OCT 5



(d) ESSA I meteorological satellite view of India and the surrounding area (8:16 G.m.t., September 14, 1966).

Figure 8.6-1. - Concluded.

8.7 EXPERIMENT S009, NUCLEAR EMULSION

8.7.1 Objective

The S009 Nuclear Emulsion experiment was designed to explore the cosmic radiation incident on the earth's atmosphere, with the nuclear emulsion stack under a negligible thickness of material. In particular, there was interest in studying the heavier component of the primary radiation, consisting of nuclei heavier than hydrogen or helium. Cosmic rays are atomic nuclei moving with nearly the speed of light and provide a means for investigating remote parts of the Milky Way galaxy where high-energy processes are in progress.

The cosmic-ray detector consisted of a stack of nuclear photographic emulsions which could register some 400 tracks of heavy nuclei, the minimum acceptance number for each 10 hours of useful exposure. Useful exposure required that the spacecraft be oriented in a heads-up attitude.

8.7.2 Equipment

The experiment equipment consisted of a rectangular package measuring 8.5 by 6 by 3 inches and weighing 13 pounds. An electrical connector on the bottom face of the package provided spacecraft power to and telemetry information from the package. The top face of the package had a thin (0.010 of an inch) aluminum window for the emulsion exposure to ambient radiation outside the spacecraft. The package was housed in a temperature-controlled well directly behind the pilot's hatch and in the adapter retrograde section of the spacecraft. During launch, protection was provided by a hinged cover which was opened 190 degrees at the time of spacecraft/launch vehicle separation. The package was equipped with a deployable handle for manual removal and placement inside the spacecraft after retrieval. Figure 8.7-1 shows the experiment package configuration.

Within the experiment package were: (1) a nuclear emulsion stack composed of a lower section moving with respect to an upper section during the exposure period; (2) a motor and mechanical coupling for driving the lower stack; (3) a timer, with an internal battery, which activated the motor, thereby advancing the lower emulsion stack at predetermined time intervals; and (4) a transducer (potentiometer) that indicated the distance traveled by the lower section.

Telemetry information consisted of (1) the distance traveled by the lower stack, (2) the time of motor actuation, and (3) the temperature of the experiment housing.

8.7.3 Procedures

The experiment was installed in the spacecraft approximately 55 hours prior to launch. At 1:42:20 g.e.t., the experiment was activated by the pilot. Proper operation of the experiment was verified by telemetry at 4 hours 30 minutes g.e.t. The experiment continued to operate satisfactorily until the package was successfully recovered by the pilot at approximately 24 hours 5 minutes g.e.t. The package was then stowed inside the cabin by the command pilot, and it remained there for the duration of the flight. The flight plan called for spacecraft heads-up (within ±15 degrees) attitude during the exposure period, except during the South Atlantic anomaly passes when the blunt-end-forward configuration was specified.

8.7.4 Results

Test emulsions in the experiment package have been processed and microscopically examined. These emulsions indicate that the background of radiation belt particles was moderate but should not appreciably affect the analysis of data on the heavy primary nuclei. It is anticipated that this experiment will yield a statistically significant sample of approximately 1000 tracks of heavy nuclei, and this number will exceed the minimum acceptance required for a successful experiment.

8.7.5 Conclusions

The experiment exposure time was approximately 22 hours. The time periods during favorable orientation are not yet known but should be close to the total operation time. Figure 8.7-2 is a plot of the preliminary telemetry data, showing lower-stack movement versus ground elapsed time superimposed on a preflight calibration. Agreement between the telemetry and calibration data indicates that proper operation of the unit was accomplished. A postflight measurement of the total distance moved also agrees with the telemetry data. Figure 8.7-3 is a plot of package temperature compared with ground elapsed time. The recorded temperatures of 53° F maximum and 40° F minimum were within the specification values except for one point.

NASA-S-66-9091 OCT 20

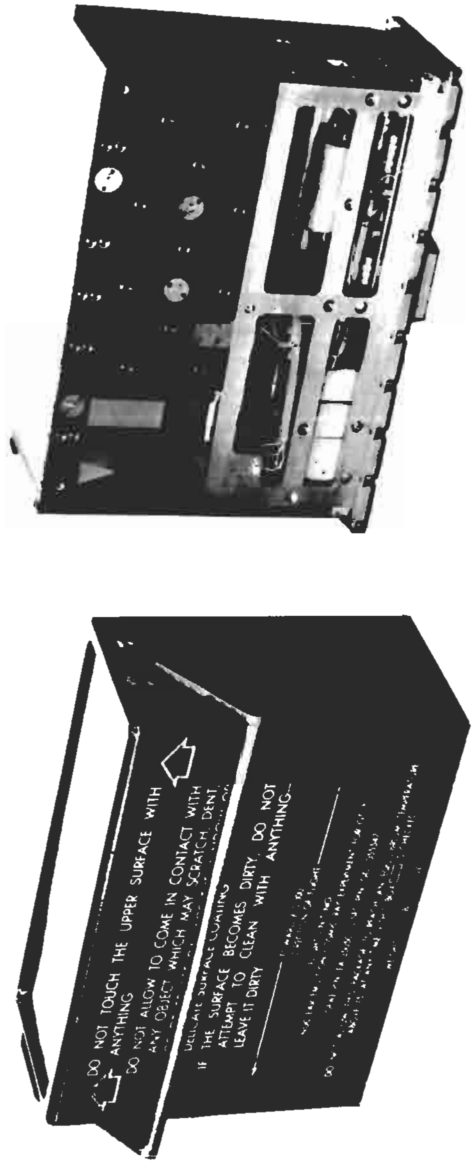


Figure 8.7-1. - Experiment S009, hardware configuration.

NASA-S-66-9046 OCT 11

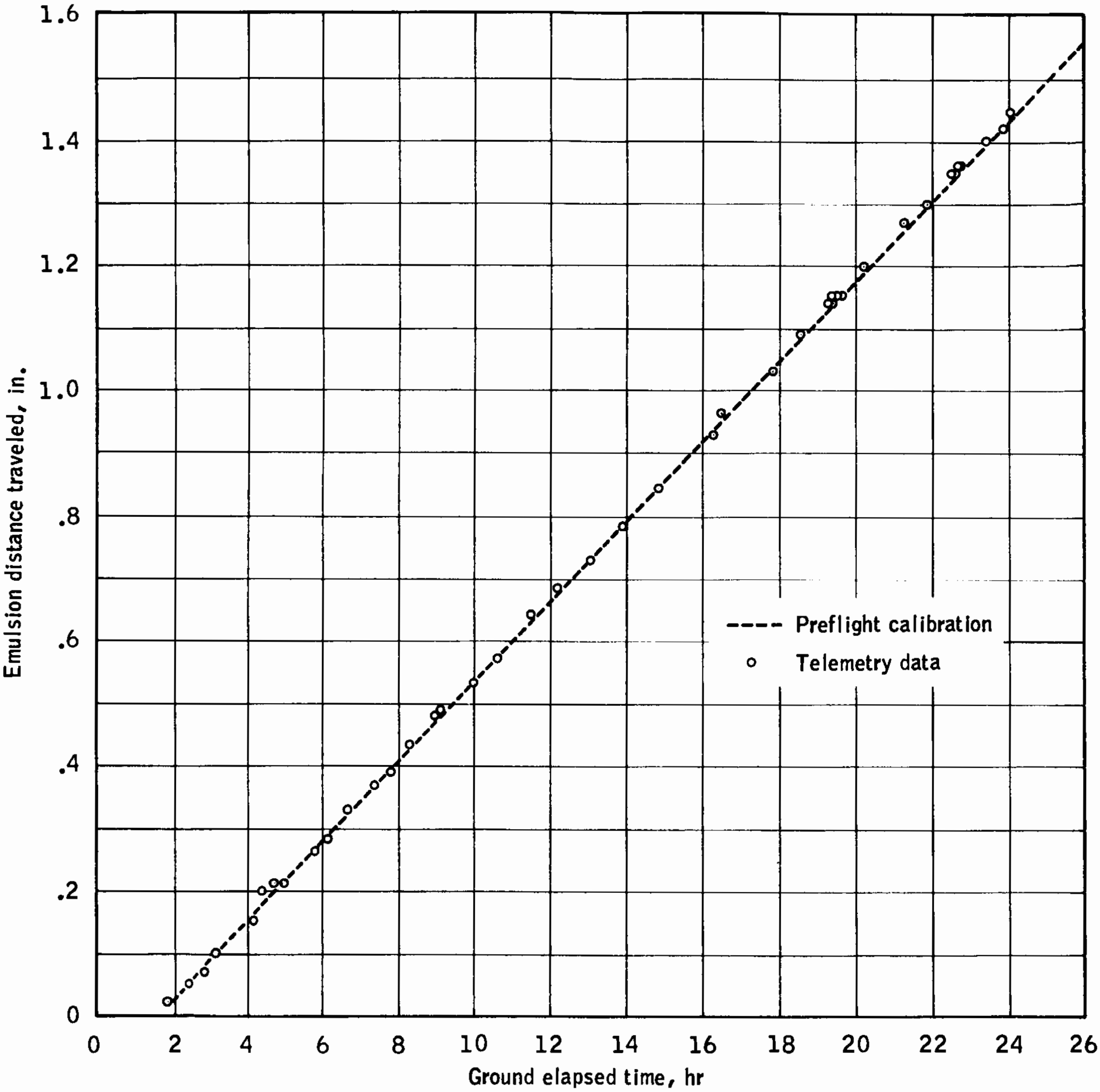


Figure 8.7-2. - Experiment S009, emulsion stack motion.

NASA-S-66-9045 OCT 11

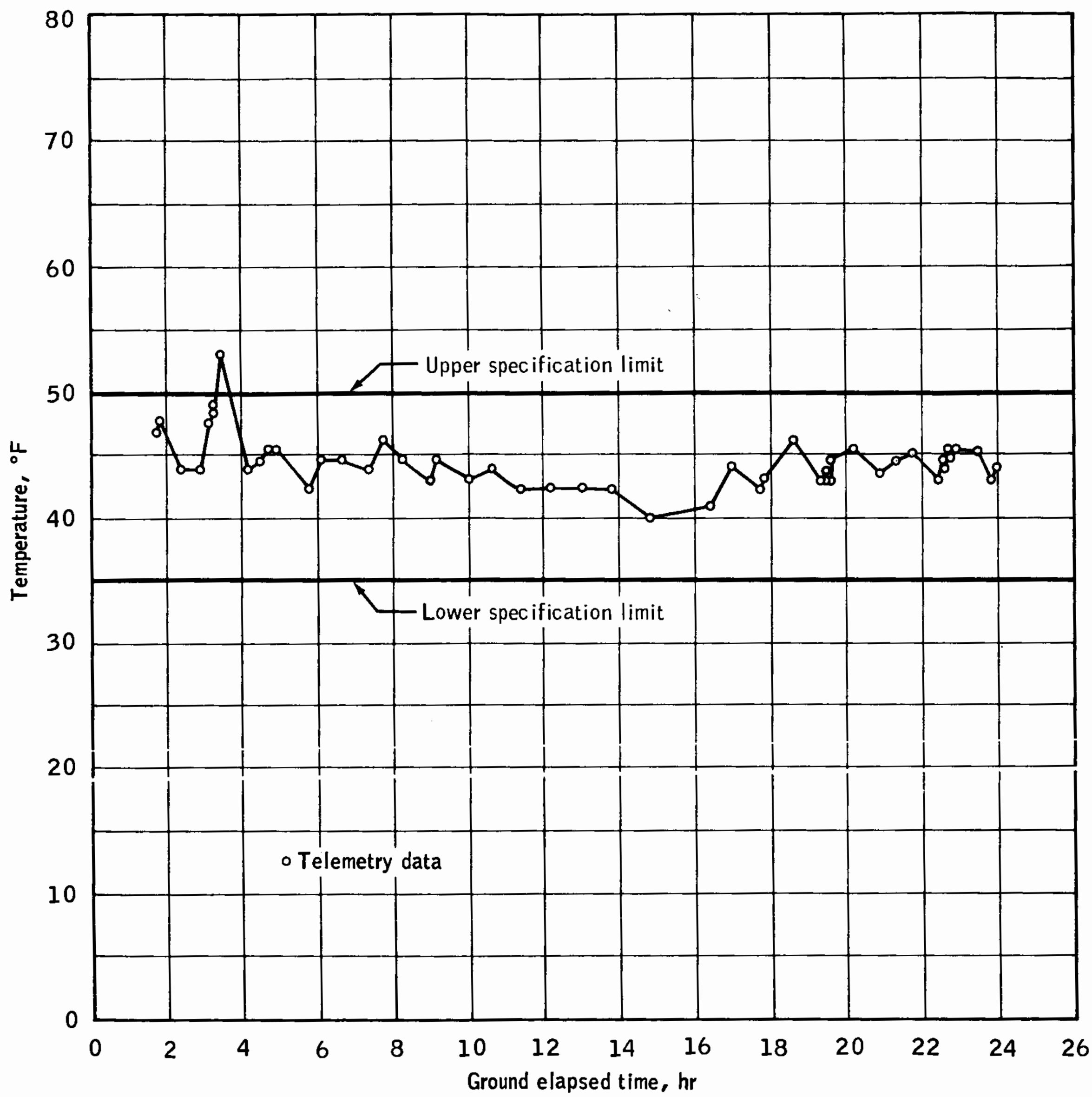


Figure 8.7-3. - Experiment S009, package temperature.

8.8 EXPERIMENT S011, AIRGLOW HORIZON PHOTOGRAPHY

8.8.1 Objective

The objective of the S011 Airglow Horizon Photography experiment was to obtain photographic data on a global scale for the study of the airglow in the upper atmosphere. The experiment was designed to photograph the night airglow layer which is visible as a bright band lying above the nightside terrestrial horizon. Photographs of the twilight horizon were also taken to record day airglow layers. The camera was optically filtered to photograph airglow in several visible bands centered at 5577 and 6300 Å for atomic oxygen, and 5893 Å for atomic sodium, where prominent airglow emissions occur. Horizon photographs taken during the nightside passes also recorded local intensities and altitudes of the emissions.

8.8.2 Equipment

The following equipment was used:

(a) A 70-mm general-purpose camera with an f/0.95 lens and a film magazine containing local-plane optical filters and black-and-white high-sensitivity film

(b) An illuminated camera sight

(c) An adjustable window-mounted camera bracket

(d) A camera lens filter.

8.8.3 Procedure

The camera was mounted to the pilot's window on a bracket which was adjustable in pitch. The line of sight of the camera was perpendicular to the window. During a nightside pass, the pilot used the bracket and illuminated sight to point the camera at the airglow layer.

Photographs were taken in azimuths east, north, west, and south. For these directions, the pilot took time-exposures with the camera lens filter installed in order to optically isolate the 5577, 5893, and 6300 Å visible wavelengths. Exposure time periods varied from 2 to 10 seconds during low-altitude orbits and from 10 to 40 seconds during the high-apogee orbits.

The first photographs were taken during the nightside in revolution 11 with the camera pointed alternately at the northern and southern airglow horizons. For the second attempt, during revolution 19, exposures were taken of the eastern airglow horizon. Also, twilight exposures were taken prior to sunrise. Photographs of the western airglow during twilight and night were taken during the high-apogee of revolution 26.

8.8.4 Results

A total of 25 useful airglow photographs were obtained covering various segments of the earth. Twelve of these were of the northern and southern airglow horizons and 13 were taken of the eastern airglow.

Because of a light leak in the camera system, exposures made during the high-apogee orbit were not of a usable quality. The other photographs are of excellent quality and show that performance by the crew for the experiment was exceptional. The photographs obtained show variations in altitude and intensity of the airglow. Several months of densitometry study will yield valuable information concerning the properties of the earth's upper atmosphere.

8.9 EXPERIMENT S013, ULTRAVIOLET ASTRONOMICAL CAMERA

8.9.1 Objective

The fundamental objective of the S013 Ultraviolet Astronomical Camera experiment was to record the ultraviolet radiation of stars in the wavelength regions from 2000 to 4000 Å. The objective was to be accomplished by recording radiation spectra, using the 70-mm general-purpose camera and an objective prism or an objective grating. An analysis of the surface temperatures of these stars, of the absorption effects taking place in their atmospheres, and of the absorption effects of the interstellar dust will be made of the photographic data obtained. The high resolution photographs are expected to show the absorption and emission lines, making possible the study of atomic excitation and ionization processes in these wavelength regions.

In addition to the acquisition of basic astronomical data, techniques by which objective-prism spectra may be best obtained were determined. The practical experience gained will be useful in planning similar astronomical observations with larger telescopes on future missions.

8.9.2 Equipment

The experiment equipment consisted of the 70-mm general-purpose camera equipped with a 73-mm ultraviolet lens, a 10-degree objective prism in a cell which attached to the ultraviolet lens, and a reflection grating in a cell which attached to the ultraviolet lens.

8.9.3 Procedures

Prior to the standup EVA, the pilot unstowed the camera and the prism or grating, then locked them to the bayonet joint of the lens. The camera was then attached to the bracket located near the pilot's seat.

After hatch opening, the spacecraft was pointed toward the first star target, using a reticle located on the command pilot's window. Because the camera axis was parallel to the roll axis of the spacecraft, the roll rate was the least critical of the three spacecraft motions. Roll rates to 0.5 deg/sec could have been tolerated with little loss of image definition. Both pitch and yaw rates were to be decreased to 0.1 deg/sec or less. Pitch motion was the most critical because the pitch axis was parallel to the direction of dispersion and motion would degrade the wavelength resolution of the spectra.

Three 5-second time exposures were made on each star field and the film advanced between each exposure. Two exposures of one minute each were made during periods when the stabilizing thrusters were operated to hold the spacecraft attitude constant. Finally, a sixth exposure was made with a yaw rate appreciably greater than the pitch rate.

The experiment was performed while the spacecraft was docked with the Gemini Agena Target Vehicle (GATV) in order to use the GATV control system for stabilization. During each set of exposures, the GATV was stabilized using flight control mode 2, with the geo-rate and horizon stabilization switched OFF. Six star fields were photographed—three using the grating and three with the prism. The grating fields were centered on Shaula, Canopus, and Alnilam. The prism fields were centered on Antares, Shaula, and Iota Orionis. The sequences of six exposures on each field were made according to the flight plan. The activation time and period of each exposure for the prism fields were obtained from transcripts of onboard voice tapes; however, these data for the grating fields were not critical to the experiment analysis and were not recorded.

8.9.4 Results

There were apparently no problems in the assembly and operation of the camera equipment during the flight. The use of a carbon dioxide cartridge eliminated all traces of static electricity markings on the film, a condition that had been noticed on the film from the Gemini X mission. Fogged streaks appear on several frames because of light leaks in the film magazine. There is no evidence of a light leak from the vent hole which was drilled in the film magazine just prior to launch.

The stabilization supplied by the GATV was somewhat erratic. One-third of the exposures show excellent stabilization, as indicated by the smooth image motion in the yaw direction (fig. 8.9-1). The remaining exposures show motion in both yaw and pitch, thus degrading wavelength resolution. A series of jumps in yaw may have taken place giving multiple narrow spectra which degraded the fine detail. This is shown in figure 8.9-4. The jumps were in excess of the width of the GATV yaw control deadband.

Image quality was still variable. This was observed by inspection of the zero-order grating images or of those prism spectra which were unwidened. In both cases, the lens was not expected to produce sharp images of light with wavelengths longer than 3000 Å. In the zero-order images, stars with strong ultraviolet spectra should have produced sharp points of light with a diffuse halo of blue-violet light, whereas cool stars with little ultraviolet energy should show only the diffuse image of the blue-violet light. Therefore, the spectral class of the star must be considered when judging image quality. Further complications were encountered by the variations of chromatic effects with field position. Evaluation of the flight lens will be required before a complete understanding of the image quality problem is known.

Grating spectra of 99 stars in three star fields were obtained. About half of these were strong enough to yield quantitative measures of ultraviolet energy curves. The prism spectra also show some detail. The limits of the hydrogen Balmer series and the 2^3S helium series appeared and the presence of the MgII line and the stronger iron multiplets was suspected in many of the spectra. Several of the more interesting photographs are shown as figures 8.9-1 through 8.9-4.

A frame-by-frame log of the flight film is presented in table 8.9-I. The only deviation from the flight plan was the observation of Canopus, an F0 supergiant, rather than Achernar, a B5 star. This departure was fortunate in that the spectrum of Canopus between 2000 and 3000 Å shows more detail than had been expected of the Achernar spectrum. The lack of strong ultraviolet lines in B-star spectra is graphically confirmed by figure 8.9-3. The wavelength resolution in this photograph is demonstrated by the forbidden OII emission line at 3727 Å in the spectrum of the Great Nebula and the Balmer series of hydrogen in the spectrum of Sirius; however, no trace of strong lines appears in the spectra of the O and B stars. This was expected because predictions indicate that a resolution about 50 times higher would be required to resolve the weak metallic lines in the 2000 to 3000 Å region of B-star spectra.

The ultraviolet spectrum of Canopus (figs. 8.9-1 and 8.9-2) showed detail similar to that observed in the ultraviolet spectrum of the sun. The MgII resonance line at 2800 Å was especially strong; lines of MgI at 2852 Å and SiI at 2881 Å were indicated, and multiplets of FeI and FeII were prominent below 2700 Å. The Balmer lines and the CaII, H, and K lines were seen in the blue-violet part of the spectrum.

8.9.5 Conclusions

The stability of the docked spacecraft configuration provided adequate guiding on only one-third of the exposures and therefore requires improvement.

The light leaks in the magazine are a continuing problem. It is recommended that the magazines for the Gemini XII mission be thoroughly tested for light leaks prior to the mission and that protection from sunlight be provided for all film during the mission.

In summary, this experiment can be considered successful in that useful scientific data were obtained and requirements for better equipment and procedures were established for future missions.

UNCLASSIFIED

TABLE 8.9-I.- EXPERIMENT S013 INFLIGHT EXPOSURES

Frame	Field	Grating condition	
		Vehicle attitude control	Remarks
S66-53091	Wasted frame	--	Lightstruck
S66-53092	Scorpius	Poor	Spectra wide, streaked - no lines
093		Fair	Spectra double - Balmer lines in Shaula
094		Poor	Spectra wide, streaked - no lines
095		Poor	Spectra wide, streaked - lines in Shaula, θ Sco
096		Poor	Spectra wide, streaked - lines in Shaula, Sco, θ Sco, Ara
S66-53097	Canopus	Good	Lines rather wide - UV well-exposed
098		Excellent	Lines rather wide - UV a bit weak
099		Excellent	Lines, UV well-exposed
100		Excellent	Lines, UV well-exposed - spectrum streaked
101		Good	Lines, spectrum double
102		Excellent	Lines, spectrum double
S66-53103	Orion	Bad	Spectra extremely wide - no lines
104		Fair	3727 Å emission (OII) in Nebula - lines in Sirius
105		Poor	Spectra wide, streaked - probably no lines

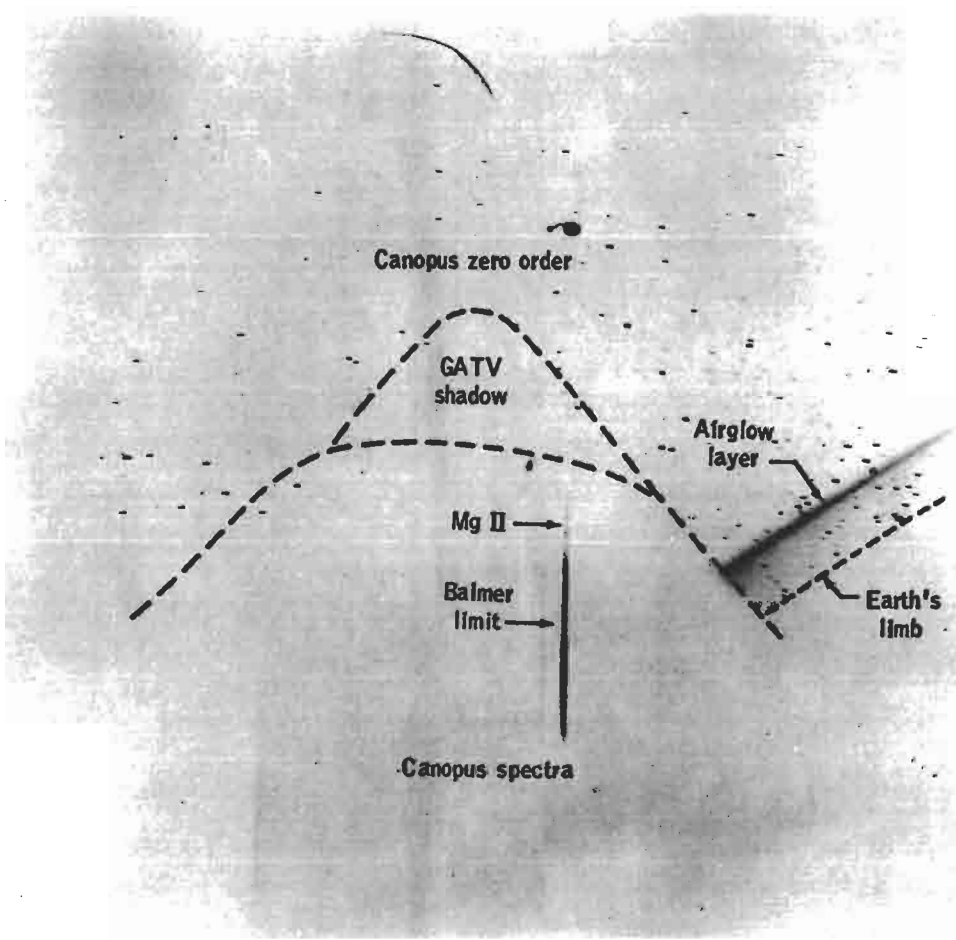
TABLE 8.9-I.- EXPERIMENT S013 INFLIGHT EXPOSURES - Continued

Grating condition			
Frame	Field	Vehicle attitude control	Remarks
106	Orion	--	Grossly underexposed - no spectra
107		Good	Strongly exposed - 3727 Å in Nebula, lines in Sirius
108		--	Lightstruck, ruined
S66-53109	Wasted frame	--	Lightstruck
110	Scorpius head	Poor	Spectra streaked - focus poor - no lines
111		Good	Spectra smooth - lines visible
112		Poor	Spectra streaked - focus poor - no lines
113		Good	Spectra double, smooth - lines visible
114		Poor	Spectra streaked - focus poor - no lines
115		Poor	Spectra streaked - focus poor - some lines
S66-53116	Scorpius tail	Fair	Spectra very wide, streaked - lines visible
117		Fair	Spectra wide, streaked - lines visible
118		Good	Spectra wide, smooth - focus poor - lines visible
119		Poor	Motion mainly in pitch - no lines
120		Fair	Spectra streaked - focus poor - some lines

TABLE 8.9-I.- EXPERIMENT S013 INFLIGHT EXPOSURES - Concluded

Frame	Field	Grating condition: Vehicle attitude control	Remarks
S66-53121	Scorpius tail	Poor	Spectra streaked - focus poor - some lines
122		Bad	Spectra very wide - focus poor - no lines
S66-53123	Orion	Fair	Spectra streaked - some lines
124		Fair	Spectra streaked - some lines
125		Excellent	Spectra smooth - lines visible
126		Poor	Motion in pitch - no lines
127		Fair	Spectra smooth - focus poor - some features
128		Poor	Spectra streaked - no lines
129	Wasted frame	--	

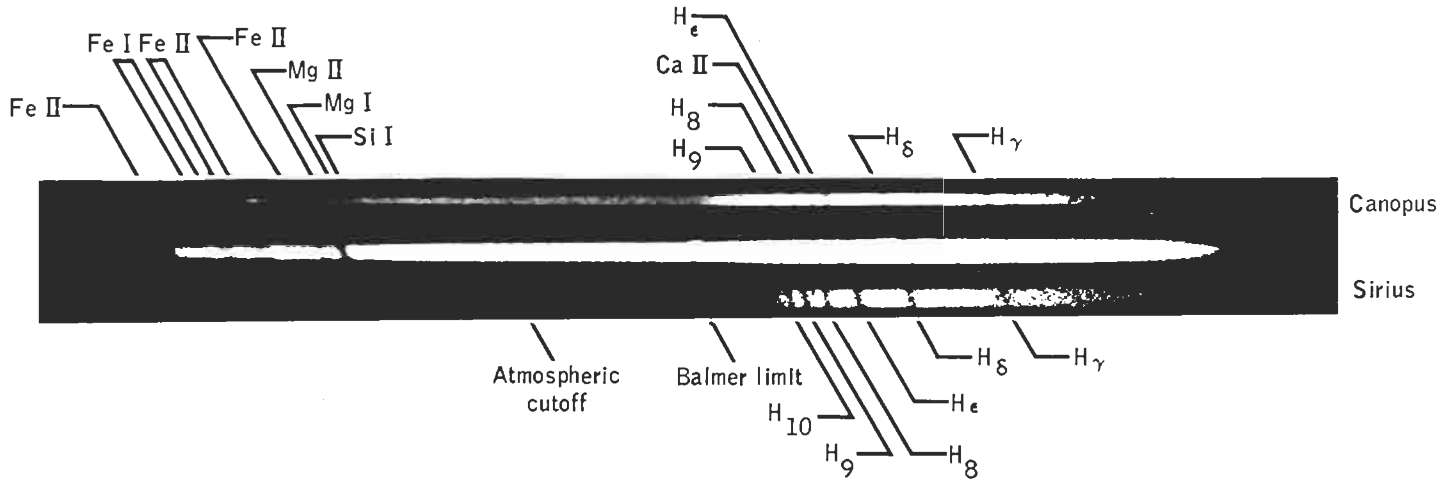
NASA-S-66-9047 OCT 11



Obtained during the standup EVA September 14, 1966. The docked GATV and the R and R section of the spacecraft are superposed on the starfield. The spectrum is produced by a diffraction grating which gives both a direct image (above) and a spectrum (below) of each star. The details in the upper end of the spectrum (lines of magnesium and iron) are not transmitted by the earth's atmosphere and are recorded here for the first time in the spectrum of a star. The streak of light to the right is the airglow layer above the earth's horizon.

Figure 8.9-1. - The ultraviolet spectrum of Canopus.

NASA-S-66-9048 OCT 11



The opaqueness of the earth's atmosphere is clearly shown by the lack of spectral data in the ultraviolet band from Sirius.

Figure 8.9-2. - Comparative spectra of Canopus and Sirius.

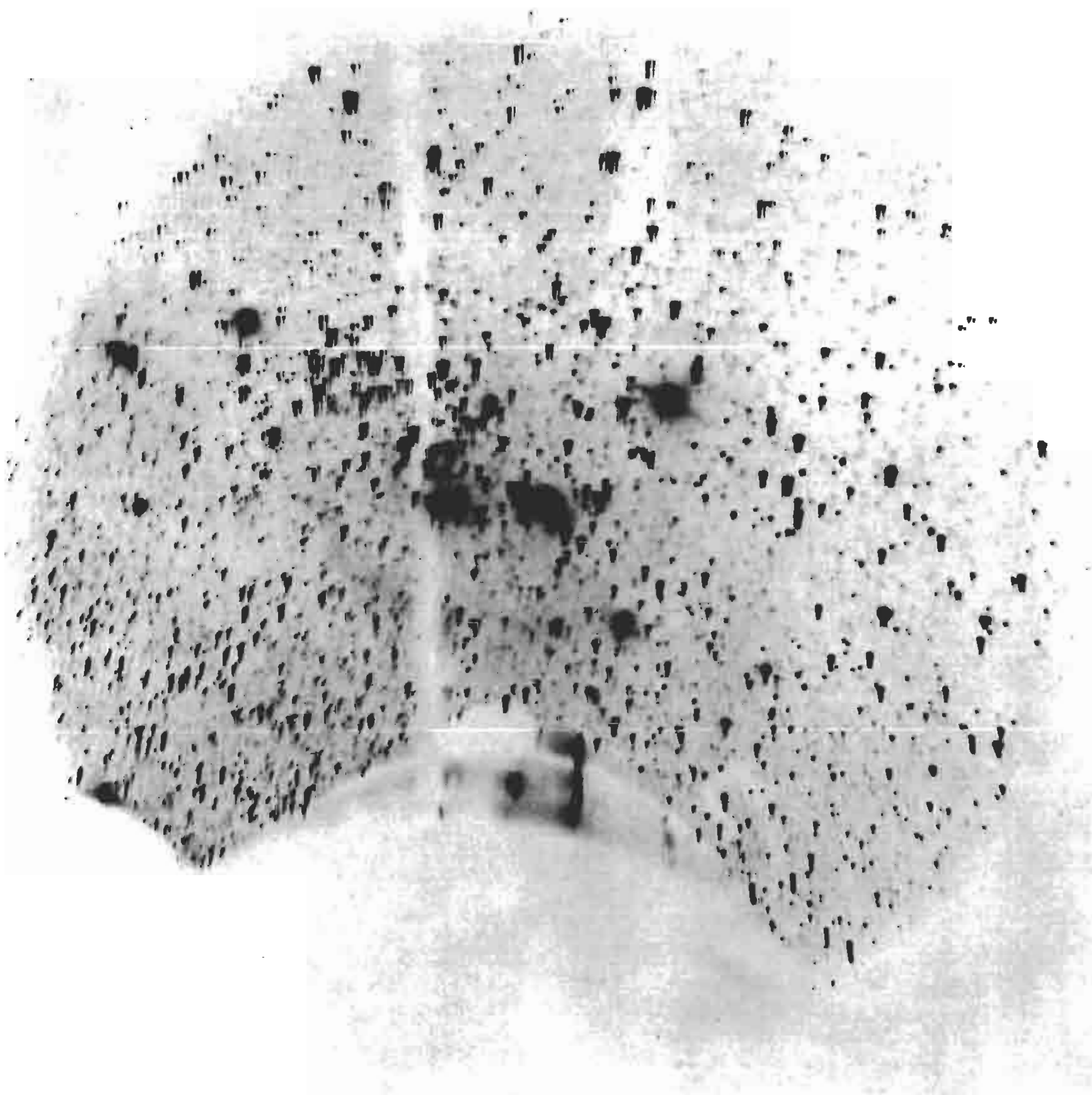
NASA-S-66-9042 OCT 11

Obtained during the standup EVA on September 14, 1966. The docked GATV and the R and R section of the spacecraft are superposed on the star-field. The spectra are produced by a diffraction grating which gives both a direct image (above) and spectrum (below) of each star.

Figure 8.9-3. - Ultraviolet grating spectra of hot stars in the constellation Orion.

UNCLASSIFIED

NASA-S-66-9044 OCT 11



Obtained during the standup EVA on September 14, 1966. The docked GATV and the R and R section of the spacecraft are superposed on the star-field. The elongation of the star images is caused by the dispersion in wave-length caused by a thin prism of quartz in front of the lens.

Figure 8.9-4. - Ultraviolet prism spectra of hot stars in the constellation Orion.

UNCLASSIFIED

8.10 EXPERIMENT S026, ION-WAKE MEASUREMENT

8.10.1 Objective

The objective of the S026 Ion-Wake Measurement experiment was to measure and confirm the ion and electron wake structure and perturbation of the ambient medium produced by the orbiting Gemini spacecraft. The experiment was designed to obtain the following:

(a) A mapping of the spacecraft ion-density wake as a function of position coordinates relative to the reference frame of the spacecraft

(b) A contour mapping of the spacecraft electron-density wake as a function of the same position coordinates

(c) Determination of electron temperature as a function of the position coordinates

(d) Detailed information on ambient ion and electron densities and electron temperature as a function of altitude and diurnal variations from the Gemini Agena Target Vehicle (GATV)

(e) Ionization transients caused by spacecraft thruster firings.

8.10.2 Background Information

During flight, the Gemini spacecraft moves through the ionospheric medium with a velocity that is high when compared with the random thermal velocities of the ions, but small when compared with the random thermal motions of the electrons. The vehicle motion is supersonic with respect to the ions and subsonic with respect to the electrons. Electrons, therefore, approach the vehicle from all directions as if it were standing still, whereas the ions are swept up by the vehicle motion.

To an observer on the spacecraft, there is a ram ion flux to the vehicle along the direction of the vehicle velocity vector. The motion of the vehicle results in a sweeping out of the ions and neutral particles in its path. If the constituents of the ionosphere were completely at rest, a shadow zone would extend an indefinite distance behind the spacecraft.

As a result of the random thermal motions, the shadow or hole region is filled in by a sequence of interacting mechanisms, with the region behind the orbiting vehicle actually being a plasma rather than an ion wake. Because the electrons approach the spacecraft from all directions, it would be expected that these would rapidly fill the shadow region. The electrostatic forces between these charged particles prevent substantial imbalances in the local space charge from occurring.

8.10.3 Equipment

For the Gemini XI mission, the electron detector was located on the GATV Target Docking Adapter (TDA) and operated continuously during the experiment. Operation of the inboard ion detectors depended upon the angular relationship of the GATV with respect to the orbital velocity vector. The inboard ion detector provided useful data whenever the GATV moved TDA-forward with its axis parallel to the orbital path; the outboard detector was operative whenever the GATV yawed at right angles to the orbital path. The location of the equipment on the TDA was shown in figure 8.14-1 of the Gemini X Mission Report.

The sensors were five-element retarding potential analyzers with ac-modulation for low-threshold operation. They were designed to measure ion and electron currents over a range from 5×10^{-11} to 5×10^{-6} amperes, with electron temperature measurements in a range from three electron volts down to zero. Ion densities as low as 50 ions per cm^3 were considered detectable for this experiment. For contour mapping, position resolution to approximately one foot in accuracy was obtained from a 16-mm general-purpose sequence camera.

The sensor-electrometer systems each collected and modulated plasma current in a Faraday cup containing four grids followed by a collector plate. The voltage bias placed on the front grid limited the minimum energy plasma particle which can enter the sensor. The second grid accelerated the properly charged particles which passed the first grid.

A third grid was driven by a 3840-cps square wave which modulated the plasma current by alternately blocking and accelerating the particles passing through the second grid. A fourth grid actually consisted of three screens connected together to act as a capacitive shield between the modulation grid (grid three) and the final collector. The third screen in the final grid also served as a collector for secondary photo electrons produced in the sensor.

The sensor output current was designed to swing from zero to the dc value of the input plasma current and back within one microsecond, with a 50-percent duty cycle at a frequency of 3840 cps. This square-wave current was amplified by an ac electrometer located behind the sensor. Electrometer signals were synchronously demodulated and averaged by an analog signal processor carried aboard the GATV. A resulting voltage proportional to the logarithmic average was generated and buffered, then input to the analog-to-digital converter in the GATV telemetry system for transmission to the network tracking stations.

8.10.4 Procedures

The flight plan contained five distinct modes for the ion-wake experiment. These included two out-of-plane maneuvers, one at night and one in the daylight, one nighttime in-plane mapping, and one linear departure. These four phases were planned and executed between 2 hours 10 minutes and 3 hours 50 minutes g.e.t. Real-time telemetry and delayed-time telemetry received over the high-speed data lines indicated that all sensors performed satisfactorily. The fifth phase of the experiment consisted of a 360-degree roll at the apogee of the first revolution of the highly elliptical 740 by 160-nautical-mile orbit.

8.10.5 Results

Data correlation and reduction, particularly in correlating the GATV telemetry data with the relative position coordinates of the two vehicles, will involve considerable effort. The radar system, which was to be employed for backup range information, was not functioning during the experiment. The onboard voice tape recorder apparently was also inoperative during periods when the crew was to record start-and-stop times of the 16-mm boresighted sequence camera. In addition, the auxiliary receptacle which was to provide time markers was not functioning. Photographic data appear to be of usable quality for eventual correlation of experiment data with position information. Accurate time determination can probably be achieved by using thruster firing durations and on-off times.

The following effects were observed in real-time and from delayed-time telemetry during the mission:

(a) The spacecraft wake shadow produced ion depletions at least an order of magnitude below the ambient levels.

(b) The bow shock for the enhanced ion-count phenomenon, previously reported during the Gemini X mission, was repeated during the terminal rendezvous-and-docking phases in the TDA-north configuration.

(c) Reflection of ions from the pilot during his extravehicular activity was observed.

(d) Strip-chart real-time data from Cape Kennedy and delayed-time telemetry from the Rose Knot Victor tracking ship were used to determine the rotation rate of the tethered spacecraft/GATV configuration.

(e) A change in potential of the docked configuration under GATV primary propulsion system firings was observed. The same effect had been observed previously during the Gemini X mission.

(f) The effects of thruster firings apparent during the Gemini X mission were also apparent in this mission. These effects appeared to be readily separable from the wake measurements. This was not possible with the Gemini X data.

8.10.6 Conclusions

It is possible to make certain tentative conclusions: Thruster firings in the TDA-south configuration produce a decrease in the observed ion flux to the outboard ion sensor, an apparent increase in the ion flux to the inboard ion sensor, and an enhanced electron concentration by the outboard electron sensor.

Visual inspection of strip-chart data shows that definitive wake-cone angles can be determined. It is also apparent for many cases that the electron distribution follows the ion depletion effects, indicating that the wake is a plasma rather than an ion wake.

8.11 EXPERIMENT S030, DIM SKY PHOTOGRAPHS/ORTHICON

8.11.1 Objective

The objective of the S030 Dim Sky Photographs/Orthicon experiment was to use the image orthicon system of the D015 Night Image Intensification experiment to obtain photographic data on faint diffuse astronomical phenomena.

The astronomical phenomena of interest were the Milky Way, the airglow layer viewed in profile, the zodiacal light, the gegenschein, and the stable Lagrangian libration points. The noise threshold sensitivity of the D015 experiment was estimated at 10^{-7} foot-lamberts of object brightness. The brightness of the astronomical objects of interest are:

Airglow layer	1×10^{-4} foot-lamberts
Brightest Milky Way	3×10^{-5} foot-lamberts
Zodiacal light	1×10^{-5} foot-lamberts
Gegenschein	1×10^{-6} foot-lamberts
Lagrangian points	1×10^{-7} foot-lamberts

It is evident that the airglow layer should have been easily observed by the D015 equipment, while the Lagrangian libration points, if they actually exist, approach the noise level of the system. The gegenschein is considered of paramount importance, but, because of its low brightness, evaluation techniques other than visual observance of photographs is required. Photographic negatives will have to be examined with a microdensitometer to extract the maximum of astronomical information and to derive absolute values of the surface brightness of the objects in question.

8.11.2 Equipment

The equipment required was that used for the D015 experiment described in section 8.2.

8.11.3 Procedures

The procedures for the S030 experiment were similar to those of the D015 experiment, except for the observed and recorded objects of interest. The flight plan scheduled 12 operational sequences for this experiment. They were performed during the night phase of revolution 41 at 65 hours 35 minutes g.e.t. The sequence of events requiring crew participation was as follows:

Sequence 1 - Activate D015 equipment before sunset

Sequence 2 - After sunset, acquire the gegenschein area from ground instructions, then drift in the general star area for 10 seconds. Observe the TV monitor screen and activate the photo-record button as required

Sequence 3 - Acquire the earth horizon and make a 360-degree sweep of the earth airglow and photographically record observations

Sequence 4 - Re-acquire gegenschein and repeat sequence 2

Sequence 5 - Acquire the dark area 15 degrees east of the star Canopus. Drift through this area for 30 seconds and photographically record observations

Sequence 6 - Position spacecraft to acquire Magellenic clouds located 15 degrees south of Canopus. Drift within this area for 15 seconds and photographically record observations

Sequence 7 - Repeat sequence 4

Sequence 8 - Acquire and occult moon with the spacecraft nose for 15 seconds. Observe and record observations

Sequence 9 - Repeat sequence 4

Sequence 10 - Acquire the eastern horizon before sunrise and observe and record zodiacal areas

Sequence 11 - Acquire, observe, and photographically record libration regions for a 30-second period in accordance with ground instructions

Sequence 12 - Acquire and observe other astronomical phenomena as recommended from ground mission control.

8.11.4 Results

The crew indicated during the postflight experiments debriefing that sequences 1, 2, 3, 5, and 7 were performed without difficulty. The 16-mm photographic film data consist of 400 frames, showing that part of sequence 2 and most of sequence 3 were the only sequences photographically recorded. Evaluation of the complete film records has shown that 30 percent of the available film for experiments D015 and S030 was not exposed. Apparently the recording camera was not functioning during the time of crew participation, except for the airglow sequence. This could have resulted from failure of the pilot to press the photo-record button or through malfunction of the camera recording system. The camera will be checked for system failure and telemetry data will indicate if activation of the camera shutter occurred during the sequences that did not have photographic records.

Photographic data of the 360-degree sweep of earth's horizon show stars of down to the fifth and sixth magnitude. Figure 8.11-1 shows one frame of the 3-frame-per-second, 1/30-second exposure, coverage. The airglow, the earth horizon, the star fields, and stars between the airglow layer and the earth are clearly shown and identified. The photographs show the airglow sharply delineated on top, and they will be useful in determining the height of the airglow layer at all points around the horizon. The photographs taken to the northwest seem to show a splitting of the airglow layer. To determine the reality of this effect the original film will have to be analyzed with an isodensitracer. In about 20 exposures taken to the west, the horizon becomes very distorted by some phenomena associated with the spacecraft. In all of the pictures, an electronic effect in the image intensifier caused a diffuse glow in the center of the frame. This glow makes it very difficult to search for diffuse sources of astronomical interest. Also, a bright band frequently appears in the sky portion of the photographs and seems to be a reflection or ghost-image produced by the bright airglow layer.

8.11.5 Conclusions

Isodensitometry analysis of the photographic records have not been completed. Since photographic data from most of the scheduled sequences were not obtained, emphasis will be on the geometry and densitometer measurements of the airglow, the zodiacal light, and other possible astronomical phenomena.

A preliminary review of the film by the flight crew indicated that the onboard TV monitor provided visual information of greater detail and magnitude than was recorded by the camera. The usefulness of an image orthicon and camera recording system over other recording techniques appears to be unsuitable for the study of dim, diffuse astronomical sources of light.

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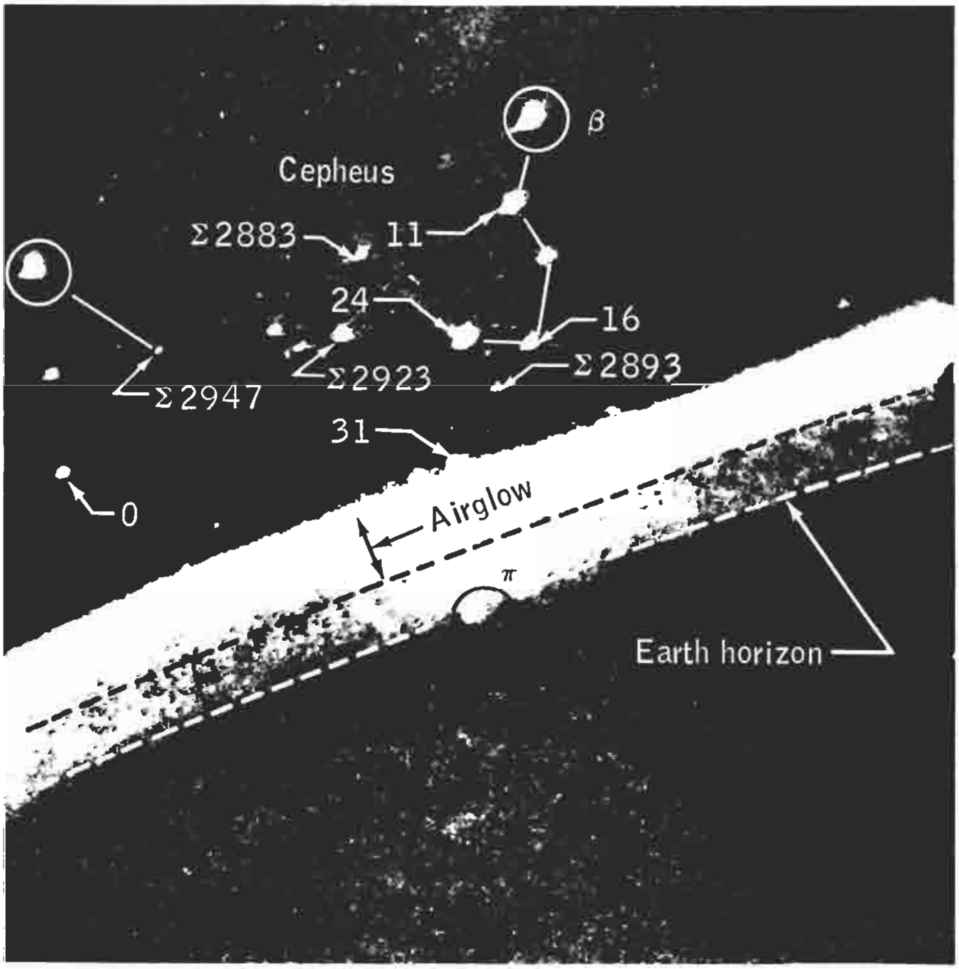

This photograph was taken at night at 65:51:27 g.e.t. using the D015 Night Image Intensification tube as a sensor. It was photographed at a 1/30 of a second exposure with a 16-mm camera. The earth horizon and airglow are clearly visible. Several stars between the airglow and earth are easily distinguishable as are stars above the airglow layer. The photograph was taken of the constellation Cepheus. The visual magnitude of O Cepheus is 4.76 and β Cepheus is 3.23.

Figure 8.11-1. - Airglow and star fields.

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9.0 CONCLUSIONS

The two launch vehicles, the Gemini Agena Target Vehicle, the spacecraft, the flight crew, and mission support were excellent for all phases of the Gemini XI mission. The flight contributed significantly to the knowledge of manned space flight, particularly in the areas of rendezvous, extravehicular activity, tethered vehicle operations, and controlled reentry.

The following conclusions were obtained from data evaluation and crew observations:

1. A rendezvous during the first spacecraft revolution was conducted with extremely high precision. All maneuvers required to complete the rendezvous were computed on board the spacecraft. The crew successfully used onboard backup charts and optical techniques to complete the rendezvous when angle data from the spacecraft radar became erratic after the first midcourse correction. Approximately 405 pounds of propellant, within plus one sigma of the planned amount, were required to complete the insertion and rendezvous. Because propellants had been used conservatively during the mission, a coincident-orbit rendezvous with a 292-degree angle of orbit travel to rendezvous, was added to the flight plan. The spacecraft was lagging the Gemini Agena Target Vehicle by approximately 25 nautical miles at terminal phase initiate, and the rendezvous was successfully accomplished with a propellant expenditure of about 74 pounds, including eight pounds used for experiments between the rendezvous maneuvers.

2. The crew successfully demonstrated the feasibility of tethered vehicle operations during the Gemini XI mission. They imparted a 38 deg/min rotational rate to the tethered system and later increased the rate to 55 deg/min. This evaluation demonstrated the stable operation and natural damping of a tethered rotating system, showing tethered operation to be an economical means of long-term, unattended station keeping. In addition to the natural damping, the crew were able to use the spacecraft control system to more rapidly damp oscillations, when desired. The artificial gravity field generated during the tether evaluation was not great enough to be felt by the crew, but a simple test with a loose article demonstrated that this field did, in fact, exist.

3. Two periods of extravehicular activity (EVA) were completed. During the umbilical EVA, the pilot installed the EVA camera, retrieved the S009 experiment package, and attached the spacecraft/GATV tether; however, this EVA had to be prematurely terminated after 33 minutes

because of pilot fatigue. The pilot found that the planned tasks required a great deal of time and effort because maintaining the desired body position was very difficult. He had performed the same tasks with comparative ease during training, and the desired body position had been easily maintained. During the 2 hours and 8 minutes of standup EVA, all of the planned tasks were completed. The pilot was tethered to the interior of the spacecraft throughout this EVA, and body positioning was much easier than it had been when outside the spacecraft.

4. The pilot had donned the Extravehicular Life Support System (ELSS) and completed checkout two hours prior to the scheduled time for the umbilical EVA hatch opening. This caused increased spacecraft oxygen usage and insufficient pilot cooling. As a result, the pilot reconfigured to the spacecraft system and had to repeat much of the EVA preparations closer to the time of hatch opening.

5. The pilot accidentally cracked the extravehicular sunvisor while attempting to install it on his helmet. The planned procedure to install the visor while pressurized made the operation very difficult and added unnecessary work to the activity, contributing to the fatigue that eventually caused premature termination of the umbilical EVA. This procedure was used to circumvent a design limitation which required that the pressure visor be completely closed before the sunvisor could be installed.

6. The pilot's high expenditure of energy during the umbilical EVA was caused by a combination of the following factors:

(a) High work level required for mobility in the pressurized Gemini space suit

(b) Inadequate body restraint for the pilot to position his body astride the Rendezvous and Recovery section of the spacecraft

(c) Preoccupation with the accomplishment of a series of tasks under a schedule limitation that led to the use of excessive work rates

(d) Possible buildup of carbon dioxide in the ELSS suit loop resulting from the high work levels and associated respiration rates. It is known that high workloads with a moderate buildup of carbon dioxide can cause early onset of fatigue.

7. The use of tethers and lanyards to retain loose equipment during EVA is a practical method of equipment management. Using this method, no equipment was lost during the Gemini XI EVA.

8. Spacecraft window contamination was particularly severe on this mission. The visibility through the left window was particularly poor, hindering rendezvous operations and degrading the quality of photographs taken through that window. During postflight inspection, deposits were found on all exposed surfaces of the windows, including those that were exposed to the vented area between the middle and outer panes of glass.

9. The voice tape recorder operated intermittently throughout the mission. This intermittent operation was caused by a bearing failure due to poor quality control and resulted in the loss of considerable onboard commentary and experiment data during all of the rendezvous maneuvers, the two orbits of high-altitude operation, nearly all of the two EVA's, the automatic reentry, and other critical phases of the flight.

10. The quality of real-time and delayed-time telemetry data received during this mission was better than on any previous flight, with coverage of all possible real-time periods except for about two minutes. Of the delayed-time data processed, 99.8 percent was usable.

11. The inaccurate angle data from the rendezvous radar system during the final phase of the first rendezvous were caused by faulty transmitter operation in the Target Docking Adapter transponder. The failure most likely occurred in either the modulator, the high-voltage power circuit, or the transmitter tube. The transponder continued to receive but would not transmit; therefore, accurate angle data were not available to the spacecraft onboard computer for the second midcourse correction and final closure on the target.

12. The Inertial Guidance System and the associated spacecraft control system performed satisfactorily during the reentry and automatically controlled the spacecraft to a landing within three nautical miles of the planned landing point.

13. Fuel-cell stack 2C failed during a 27-second period starting at 59 hours 31 minutes ground elapsed time. The failure appears to have been caused by a membrane perforation. A protective check valve in the hydrogen supply system performed the designed function to cut off the supply and prevent any further damage. Loss of this stack did not impose any restrictions on the completion of the mission.

14. Late in the mission, a tube cutter was actuated to allow complete evacuation of the annulus between the inner and outer shells of the hydrogen container to investigate the feasibility of this technique. The test showed a 9.5-percent improvement in thermal performance with the hard vacuum in the annulus.

15. Some degradation of performance was noted in thrusters no. 6 and no. 8; however, the crew had no difficulty in controlling spacecraft attitude.

16. Crew-station furnishings and equipment performed better during the Gemini XI mission than during any previous mission. Except for minor difficulties with cameras and a switching anomaly with the propellant pressure/temperature gage, all items were satisfactory.

10.0 RECOMMENDATIONS

The following recommendations are made as a result of engineering analyses and crew observations of the Gemini XI mission:

1. During the Gemini XII mission, every effort should be made to better define man's capabilities in the extravehicular environment. If necessary, this should be given preference over other objectives.

2. The following steps should be taken to minimize the work levels required to accomplish the extravehicular activity (EVA):

(a) Plan the EVA timeline with liberal margins so that the crew have adequate time for completing assigned tasks.

(b) Provide the flight crew with a method for estimating and controlling their approximate work level during EVA. This method must be usable with or without ground contact.

(c) Conduct thorough analyses and tests to establish satisfactory body restraints for all extravehicular work tasks. Tether restraints should be considered, and should be provided where practicable.

(d) Modify operating procedures for the Extravehicular Life Support System (ELSS) to make the use of bypass flow a standard procedure when high work levels are encountered.

3. For the Gemini XII mission, the time for donning the ELSS should be specifically defined in the flight plan. If the crew are ahead in the schedule for EVA preparations, they should stop and wait until the designated time for donning the ELSS to avoid a heat buildup and excessive spacecraft oxygen consumption.

4. For the Gemini XII mission, the extravehicular sunvisor should be modified to eliminate the interference and binding between the visor attachment hardware and the mating hardware on the space suit helmet. A procedure should also be devised to permit the pilot to install the extravehicular sunvisor before the suit is pressurized, preferably with the helmet off. For future programs, the designs for the extravehicular sunvisors should permit opening the pressure visor after the sunvisor is installed.

5. Handrails should be provided for EVA transit over smooth surfaces.

6. Equipment should not be stowed in the areas intended for crew habitability.

7. Either a range-finding telescope or a telescope with a calibrated reticle should be provided for measuring range during the terminal phase of rendezvous.

8. The 70-mm general-purpose camera should be modified to assure easier installation of the various lenses.

9. A concentrated effort should be made to prevent window contamination on Spacecraft 12. An understanding of this class of problem is very important to the Apollo Program and all succeeding space programs.

10. Pulse attitude control may be used to increase the accuracy of platform alignments; however, this type of control requires complete and undivided attention, and, in general, the increase in accuracy does not justify the use of pulse control.

11. A study should be made of the feasibility of medically inducing sleep for one crewmember during the first night in space, or the flight plan should be arranged so that the second day in space is less strenuous.

12. Recovery personnel should not initiate communications with the flight crew before the spacecraft has landed. Also, when transmitting descriptions of the recovery operations, recovery personnel should not use the same frequency as the spacecraft UHF system (298.6 mc).

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12.0 APPENDIX

12.1 VEHICLE HISTORIES

12.1.1 Spacecraft Histories

The spacecraft history at the contractor's facility in St. Louis, Missouri, is shown in figures 12.1-1 and 12.1-2. The spacecraft history at Cape Kennedy, Florida, is shown in figures 12.1-3 and 12.1-4. Figures 12.1-1 and 12.1-3 are summaries of activities, with emphasis on spacecraft systems testing and prelaunch preparation. Figures 12.1-2 and 12.1-4 are summaries of significant problem areas.

12.1.2 Gemini Launch Vehicle Histories

The Gemini Launch Vehicle (GLV) history and significant manufacturing activities at the contractor's facilities in Denver, Colorado, and in Baltimore, Maryland, are presented in figure 12.1-5. The GLV history at Cape Kennedy is presented in figure 12.1-6. This figure also includes the problems which were concurrent with the normal GLV launch-preparation activities.

12.1.3 Gemini Agena Target Vehicle and Target Docking Adapter Histories

The Gemini Agena Target Vehicle (GATV) history at the contractor's facility in Sunnyvale, California, is shown in figure 12.1-7. The history of the GATV and Target Docking Adapter (TDA) and the significant events that occurred after delivery to Cape Kennedy are shown in figure 12.1-8.

12.1.4 Target Launch Vehicle History

The Target Launch Vehicle (TLV) history at the contractor's facility in San Diego, California, is shown in figure 12.1-9. Figure 12.1-10 includes significant problems that were encountered during testing at Cape Kennedy.

12.1.5 Extravehicular Life Support System History

Figure 12.1-11 is a history of the Extravehicular Life Support System (ELSS). The figure also identifies the significant problems that occurred during testing at Cape Kennedy.

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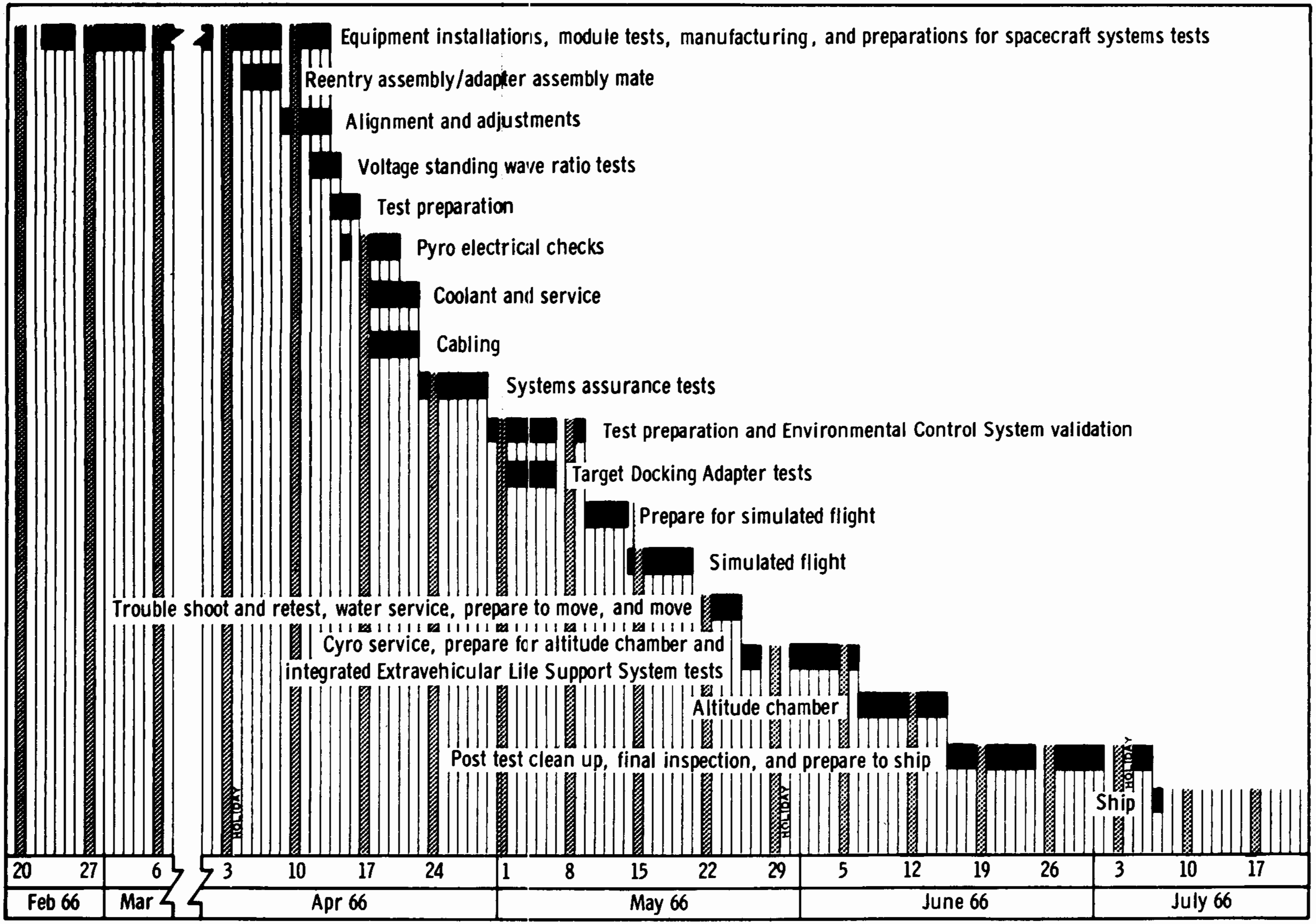

Figure 12.1-1. - Spacecraft 11 test history at contractor facility.

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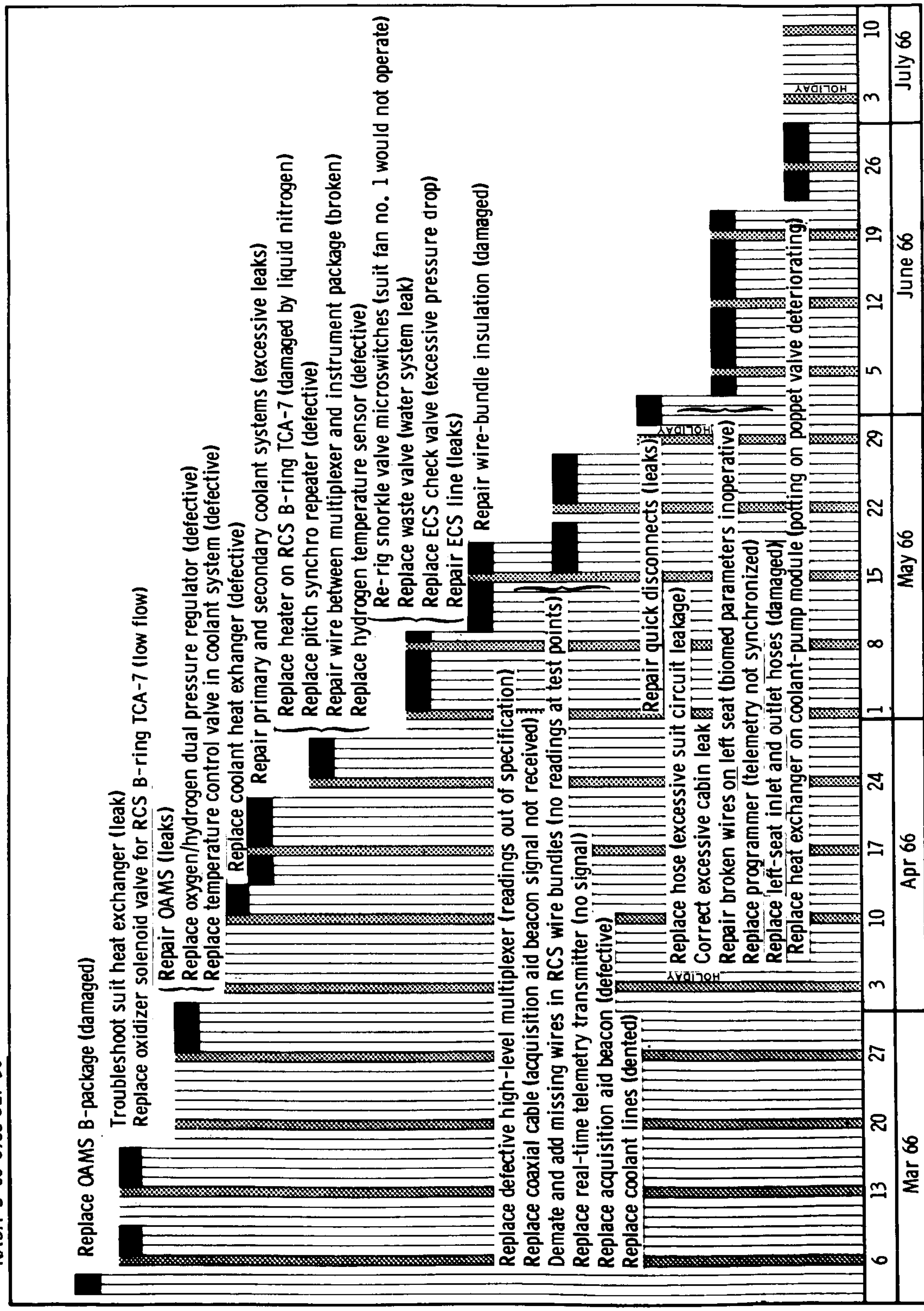

Figure 12.1-2. - Spacecraft 11 significant problems at contractor facility.

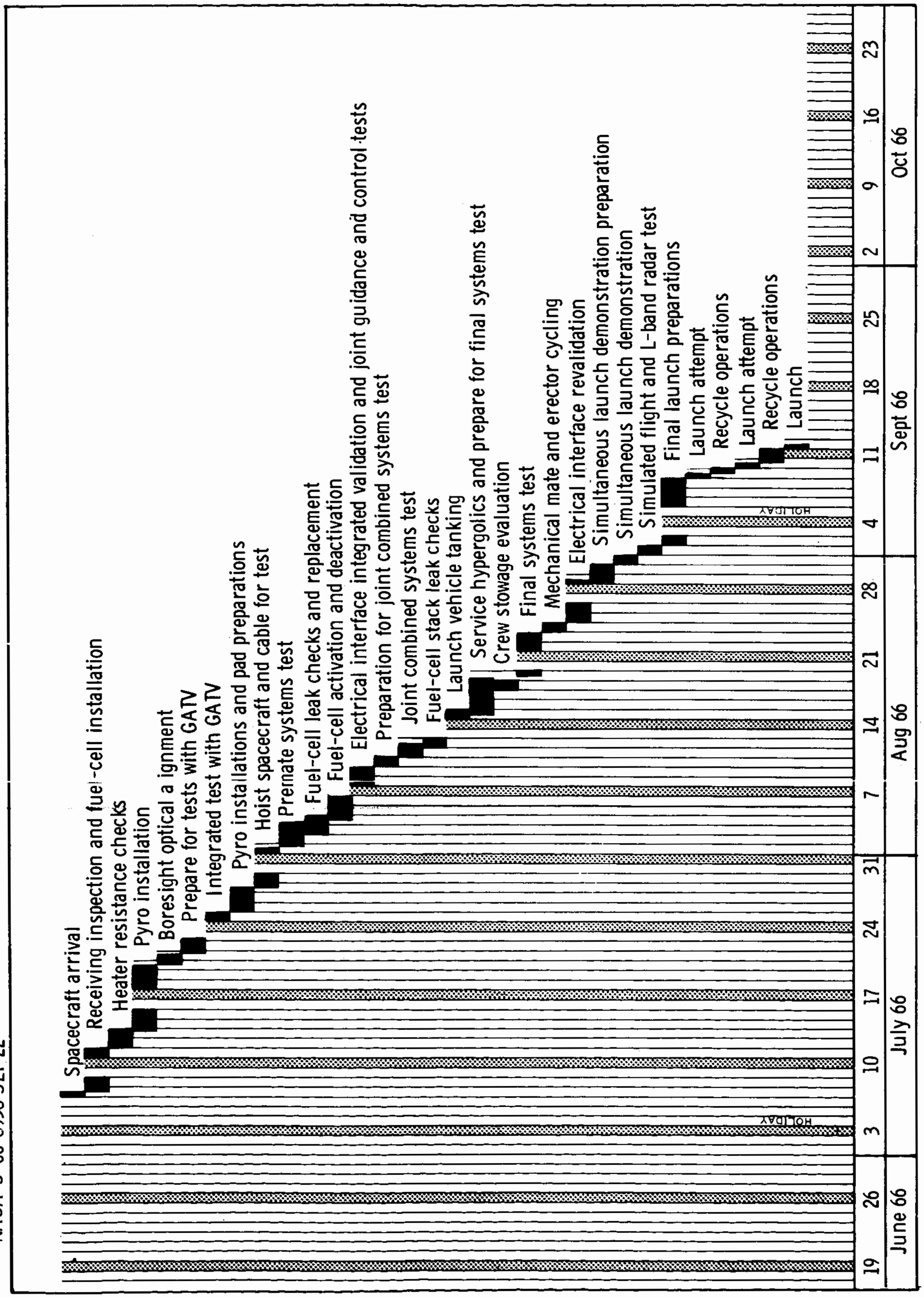

Figure 12.1-3. - Spacecraft 11 history at Cape Kennedy.

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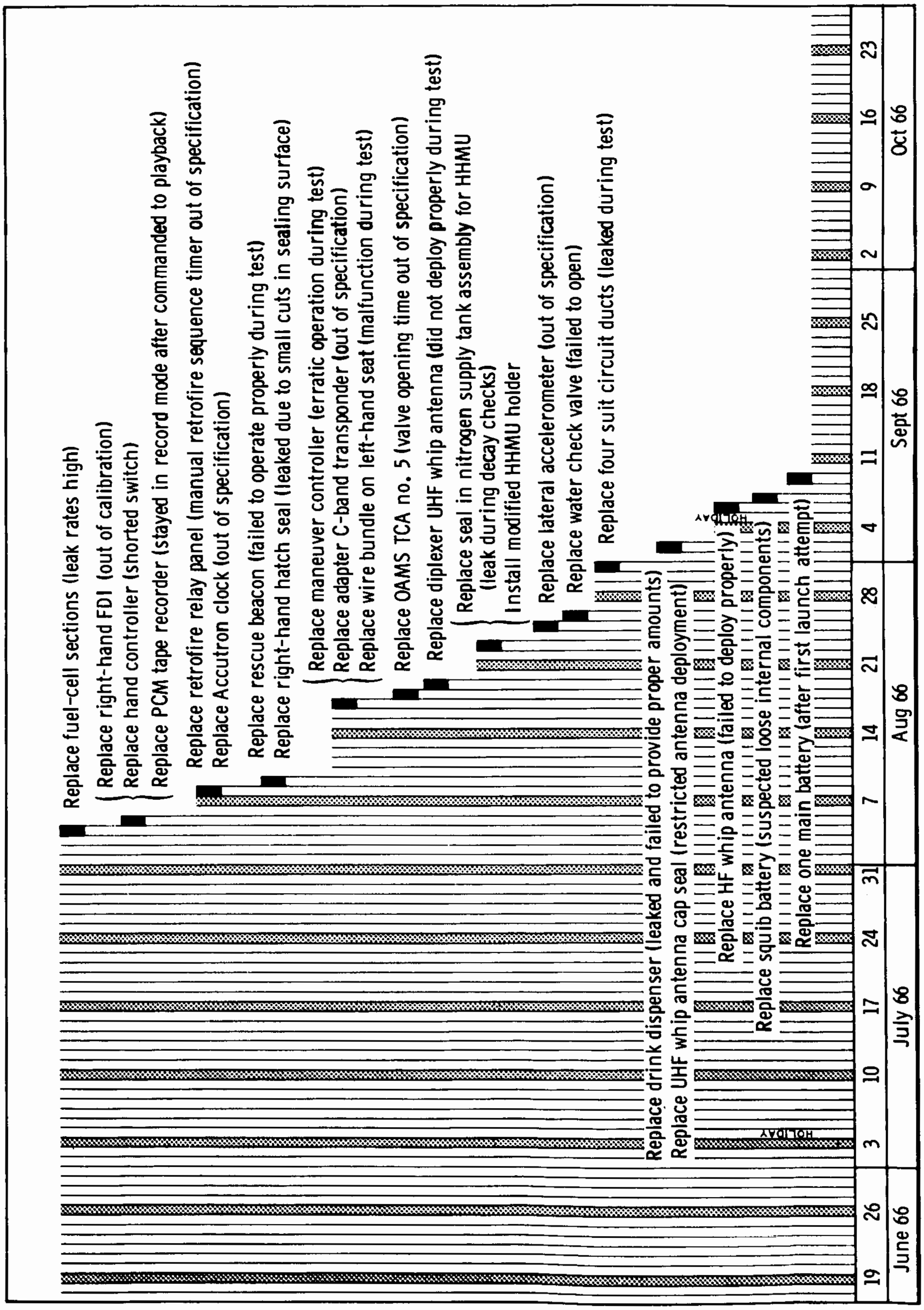

Figure 12.1-4. - Spacecraft 11 significant problems at Cape Kennedy.

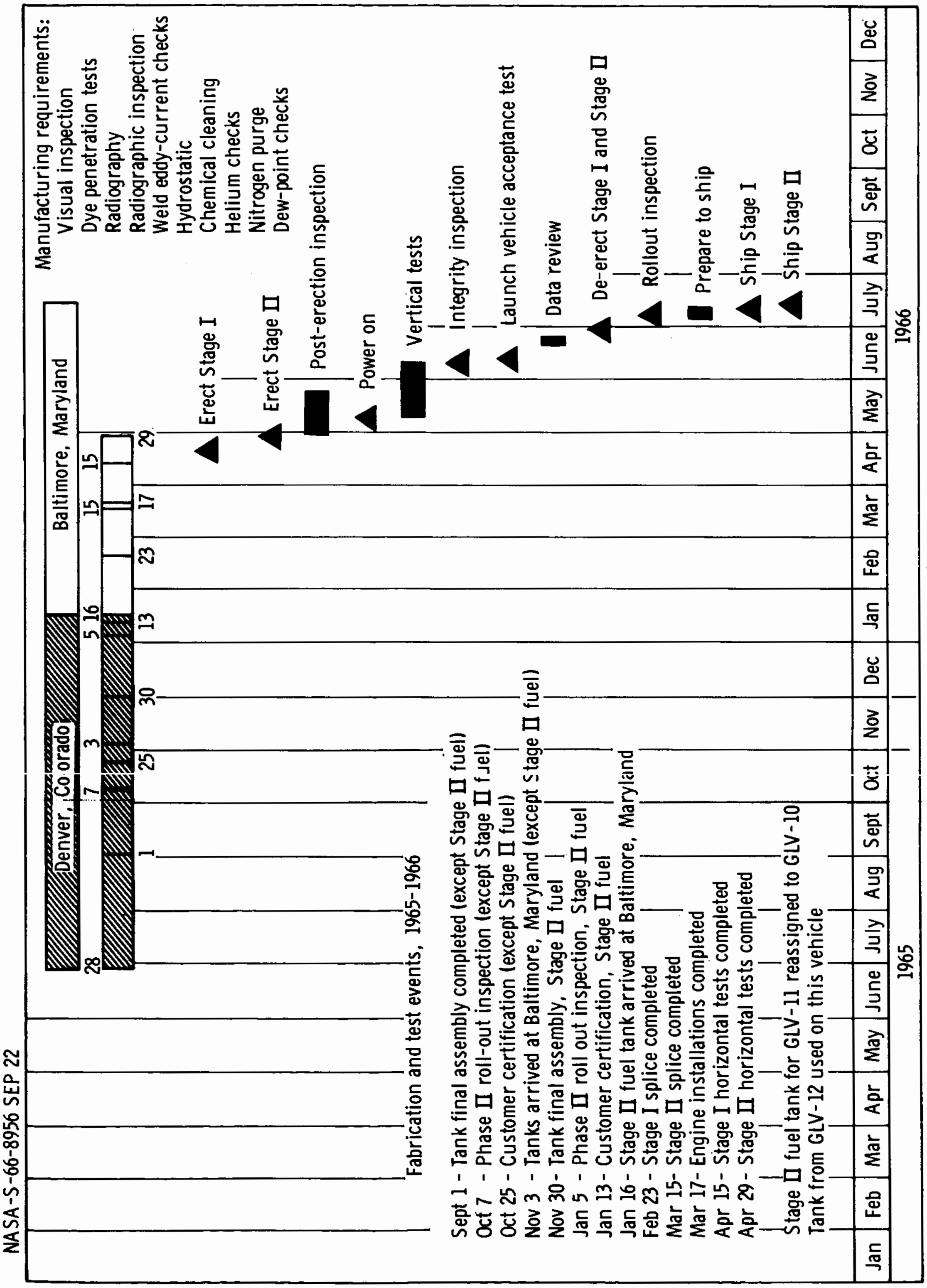

Figure 12.1-5. - GLV-11 history at Denver and Baltimore.

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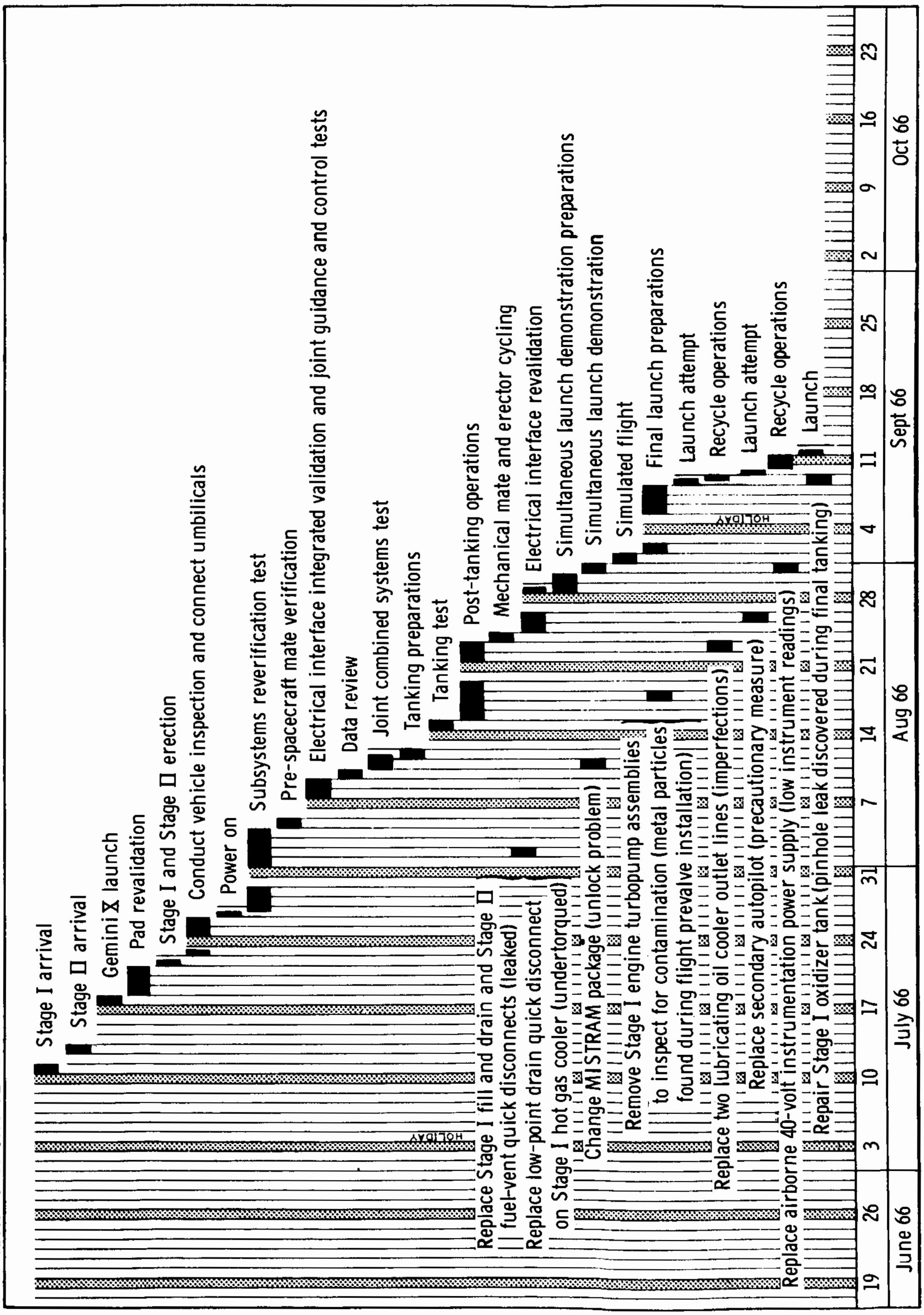

Figure 12.1-6. - GLV-11 significant problems at Cape Kennedy.

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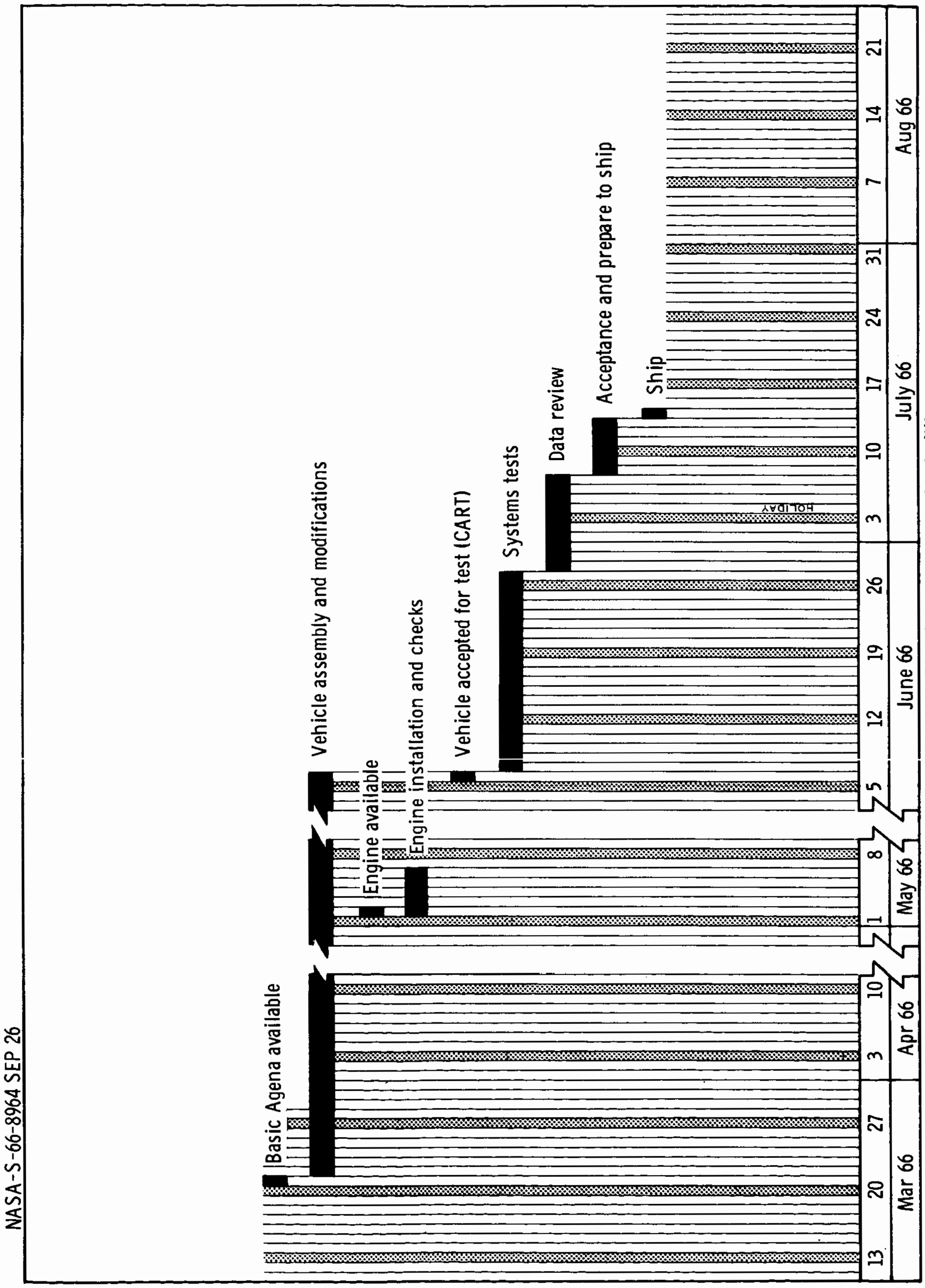

Figure 12.1-7. - GATV-5006 history at contractor facility.

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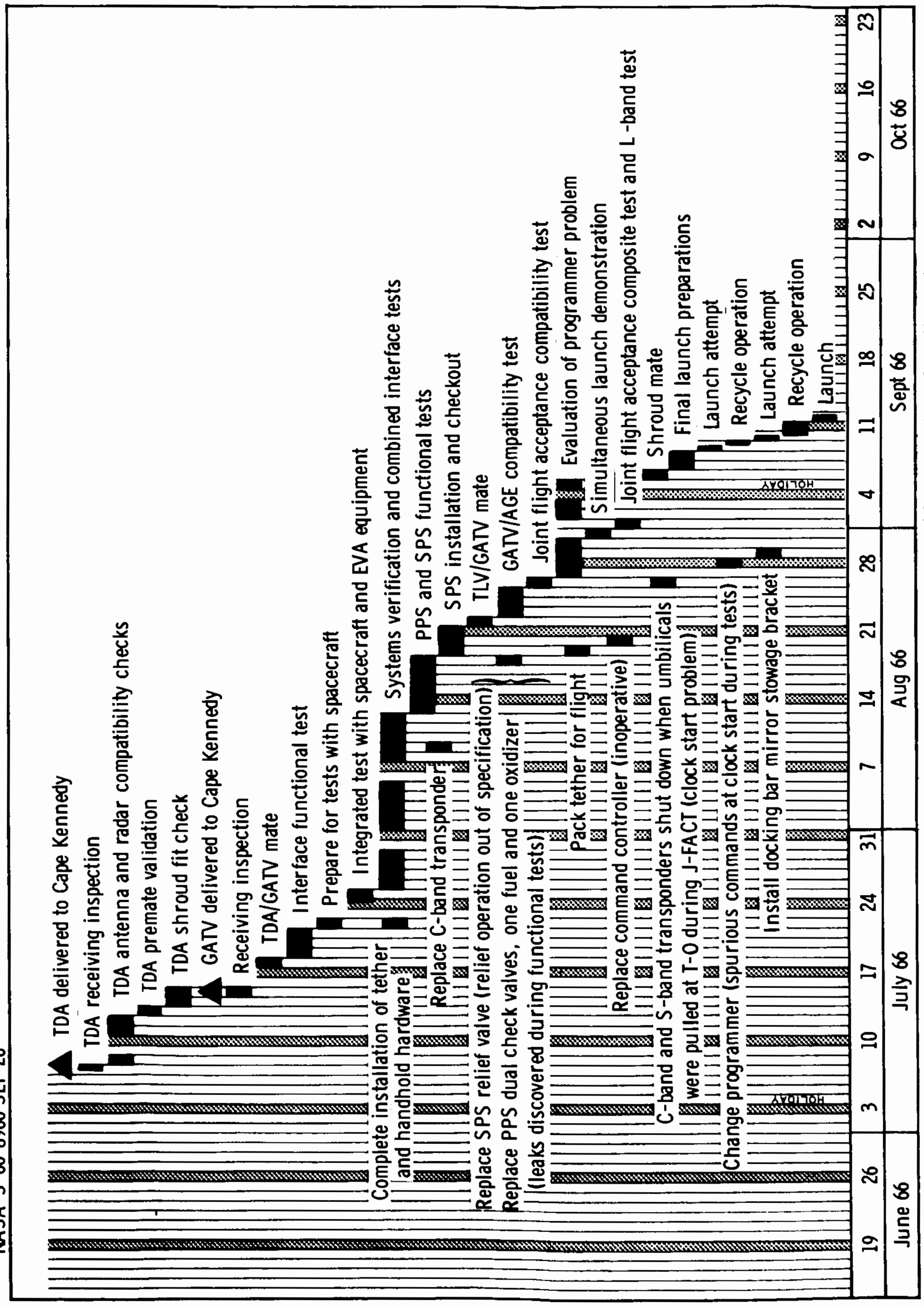

Figure 12.1-8. - GATV-5006 and TDA-6 test history and significant events at Cape Kennedy.

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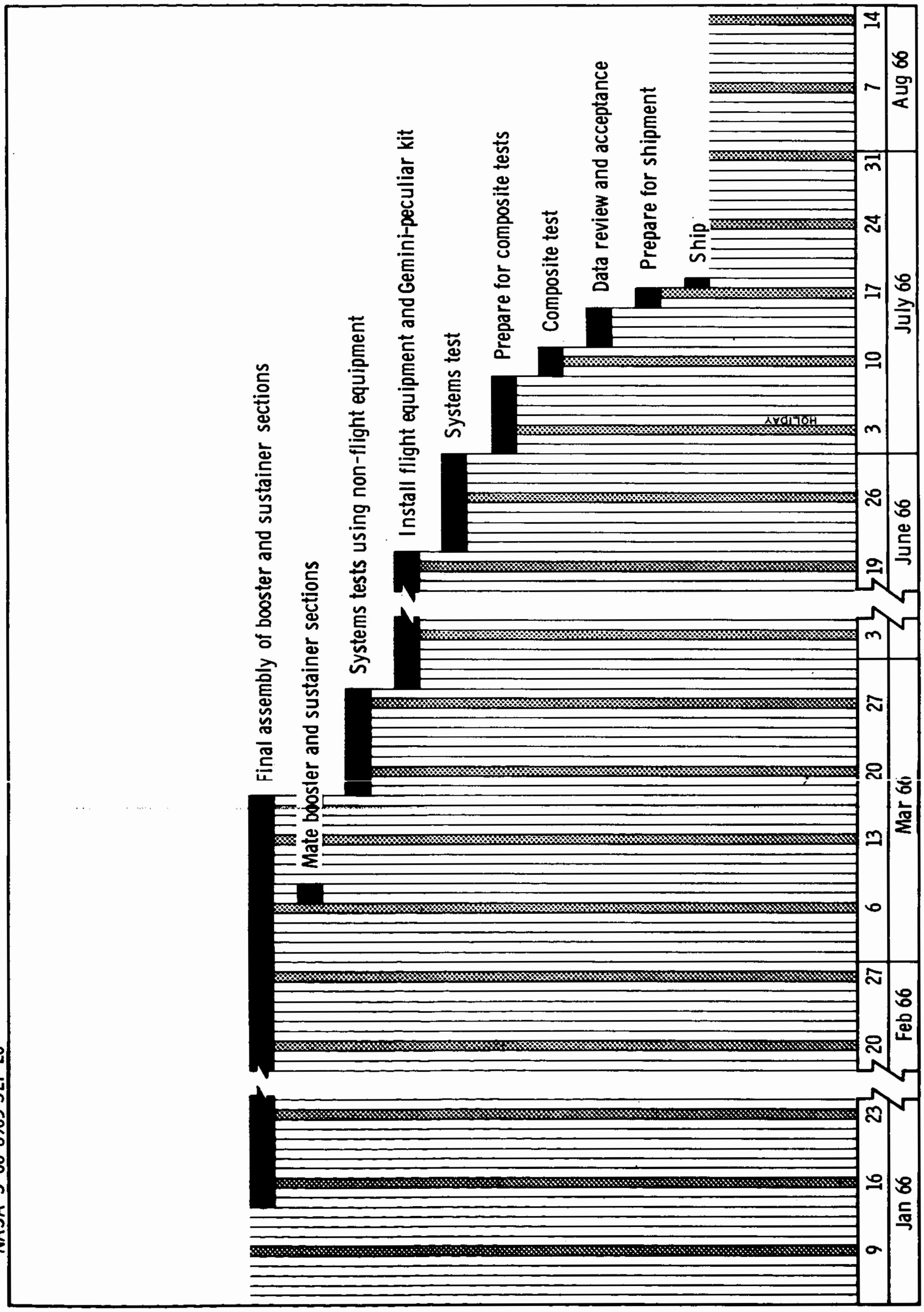

Figure 12.1-9. - TLV-5306 history at contractor facility.

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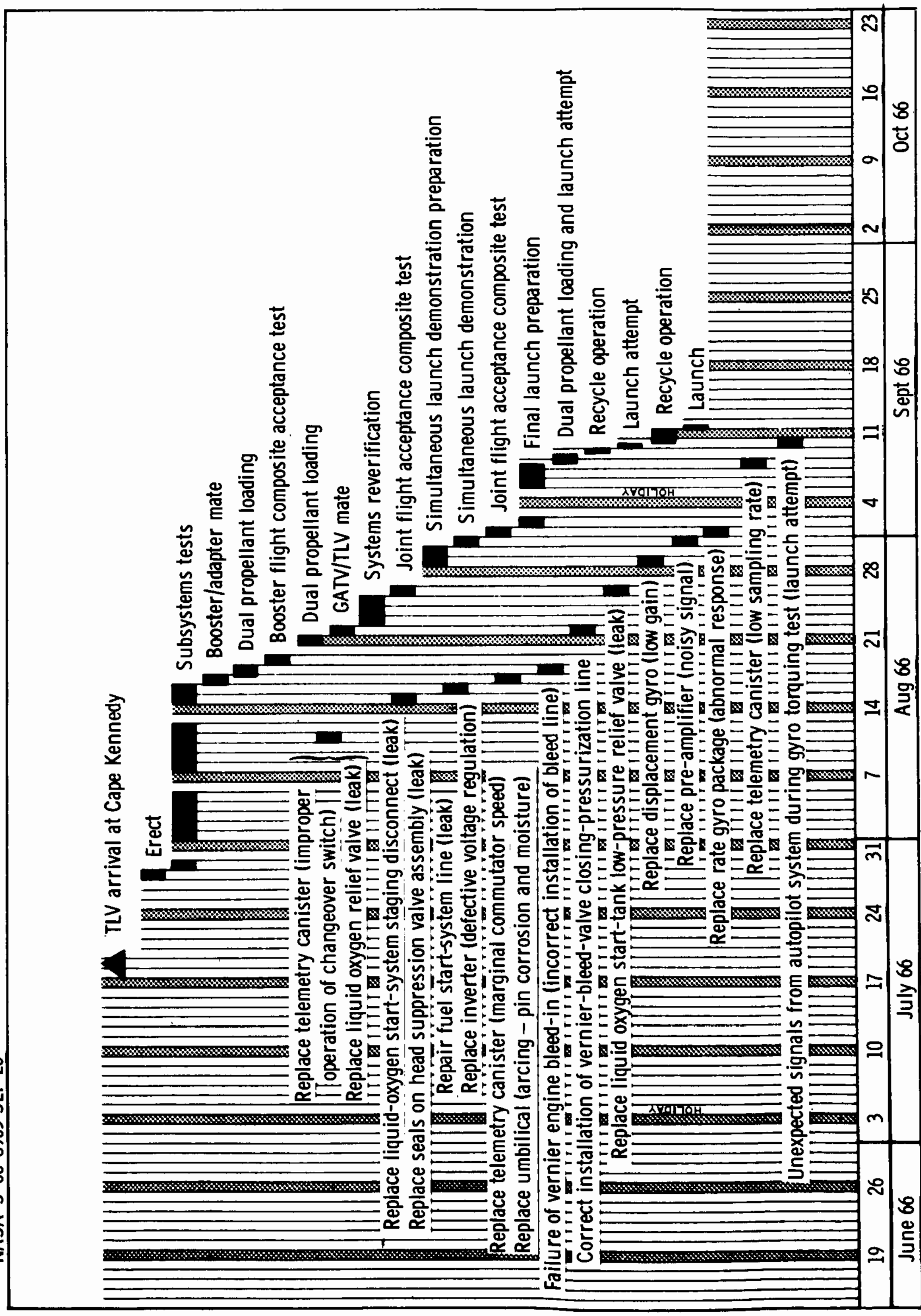

Figure 12.1-10. - TLV-5306 history and significant events at Cape Kennedy.

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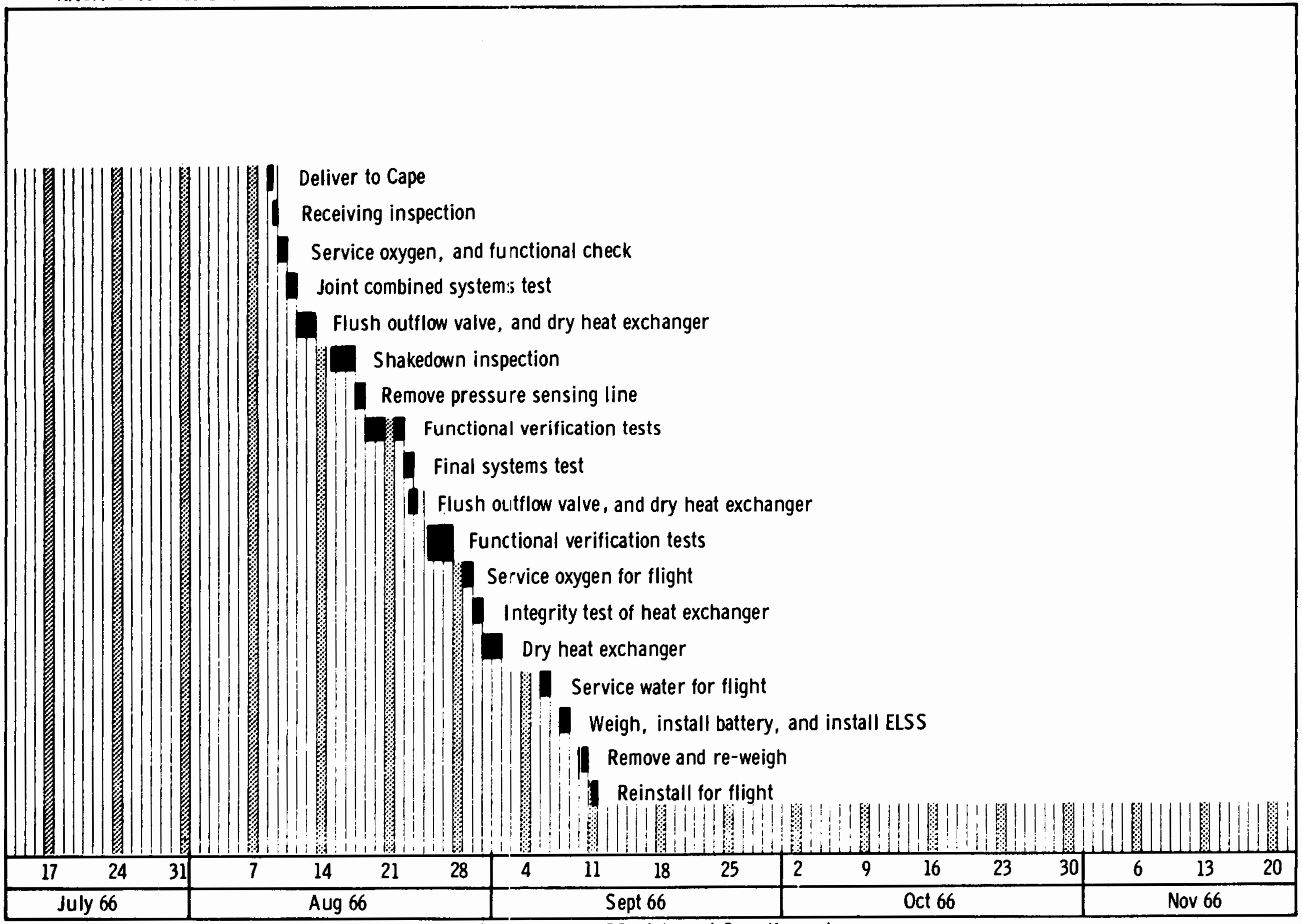

Figure 12.1-11. - ELSS history at Cape Kennedy.

12.2 WEATHER CONDITIONS

The weather conditions at Cape Kennedy were satisfactory for all operations on the day of the launch, September 12, 1966. Surface weather conditions at 9:46 a.m. e.s.t. were as follows:

Cloud coverage	900 feet, scattered 1600 feet, scattered 1300 feet, broken high broken
Wind direction, deg from North	200
Wind velocity, knots	3
Visibility, miles	10
Pressure, in. Hg	30.00
Temperature, °F	82
Dew point, °F	73
Relative humidity, percent	75

The prime recovery ship for the Gemini XI mission, U.S.S. Guam, was stationed at 24 degrees 17.4 minutes north, 70 degrees 1.4 minutes west on September 15, 1966. Weather conditions observed in the area at 14:00 G.m.t. were as follows:

Cloud coverage	4/10 cumulus, 2500 feet high scattered
Wind direction, deg from North	160
Wind velocity, knots	13
Visibility, miles	8
Pressure, in. Hg	30.00
Temperature, °F	86
Dew point, °F	73

Relative humidity, percent	67
Sea temperature, °F	82
Sea state	2-foot waves from 100 deg true

Atmospheric conditions for the launch of the Gemini Atlas-Agena Target Vehicle are shown in table 12.2-I. Atmospheric conditions for the launch of the Gemini Space Vehicle are shown in table 12.2-II and for the spacecraft recovery area in table 12.2-III. Figures 12.2-1 and 12.2-2 show the launch area and reentry area wind velocities and directions plotted against altitude.

TABLE 12.2-I.- LAUNCH AREA ATMOSPHERIC CONDITIONS FOR THE GEMINI ATLAS-AGENA TARGET VEHICLE AT 13:05 G.m.t., SEPTEMBER 12, 1966

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/ft^2 (a)	Density, slugs/ft^3 (a)
0×10^3	79.0	2120.3	2268.6×10^{-6}
5	62.8	1781.3	1972.9
10	48.6	1487.0	1696.4
15	35.2	1234.9	1448.8
20	18.3	1019.6	1240.6
25	1.2	835.8	1056.1
30	-17.7	679.8	896.0
35	-40.7	547.4	761.4
40	-63.6	435.5	640.5
45	-82.8	341.9	528.7
50	-90.8	266.1	420.3
55	-90.2	206.6	325.8
60	-81.8	161.0	248.4
65	-72.8	126.4	190.3
70	-68.3	99.4	148.1
75	-60.5	78.5	114.7
80	-60.3	62.2	90.8
85	-53.5	49.5	71.02
90	-51.0	39.5	56.1
95	-46.3	31.5	44.2
100	-37.3	25.3	34.7
105	-36.6	20.3	27.8
110	-34.2	16.3	22.1

[a]The accuracy of the readings is shown in the following table:

Altitude, ft	Temperature error, °F	Pressure rms error, percent	Density rms error, percent
0 to 60×10^3	1	1	0.5
60 to 110×10^3	1	1	.8

TABLE 12.2-II.- LAUNCH AREA ATMOSPHERIC CONDITIONS

FOR GEMINI SPACE VEHICLE

AT 14:42 G.m.t., SEPTEMBER 12, 1966

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/ft^2 (a)	Density, $slugs/ft^3$ (a)
0×10^3	79.0	2120.3	2268.6×10^{-6}
5	62.8	1781.3	1972.9
10	48.6	1487.0	1696.4
15	35.2	1234.9	1448.8
20	18.3	1019.6	1240.6
25	1.2	835.8	1056.1
30	-17.7	679.8	896.0
35	-40.7	547.4	761.4
40	-63.6	435.5	640.5
45	-82.8	341.9	528.7
50	-90.8	266.1	420.3
55	-90.2	206.6	325.8
60	-81.8	161.0	248.4
65	-72.8	126.4	190.3
70	-68.3	99.4	148.1
75	-60.5	78.5	114.7
80	-60.3	62.2	90.8
85	-53.5	49.5	71.0
90	-51.0	39.5	56.1
95	-46.3	31.5	44.2
100	-37.3	25.3	34.7
105	-36.6	20.3	27.8
110	-34.2	16.3	22.1
115	-14.3	13.3	17.4
120	-11.9	10.8	14.1
125	-7.4	8.8	11.3
130	-3.5	7.2	9.2
135	5.5	5.9	7.4
140	18.5	4.8	5.9
145	25.7	4.0	4.8

[a]The accuracy of the readings is indicated at the end of the table.

TABLE 12.2-II.- LAUNCH AREA ATMOSPHERIC CONDITIONS

FOR GEMINI SPACE VEHICLE

AT 14:42 G.m.t., SEPTEMBER 12, 1966 - Concluded

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/ft^2 (a)	Density, $slugs/ft^3$ (a)
150	30.4	3.3	3.9
155	30.7	2.7	3.2
160	27.3	2.3	2.7
165	25.9	1.9	2.3
170	26.6	1.6	1.9
175	27.0	1.3	1.5
180	27.7	1.1	1.3
185	28.8	0.9	1.1
190	24.9	.7	0.9
195	20.0	.6	.7

[a]The accuracy of the readings is shown in the following table:

Altitude, ft	Temperature error, °F	Pressure rms error, percent	Density rms error, percent
0 to 60 × 10^3	1	1	0.5
60 to 120 × 10^3	1	1	.8
120 to 165 × 10^3	4	1.5	1.0
165 to 195 × 10^3	6	1.5	1.5

TABLE 12.2-III.- REENTRY AREA ATMOSPHERIC CONDITIONS

AT 13:59 G.m.t., SEPTEMBER 15, 1966

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/ft^2 (a)	Density, slugs/ft^3 (a)
0×10^3	75.2	2109.0	2270.2×10^{-6}
5	60.8	1771.1	1967.1
10	44.6	1477.4	1700.3
15	32.0	1224.7	1452.9
20	15.8	1010.0	1237.5
25	0.4	827.3	1049.7
30	-20.2	672.1	894.5
35	-40.0	540.5	751.5
40	-63.4	430.0	632.9
45	-77.8	337.9	517.5
50	-88.6	263.8	415.8
55	-88.6	205.3	323.1
60	-81.4	160.0	246.4
65	-74.2	125.3	189.6
70	-68.8	98.6	147.3
75	-65.2	77.9	115.1
80	-58.0	61.6	89.5
85	-50.4	49.1	69.9
90	-50.4	39.1	55.7
95	-45.3	34.1	43.9
100	-34.6	25.1	34.3
105	-31.5	20.1	27.4
110	-33	16.3	22.1
115	-34.4	13.2	17.9
120	-26.8	10.4	14.2
125	-23	8.6	11.5
130	-8.4	6.9	8.9
135	-2.5	5.6	7.2
140	11.7	4.6	5.8
145	11.9	3.8	4.7

[a]The accuracy of the readings is indicated at the end of the table.

TABLE 12.2-III.- REENTRY AREA ATMOSPHERIC CONDITIONS

AT 13:59 G.m.t., SEPTEMBER 15, 1966 - Concluded

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/ft^2 (a)	Density, slugs/ft^3 (a)
150	11.9	3.1	3.9
155	15.4	2.5	3.1
160	23.5	2.1	2.5
165	26	1.7	2.1
170	25.6	1.5	1.8
175	25.6	1.3	1.4
180	29.7	1.0	1.2
185	22.3	0.8	1.2
190	14.7	.6	0.8

[a]The accuracy of the readings is shown in the following table:

Altitude, ft	Temperature error, °F	Pressure rms error, percent	Density rms error, percent
0 to 60 × 10^3	1	1	0.5
60 to 120 × 10^3	1	1	.8
120 to 165 × 10^3	4	1.5	1.0
165 to 190 × 10^3	6	1.5	1.5

NASA-S-66-8998 OCT 4

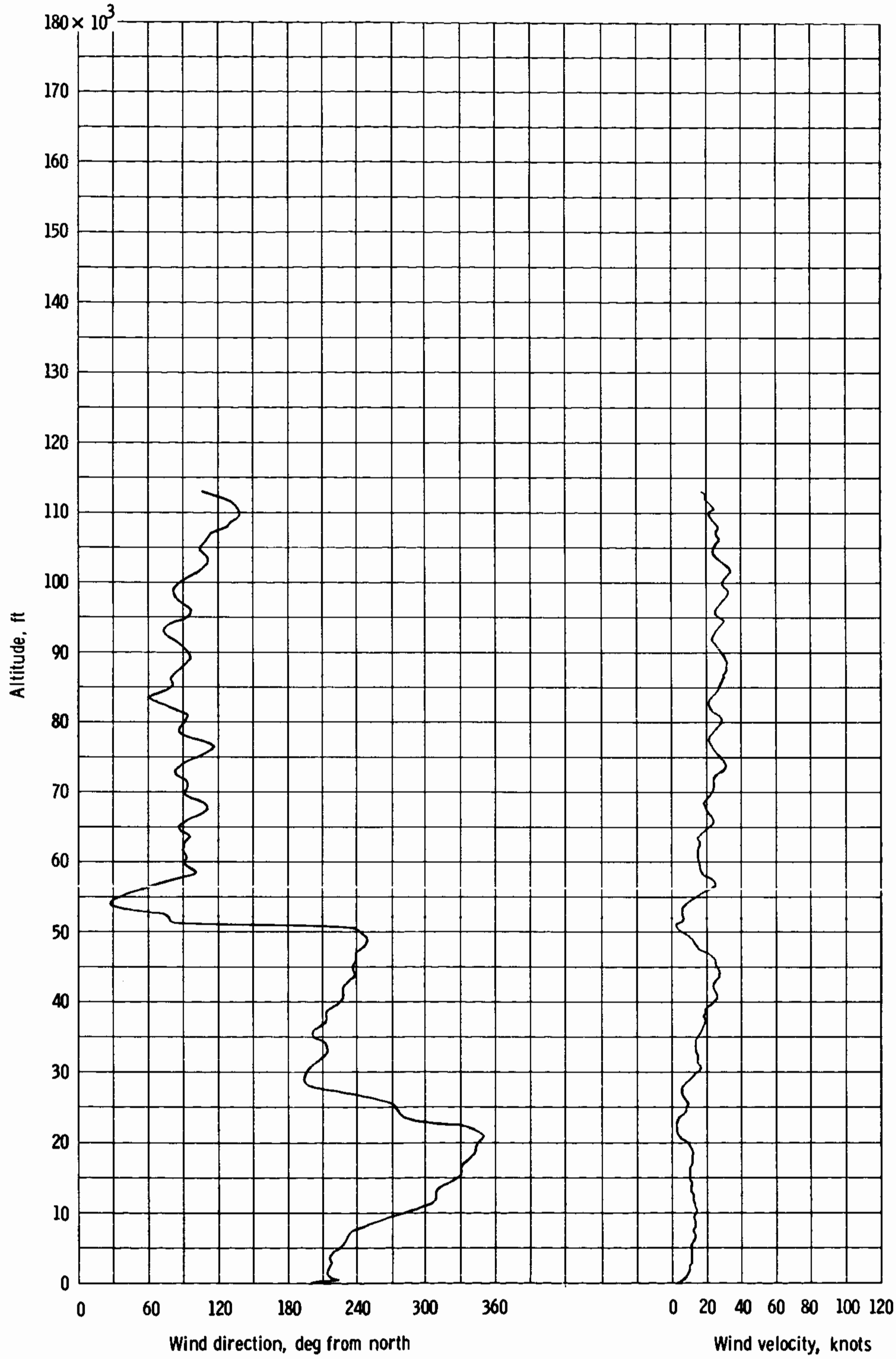

Figure 12.2-1. - Variation of wind direction and velocity with altitude for the GAATV at 13:05 G.m.t., September 12, 1966.

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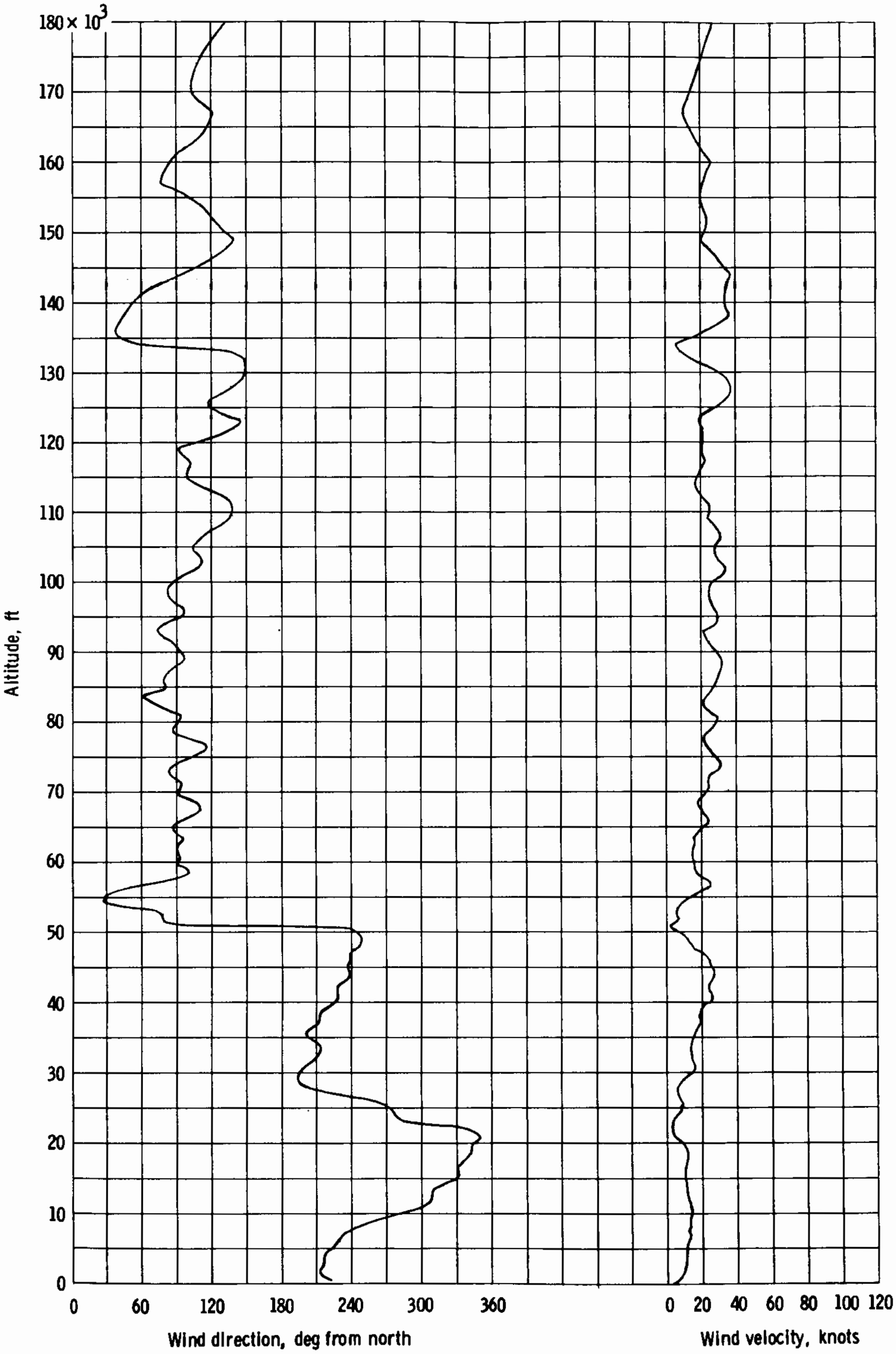

Figure 12.2-2. - Variation of wind direction and velocity with altitude for the Gemini Space Vehicle at 14:42 G.m.t., September 12, 1966.

NASA-S-66-8997 OCT 4

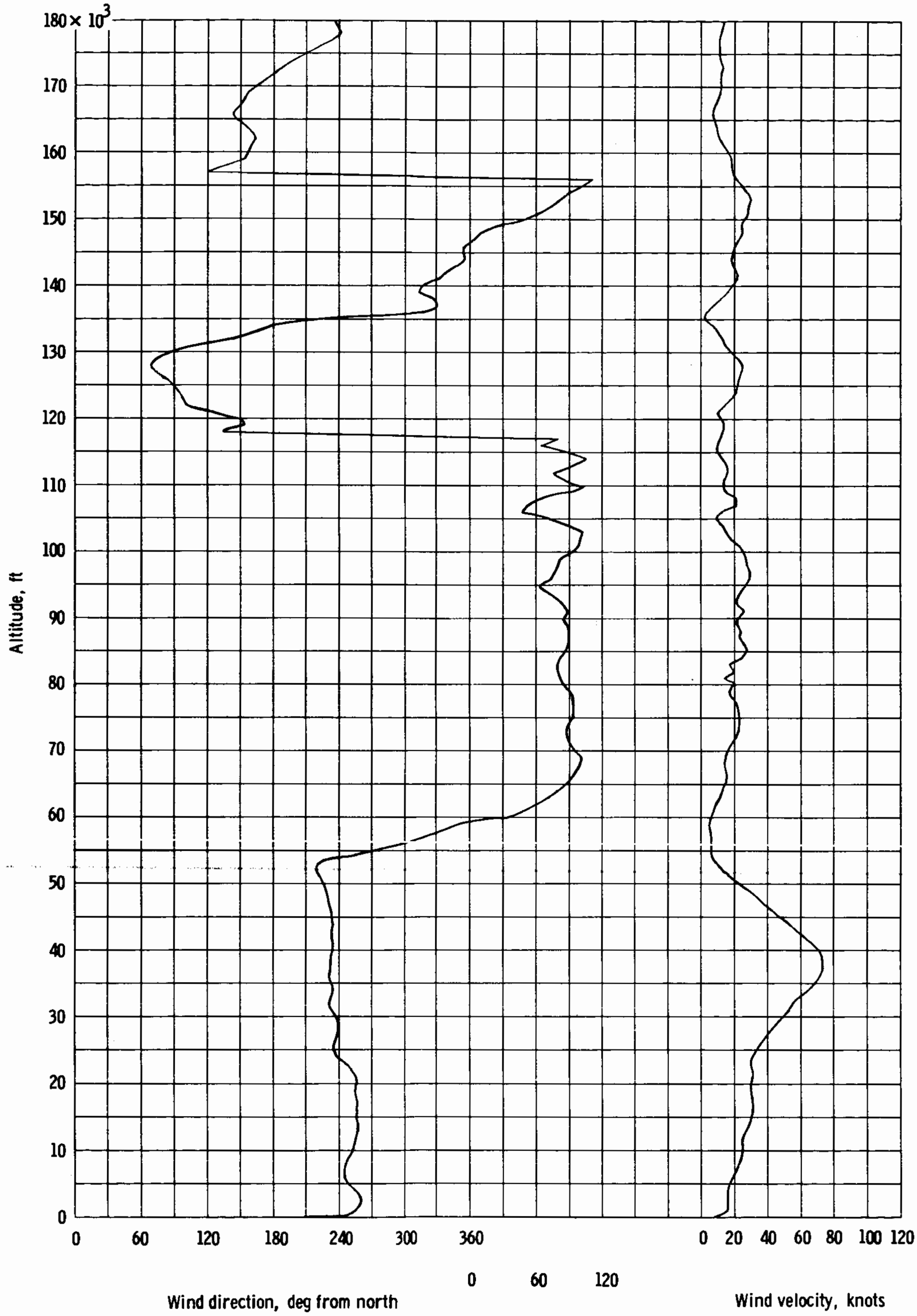

Figure 12.2-3. - Variation of wind direction and velocity with altitude for the Gemini XI reentry area at 13:59 G.m.t., September 15, 1966.

12.3 FLIGHT SAFETY REVIEWS

The flight readiness of the spacecraft, the Gemini Agena Target Vehicle, both launch vehicles, and all support elements for the Gemini XI mission were determined at the following review meetings.

12.3.1 Spacecraft Readiness Review

The Spacecraft 11 Flight Readiness Review was held on August 26 and 27, 1966, at the Kennedy Space Center. The following action items were to be completed prior to launch:

(a) A firm stowage-item jettison list was to be established.

(b) The contractor was to perform a failure analysis on the umbilical quick disconnects which had exhibited momentary hangup.

(c) The Gemini Program Office was to investigate the use of thin-base photographic film.

(d) The contractor was to paint the leading edge of the TDA with a flat black paint.

(e) The contractor was to make a final leakage check of the water management system after servicing.

(f) The contractor was to verify docking-bar jettison dynamics of the flight configuration with the tether loop in place, the clamp on the docking bar, and the tether free of the clamp.

(g) The flight crew was to evaluate the modified lap belt buckle, and, if it was of the desired configuration, the contractor was to incorporate the change in the spacecraft.

All action items were satisfactorily resolved prior to the final preparations for the launch.

12.3.2 Gemini Launch Vehicle Technical and Preflight Reviews

On August 23, 1966, a Technical Review of the Gemini Launch Vehicle (GLV) was held at the Manned Spacecraft Center. On September 6, 1966, a Preflight Readiness Review was held at Cape Kennedy. All items affecting GLV-11 were discussed and resolved.

12.3.3 Gemini Atlas-Agena Target Vehicle Technical and Preflight Reviews

On August 24, 1966, a Technical Review of Target Launch Vehicle 5306 and Gemini Agena Target Vehicle 5006 was held at the Manned Spacecraft Center. On September 6, 1966, a Preflight Readiness Review was held at Cape Kennedy. All factory and launch-site problems were discussed and resolved.

12.3.4 Mission Briefing

The Mission Director conducted the Gemini XI Mission Briefing on September 7, 1966, at the Kennedy Space Center. The status of each element of the mission was reviewed and all elements were declared ready to support the mission.

12.3.5 Launch Vehicles Flight Safety Review Board

The AFSSD Flight Safety Review Board met on September 8, 1966, at Cape Kennedy. All flight systems and ground support systems for the GLV and the Gemini Atlas-Agena Target Vehicle were reviewed and found satisfactory. A recommendation was made to the Mission Director that both launch vehicles and the target vehicle be committed to flight for the Gemini XI mission scheduled to start September 9, 1966.

Subsequent action was required by the AFSSD Flight Safety Review Board because of two launch delays.

(a) During the prelaunch preparations September 8, 1966, a pin hole leak was discovered in the GLV Stage I oxidizer tank. This leak was subsequently repaired. The Status Review Team met September 9, 1966, and reviewed the corrective action. A recommendation was made to the AFSSD Flight Safety Review Board that the GLV be committed to flight. The mission was rescheduled to start September 10, 1966.

(b) During the countdown on September 10, 1966, unexpected signals were received from the TLV autopilot when the final autopilot test was being conducted. The Status Review Team met September 11, 1966, and reviewed the applicable data. These data, when compared with data from previous Gemini missions and other Atlas launches from Complex 14, revealed that signals of this nature could be expected when this test is being conducted during liquid-oxygen tanking. A recommendation was made to the AFSSD Flight Safety Review Board that the TLV be committed to flight. The recommendation was accepted, and the mission was rescheduled to start September 12, 1966.

12.4 SUPPLEMENTAL REPORTS

Supplemental reports for the Gemini XI mission are listed in table 12.4-I. The format of these reports will conform to the external distribution format of NASA or to that of the external organization preparing the report. Each report will be identified on the cover page as a Gemini XI supplemental report. Distribution of the supplemental reports will be the same as that of this Gemini Program Mission Report.

TABLE 12.4-I.- GEMINI XI SUPPLEMENTAL REPORTS

Number	Report title	Responsible organization	Completion due date
1	Launch Vehicle Flight Evaluation Report - NASA Mission Gemini/Titan GT-11	Aerospace Corp.	November 14, 1966
2	Launch Vehicle No. 11 Flight Evaluation	Martin Co.	October 30, 1966
3	Manned Space Flight Network Performance Analysis for Gemini XI Mission	Goddard Space Flight Center	November 14, 1966
4	Gemini XI IGS Evaluation Trajectory Reconstruction	TRW Systems	October 30, 1966
5	Gemini XI Postflight Analysis Report	International Business Machines Corp.	October 30, 1966
6	Gemini Agena Target Vehicle 5006 Systems Test Evaluation	Lockheed Missiles and Space Co.	October 30, 1966
7	Foreign Deposits on the Gemini XI Optical Windows	McDonnell Aircraft Corp.	October 24, 1966

12.5 DATA AVAILABILITY

Tables 12.5-I through 12.5-IV list the Gemini XI mission data available at the NASA Manned Spacecraft Center. The trajectory and telemetry data will be on file in the Central Metric Data File of the Computation and Analysis Division. The photographic data will be on file at the Photographic Technology Laboratory.

TABLE 12.5-I.- INSTRUMENTATION

Data description	
Paper recordings	Trajectory data processed at MSC and GSFC
Spacecraft telemetry measurements of selected parameters (revolutions 1, 2, 3, 4, 5, 6, 11, 12, 13, 14, 15, 16, 17, 18, 19, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 40, 41, 42, 43, and reentry)	Voice transcripts
GLV telemetry measurements (launch)	Air-to-ground
Telemetry signal-strength recordings	Onboard recorder (Confidential)
MCC-H plotboards (Confidential)	Technical debriefing (Confidential)
Range safety plotboards (Confidential)	GLV reduced telemetry data (Confidential)
Radar data	Engineering units versus time plots
IP 3600 trajectory data (Confidential)	Spacecraft reduced telemetry data
MISTRAM (Confidential)	Engineering units versus time
Natural coordinate system	Ascent phase
Final reduced	Time history tabulations for all parameters
C-band (launch phase) (Confidential)	Orbital phase
Natural coordinate system	Time history tabulations of selected parameters for selected times for revolutions 1, 2, 3, 4, 5, 15, 16, 17, 18, 19, 26, 28, 29, 31, 34, 35, 36, 40, 41, and 42
Final reduced	

TABLE 12.5-I.- INSTRUMENTATION - Concluded

Data description	
Bandpass tabulations of selected parameters for revolutions 1, 2, 3, 4, 5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 25, 26, 28, 29, 30, 31, 32, 33, 34, 38, 40, 41, 42, and 43 Reentry phase Plots and tabulations of all systems parameters Event tabulations Sequence-of-event tabulations versus time (including thruster firings) for ascent, reentry, and revolutions 1, 2, 3, 4, 5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 25, 26, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 40, 41, 42, and 43 and for selected real-time passes for revolutions 17, 18, and 34 Special computations Ascent phase IGS computer-word flow-tag corrections (Confidential) Special aerodynamic and guidance parameter calculations (Confidential) Steering deviation calculation (Confidential)	MISTRAM versus IGS velocity comparison (Confidential) MOD III RGS versus IGS velocity comparison (Confidential) Orbital phase OAMS propellant-remaining, thruster-activity, and thrust-duration computations for revolutions 1, 2, 3, 4, 5, 11, 12, 13, 14, 15, 16, 17, 18, 19, 25, 26, 28, 29, 30, 31, 32, 33, 34, 35, 36, 40, 41, 42, and 43 Reentry phase RCS propellant-remaining and thruster-activity computations Lift-to-drag ratio and auxiliary computations

TABLE 12.5-II.- SUMMARY OF PHOTOGRAPHIC DATA AVAILABILITY

Category	Number of still photographs	Motion picture film, feet
Launch		
TLV/GATV	(a)	[b]2124
GLV/spacecraft	(a)	[b]4130
Recovery		
Spacecraft in water	50	325
Loading of spacecraft on carrier	20	950
Inspection of spacecraft	30	430
Mayport, Florida		
General activities	20	200
Inspection of spacecraft	20	--
Postflight inspection	44	--
Inflight photography		
Rendezvous and docking	8	300
Tether exercise	29	100
Weather and terrain	181	160
Extravehicular activity	6	100
Miscellaneous	4	55
Experiment S011, Airglow Photography	39	--
Experiment S030, Dim Sky Photography/Orthicon	--	125
Experiment S013, UV Astronomical Camera	36	--

[a]Still launch-photography is not normally used for evaluation purposes.

[b]Engineering sequential film only.

TABLE 12.5-II.- SUMMARY OF PHOTOGRAPHIC DATA AVAILABILITY - Concluded

Category	Number of still photographs	Motion picture film, feet
Experiment D015, Night Image Intensification	--	125
Experiment S026, Ion Wake Measurement	--	110

TABLE 12.5-III.- LAUNCH PHASE ENGINEERING SEQUENTIAL CAMERA DATA AVAILABILITY

(a) Spacecraft and GLV

Sequential film coverage, item	Size, mm	Location	Presentation	Total length of film, ft
1.2-9	16	50-foot tower, 19-1	GLV launch	180
1.2-10	16	50-foot tower, 19-5	GLV launch	175
1.2-12	16	50-foot tower, 19-2	Spacecraft launch	56
1.2-14	16	Umbilical tower, second level	GLV Stage II umbilical	130
1.2-15	16	50-foot tower, 19-7A	GLV, engine observation	150
1.2-16	16	East launcher	GLV, possible fuel leakage	125
1.2-17	16	West launcher	GLV, possible fuel leakage	130
1.2-18	16	North launcher	GLV, engine observation	120
1.2-19	16	South launcher	GLV, engine observation	115
1.2-20	16	Umbilical tower, first level	GLV, umbilical disconnect	105
1.2-21	16	Umbilical tower, second level	GLV, umbilical disconnect	115
1.2-22	16	Umbilical tower, fourth level	GLV, umbilical disconnect	125
1.2-23	16	Umbilical tower, fifth level	GLV, umbilical disconnect	130
1.2-24	16	Umbilical tower, sixth level	GLV, umbilical disconnect	135
1.2-25	16	Umbilical tower, sixth level	GLV, umbilical disconnect	101
1.2-26	16	Umbilical tower, top level, no. 1	GLV, upper umbilical disconnect	135
1.2-27	16	Umbilical tower, top level, no. 2	J-bars and lanyard observation	135
1.2-33	16	South southwest of Pad 19	Tracking	355
1.2-34	16	South of Pad 19	Tracking	228

TABLE 12.5-III.- LAUNCH PHASE ENGINEERING SEQUENTIAL CAMERA DATA AVAILABILITY - Continued

(a) Spacecraft and GLV

Sequential film coverage, item	Size, mm	Location	Presentation	Total length of film, ft
1.2-36	35	South of Pad 19	Tracking	179
1.2-37	35	South of Pad 19	Tracking	178
1.2-40	70	Cocoa Beach	Tracking, ROTI	48
1.2-41	70	Melbourne Beach	Tracking, ROTI	28
1.2-42	35	Patrick AFB, Florida	Tracking, IGOR	122
1.2-44	16	Sixth level umbilical tower	Cable-cutter action	166
1.2-45	16	Umbilical tower, 93-foot level	Boom deflection during launch	214

TABLE 12.5-III.- LAUNCH PHASE ENGINEERING SEQUENTIAL CAMERA DATA AVAILABILITY - Concluded

(b) TLV and GATV

Sequential film coverage, item	Size, mm	Location	Presentation	Total length of film, ft
1.2-4	16	East of Pad 14	TLV engine observation	91
1.2-5	16	West of Pad 14	TLV engine observation	140
1.2-6	16	Northwest of Pad 14	TLV engine observation	140
1.2-7	16	Ramp, south of Pad 14	TLV engine observation	76
1.2-8	16	West of Pad 14	TLV launch	65
1.2-9	16	Northwest of Pad 14	TLV launch	51
1.2-10	16	Northwest of Pad 14	TLV vernier-engine heat shield	76
1.2-11	16	Southeast of Pad 14	TLV vernier-engine heat shield	130
1.2-12	16	Umbilical tower, 72-foot level	Upper umbilical disconnect	100
1.2-13	16	Umbilical tower, 72-foot level	Lower umbilical disconnect	90
1.2-14	16	West of Pad 14	Umbilical disconnect	90
1.2-15	70	Southwest of Pad 14	Explosive-bolt action	47
1.2-16	16	Northwest of Pad 14	Tracking	200
1.2-17	16	South-southwest of Pad 14	Tracking	90
1.2-18	35	West of Pad 14	Tracking	172
1.2-19	35	Patrick Air Force Base	Tracking, IGOR	95

TABLE 12.5-IV.- SUMMARY OF DATA AVAILABILITY ON GEMINI XI GATV

GATV event	Revo-lution	Nearest station	Reduced data (engineering units) and paper recordings[a]							
			Bandpass (b)	Bileyels	Time history plot groups (b)	Time history tab groups (b)	Turbine speed and velocity meter	Programmer memory	Control gas impulse	Paper recordings
Launch		MCC-K	X	X	1-9			X		X
		ANT	X	X	1-9		X	X	X	X
L-band transponder study	1	HAW	X	X						
	1	GYM	X	X						
	1/2	MCC-K	X	X						
	2	CRO	X	X		29				
	2	HAW	X	X	8	29, 31				
	2	GYM	X	X		29				
First docking	2	TEX	X	X	1, 8	29				
Docked GATV command study	2/3	MCC-K	X	X						
S026 experi-ment	3	TAN			8	31				
	3	CRO	X	X	8	31				
	3	CRO/HAW			8	29, 31				
GATV clock study	3	HAW	X	X						
	3	Post-HAW	X	X	8	16, 17, 19, 26-31		X		X
	3	TEX		X						
	3/4	MCC-K	X	X						

[a, b]See notes at end of this table.

TABLE 12.5-IV.- SUMMARY OF DATA AVAILABILITY ON GEMINI XI GATV - Continued

GATV event	Revolution	Nearest station	Reduced data (engineering units) and paper recordings[a]							
			Bandpass (b)	Bilevels	Time history plot groups (b)	Time history tab groups (b)	Turbine speed and velocity meter	Programmer memory	Control gas impulse	Paper recordings
S026 experiment	3/4	ANT			8	31				
Dock light study	4	RKV	X	X	8	29				
S026 experiment	4	TAN			8	31				
S026 experiment; Dock light study	4	TAN/CSQ	X	X	18	29, 31				
GATV docking command study	4	CSQ	X	X						
Primary propulsion system firing no. 1	4	HAW	X	X	8		X	X	X	X
Propellant venting study	4	GYM	5, 8, 10, 20	X						
	4	TEX	5, 8, 10, 20	X						
	5	RKV	5, 8, 10, 20	X						

[a, b]See notes at end of this table.

TABLE 12.5-IV.- SUMMARY OF DATA AVAILABILITY ON GEMINI XI GATV - Continued

GATV event	Revolution	Nearest station	Reduced data (engineering units) and paper recordings[a]							
			Bandpass (b)	Bilevels	Time history plot groups (b)	Time history tab groups (b)	Turbine speed and velocity meter	Programmer memory	Control gas impulse	Paper recordings
Fourth docking	6	RKV/TAN	X	X	1					
Yaw maneuvering	26	CYI	X	X	8					
Primary propulsion system firing no. 2	27	CYI	X	X	8	31	X	X	X	
S026 experiment	27	CRO			8	31				
High apogee	28	CRO	X	X	8					
Primary propulsion system firing no. 3	28/29	ANT	X	X	1, 2, 4-9	31	X	X	X	X
Propellant venting study	29	CYI	5, 8, 10, 20	X						
	29	TAN	5, 8, 10, 20	X						
	29	CRO	5, 8, 10, 20	X						
L-band antenna switching test, beginning of tether test	32	HAW	X	X	8					

[a, b]Notes for this table are on the following page.

TABLE 12.5-IV.- SUMMARY OF DATA AVAILABILITY ON GEMINI XI GATV - Continued

GATV event	Revolution	Nearest station	Reduced data (engineering units) and paper recordings[a]							
			Bandpass (b)	Bilevels	Time history plot groups (b)	Time history tab groups (b)	Turbine speed and velocity meter	Programmer memory	Control gas impulse	Paper recordings
Tether test	33	HAW	X	X	8					
Tether jettison	34	HAW	X	X	8					
Horizon sensor study	42	TEX	X	X	8					
Secondary propulsion system firing no. 1	48	HAW	X	X	1, 2, 6-9		X	X	X	X
Secondary propulsion system firing no. 2	49	RKV	X	X	1, 2, 6-9		X	X	X	X
90-degree yaw maneuver	49	HAW	X	X	8					X
Horizon sensor study	55/56	ANT	X	X	8			X		
Secondary propulsion system firing no. 3	58/59	MCC-K	X	X	1, 2, 6-9		X	X	X	
GATV clock study	77 88	TEX TEX	X X	X X				X X		

a, bNotes for this table are on the following page.

TABLE 12.5-IV.- SUMMARY OF DATA AVAILABILITY ON GEMINI XI GATV - Concluded

[a] In addition to the data listed in this table the following data are available: TLV telemetry measurements (launch), MCC-H and Range Safety plotboards (launch), C-band overlapping trajectory (Confidential) (launch) - final reduced coordinate system 2 and 3, Rawindsonde weather data (launch), Sunrise-sunset computations (orbital).

[b] Time history plot and time history and bandpass tabulation group numbers listed in table 12.5-IV are related to GATV systems as shown in the following table. (All bandpass tab groups run unless otherwise indicated.)

Systems	Time history plot groups	Time history and bandpass tab groups
Structural	1, 2	1, 1A, 2, 3, 4A
Primary propulsion	3, 4, 5	5, 6, 7, 7A, 8, 9, 10
Secondary propulsion	6	11, 12, 13, 14, 15
Electrical	7	16, 17, 18, 19
Guidance and control	8	20, 21, 22, 23, 24
Command and communications	9	25, 26, 27, 28, 29, 30
Experimental parameters	10	31

12.6 POSTFLIGHT INSPECTION

The postflight inspection of the Spacecraft 11 reentry assembly was conducted in accordance with reference 24 and Spacecraft Test Requests (STR's) at the contractor's facility in St. Louis, Missouri, from September 17, 1966, to September 30, 1966. The rendezvous and recovery (R & R) section was not recovered. The main parachute was recovered and sent to the Manned Spacecraft Center (MSC) for evaluation (STR 11015). While the spacecraft was still aboard the recovery ship, the crew-station items defined in STR 11000 were removed and properly disposed of, and, in addition, several items were removed from the equipment bays and treated in accordance with reference 25.

The reentry assembly was received in good condition at the contractor's facility in St. Louis. The following list itemizes the discrepancies noted during the detailed inspection of the reentry assembly:

(a) As on previous spacecraft, residue was found on the surfaces of both hatch windows.

(b) An area of intensive heating was noted in the upper left-hand quadrant of the heat shield.

(c) The left-hand secondary-oxygen pressure transducer was reading full-scale pressure.

(d) One of the horizon-sensor electrical-receptacle doors was stuck in the open position.

(e) Six electrical fusistors in the pyrotechnic circuits were open circuited.

12.6.1 Spacecraft Systems

12.6.1.1 Structure.- The overall appearance of the spacecraft was good. The appearance of the heat shield was normal except for the intensive heating area noted in the upper left-hand quadrant. This portion of the heat shield was removed and sectioned (STR 11501). The heat shield stagnation point was located 1.0 inch to the right of the vertical centerline and 11.5 inches below the horizontal centerline. The heat shield was removed and dried with the reentry assembly. The dry weight of the heat shield was 311.07 pounds.

Residue similar to that found on the windows of previous spacecraft was noted, and an investigation to determine the source and method of deposit was initiated (STR 11017). Investigation of the sticking of the lower horizon-sensor electrical-receptacle door in the open position was accomplished (STR 11019). The external appearance of the shingles, doors, and adapter attach fairings appeared similar to those of previous spacecraft after reentry.

12.6.1.2 Environmental Control System.- The drinking water was removed and prepared for analysis in accordance with reference 24. The total water remaining in the system was 9193 cubic centimeters. While the spacecraft was still aboard the recovery ship, 6.5 cubic centimeters of water had been removed for analysis at MSC. The lithium-hydroxide cartridge was removed from the Environmental Control System (ECS) package and weighed. The cartridge weighed 108.87 pounds, and the center-of-gravity was determined to be 7.99 inches from the bottom.

The secondary oxygen system was deserviced in accordance with reference 24. The right-hand system was empty and the left-hand system indicator was against the stop at 6000 psia. Further investigation revealed that the left-hand system was also empty but the pressure transducer was defective. The pressure transducer was removed and sent to the contractor's failure analysis laboratory for investigation (STR 11506A).

The ECS control handles were actuated in accordance with reference 24, and the maximum force recorded was 21 pounds on the control handle for the oxygen high-rate recock.

Samples of water were taken from the condensate lines and returned to MSC for bacteria identification and count (STR 11011A). The carbon dioxide sensor and panel indicator were removed for test and analysis (STR 11502). An equipment-bay cold plate was removed to evaluate cleaning procedures (STR 11508).

12.6.1.3 Communications System.- The external appearance of all communications equipment and antennas was good. The voice tape recorder was tested in the spacecraft with external power applied. The recorder would not advance the tape in the cartridge. The recorder was removed and sent to the vendor for analysis (STR 11014A). The voice communications system was checked for extraneous audio tones reported by the crew (STR 11507).

12.6.1.4 Guidance and Control System.- While the spacecraft was still aboard the recovery ship, the Inertial Measurement Unit (IMU) and the computer were removed and packaged for delivery to the vendor representatives in Mayport, Florida (STR's 11003 and 11004). The Auxiliary Control Power Unit (ACPU), the Attitude Control and Maneuver Electronics (ACME), and the horizon sensor electronics were removed, returned to St. Louis, and then sent to the applicable vendor (STR's 11005, 11006, and 11007).

The attitude hand controller was tested in the spacecraft and then removed for further testing and analysis (STR 11009A). The command pilot's translation hand controller was removed for testing (STR 11022).

12.6.1.5 Pyrotechnic System.- Pyrotechnic resistance measurements were made of all electrically initiated pyrotechnic devices in the reentry assembly in accordance with reference 24. Tests on the firing circuit of the retrorocket-wire pyrotechnic-switch cartridge indicated a bridgewire resistance that was near the unfired value. The cartridge was removed for a visual inspection (STR 11504) which revealed that the cartridge had detonated normally. The measured resistance was due to the conductive residue remaining in the cartridge after firing. The same condition was noted on the equivalent cartridge in Spacecraft 10.

All wire-bundle guillotines, parachute bridle-release mechanisms, and other pyrotechnically operated devices appeared to have functioned normally. The electrical connectors to the mild-detonating-fuse (MDF) detonators on the left and right sides of the Z192 bulkhead had the bayonet pins sheared off and were hanging loose from the cartridges. This condition has been noted on nearly all previous spacecraft and is considered acceptable. Both of the MDF detonators appeared to have had a normal high-order detonation.

12.6.1.6 Instrumentation and Recording System.- While the spacecraft was still aboard the recovery ship, the PCM programmer and multiplexers were removed and packaged for release to the vendor's representative at Mayport, Florida (STR 11001). Instrumentation package no. 2 was also removed, but it was returned with the spacecraft to St. Louis (STR 11002). The PCM tape recorder was removed as soon as possible and returned by special courier to St. Louis for data processing (STR 11008). The dc-to-dc converters were removed and returned to St. Louis (STR 11503). The biomedical tape recorders were removed and carried by courier to MSC for data processing (STR 11000).

12.6.1.7 Electrical System.- The main and squib batteries were removed and discharged in accordance with reference 24. The following table lists the ampere-hours remaining in each battery when discharged to the level of 20 volts with the batteries still delivering the current specified in reference 24.

Main battery	Discharge, A-h	Squib battery	Discharge, A-h
1	41.25	1	8.20
2	47.50	2	9.00
3	30.40	3	4.80
4	41.25		

The main and squib batteries were recharged and placed in bonded storage for use in ground tests.

Wire bundle no. 308 was removed for evaluation of the waterproofing material (STR 11500).

No current leakage was detected on the main-bus-to-ground circuits when the main battery switches were actuated in accordance with reference 24.

The fuse blocks were checked for open fuses or fusistors in accordance with reference 24, and the following fusistors were open:

Fuse block	Pin No.	Fuse No.
XF-AG	3	5-122
XF-G	3	4-23
XF-M	5	4-53
XF-W	1	4-46
XF-AS	4	14-47
XF-AR	1	14-32

All the open fusistors were all in pyrotechnic circuits. These fusistors are placed there to free the squib batteries of a heavy drain if a pyrotechnic short circuits after firing.

12.6.1.8 Crew-station furnishings and equipment.- The appearance of the cabin interior was good. The switch positions and instrument panels were photographed in accordance with reference 24. The ejection seats were removed and deactivated in accordance with reference 24. The backboard contours, pelvic blocks, and lap belts were placed in bonded storage at the contractor's plant in St. Louis. The seat ballast was shipped to Kennedy Space Center (KSC) for reuse. The hose-nozzle interconnectors, survival packs, water-metering device, retractable pencils, 8-day clock, and Accutron clock were removed and sent to MSC (STR 11000).

12.6.1.9 Propulsion System.- The Reentry Control System (RCS) thrust chamber assemblies appeared normal. Prior to shipping the spacecraft to St. Louis, the RCS was deactivated at Mayport, Florida, in accordance with reference 23. The propellants remaining in the RCS tanks and samples of the purge gas were sent from Mayport to KSC for analysis, and the results were recorded in reference 23. The following amounts of propellants were removed from the RCS tanks at Mayport:

Propellant	A-ring, oz	B-ring, oz
Oxidizer	4	94
Fuel	3	81

The propulsion system pressure/temperature indicator and associated wiring were investigated for intermittent readings (STR 11012).

The RCS thruster 2B solenoid valves and the motor-operated shutoff valves were leak checked (STR 11013).

The RCS section was dried in the 30-foot altitude chamber in accordance with reference 24.

12.6.1.10 Postlanding recovery aids.- The flashing recovery light and the hoist-loop door appeared to have functioned normally. The sea dye marker container was removed from the spacecraft on the recovery ship and returned to St. Louis as a loose piece.

12.6.1.11 Experiments.- No effort associated with experiments was required during the postflight evaluation.

12.6.2 Continuing Evaluation

The following is a list of STR's that were approved for the postflight evaluation of reported spacecraft anomalies.

STR no.	System	Purpose
11012	Propulsion; Electrical	To determine the cause of intermittent pressure/temperature indicator readings during ground checkouts and during flight
11013	Propulsion	To establish the cause of leakage noted postflight in RCS thruster 2B
11014A	Communications	To determine why the voice tape recorder failed during flight
11016	Crew Station	To examine the flight 16-mm sequence cameras for anomalies resulting in unsatisfactory photographs taken at f/16
11017	Structure	To determine the constituents of the contamination on the spacecraft windows and to determine the source of the major concentrations
11019	Structure	To determine why one horizon-sensor door failed to close
11021	Crew Station	To determine why the left-hand side of the pilot's life vest did not inflate on actuation

STR no.	System	Purpose
11022	Guidance and Control; Propulsion	To verify proper operation of the left-hand translation hand controller and switch in response to the command pilot's report that thruster no. 15 showed less-than-expected thrust
11025	Crew Station	To determine the cause of the crack in EVA sunvisor
11501A	Structure	To evaluate the heating effect in the area of the depression found in the heat shield after the flight
11502	Instrumentation	To investigate a possible anomaly in the carbon-dioxide partial-pressure sensor
11506A	Environmental Control	To determine the reason for the inability to reduce the indicated pressure of the left-hand secondary oxygen tank
11507	Communications	To determine the cause of the extraneous audio signal heard in the crewmen's headphones
11509	Guidance and Control	To determine whether the encoder could have caused the intermittent MAP's to the spacecraft

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(Continued from inside front cover)

GEMINI FLIGHT HISTORY

Mission	Description	Launch date	Major accomplishments
Gemini VIII	Manned Three days Rendezvous and dock EVA	Mar. 16, 1966	Demonstrated rendezvous and docking with GATV. Demonstrated controlled landing and emergency recovery. Demonstrated multiple restart of GATV in orbit. Spacecraft mission terminated early because of an electrical short in the control system.
Gemini IX	Manned Three days Rendezvous and dock EVA (Canceled after failure of TLV)	May 17, 1966	Demonstrated dual countdown procedures.
Gemini IX-A	Manned Three days Rendezvous and dock EVA	June 3, 1966	Demonstrated three rendezvous techniques. Evaluated EVA with detailed work tasks. Demonstrated precision landing capability.
Gemini X	Manned Three days Rendezvous and dock EVA	July 18, 1966	Demonstrated dual rendezvous using GATV propulsion for docked maneuvers. Demonstrated removal of experiment package from passive target vehicle during EVA. Evaluated feasibility of using onboard navigational techniques for rendezvous.
Gemini XI	Manned Three days Rendezvous and dock Tether evaluation EVA	Sept. 12, 1966	Demonstrated first-orbit rendezvous and docking. Evaluated EVA. Demonstrated feasibility of tethered station keeping. Demonstrated automatic reentry capability.