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GEMINI PROGRAM MISSION REPORT

GEMINI VII

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION □ MANNED SPACECRAFT CENTER

GEMINI SPACECRAFT FLIGHT HISTORY			
Mission	Description	Launch date	Major accomplishments
GT-1	Unmanned 64 orbits	Apr. 8, 1964	Demonstrated structural integrity.
GT-2	Unmanned suborbital	Jan. 19, 1965	Demonstrated heat protection and systems performance.
GT-3	Manned 3 orbits	Mar. 23, 1965	Demonstrated manned qualifications of the Gemini spacecraft.
Gemini IV	Manned 4 days	June 3, 1965	Demonstrated EVA and systems performance for 4 days in space.
Gemini V	Manned 8 days	Aug. 21, 1965	Demonstrated long-duration flight, rendezvous radar capability, and rendezvous maneuvers.
Gemini VI	Manned 2 days rendezvous (canceled after failure of GATV)	Oct. 25, 1965	Demonstrated dual countdown procedures (GAATV and GLV-spacecraft), flight performance of TLV and flight readiness of the GATV secondary propulsion system. Mission canceled after GATV failed to achieve orbit.
Gemini VII	Manned 14 days rendezvous	Dec. 4, 1965	Demonstrated 2-week duration flight and station keeping with GLV stage II, evaluated "shirt sleeve" environment, acted as the rendezvous target for spacecraft 6, and demonstrated a controlled reentry to within 7 miles of planned landing point.

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MSC-G-R-66-1

CHANGE SHEET

FOR

GEMINI PROGRAM MISSION REPORT

GEMINI VII

CHANGE 1

PREPARED BY: Gemini VII Mission Evaluation Team

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HOUSTON, TEXAS [redacted]

[redacted]

Insert the attached replacement pages and make the following pen and ink changes in the Gemini Program Mission Report Gemini VII, MSC-G-R-66-1. Upon incorporation of the changes, insert this CHANGE sheet between the cover and the title page and write on the cover, "Change 1 inserted."

NOTE: A black bar in the margin of the Change 1 pages indicates the area of change.

changed/JWM 4/14/67

Signature of person incorporating changes — Date: April 14, 1967

[redacted]

Pen-and-ink changes:

1. Page 1-3: In the fourth line of the second paragraph, change "20" to "40".

2. Page 4-2: In the ninth line of the last paragraph, change "27:42:00" to "28:42:00".

3. Page 4-13: In table 4.2-I, delete "-2.11" from "Difference" column opposite "QAMS off" event.

4. Page 4-15: In the 14th line of the first paragraph, change "revolutions are" to "revolutions and".

5. Page 6-15: In "Station" column of table 6.2-I, change "MLA" to "MILA".

6. Page 6-26: Under "East Atlantic" in figure 6.3-1, change "Zone 1" to "Zone 2".

7. Page 7-24: Revolution 76 should end at approximately 121:26 g.e.t.

8. Page 7-35: Revolution 147 should end at approximately 235:35 g.e.t., and revolution 148 should end at approximately 237:11 g.e.t.

9. Page 7-38: Revolution 163 should end at approximately 261:18 g.e.t.

10. Page 7-52: In the first line of the second paragraph, change "On approximately the 6th day" to "Near the end of the 8th day".

11. Page 7-67: In the 11th line of paragraph 7.2.2.1.1, change "Figure 7.2.4" to "Figure 7.2-1".

12. Page 7-68: In the third line of paragraph 7.2.2.1.3, change "figure 7.2-4" to "figure 7.2-1".

13. Page 7-73: In the 26th line of paragraph 7.2.2.7, change "figure 7.2-4" to "figure 7.2-1".

14. Page 8-3: In table 8.0-I, opposite Experiment number MSC-12, change title from "Landmark Contract Measurements" to "Landmark Contrast Measurements".

15. Page 8-9: In the 15th line of the last paragraph, "abandoned" is misspelled.

16. Page 12-20: In Table 12.4-I, delete Supplemental Report Number 7, "Biomedical Analysis of the Extended Gemini Flights", to have been prepared by the MSC Center Medical Office.

The following attached pages are replacement pages:

4-3
4-4 (no change)
4-5
4-6
5-19 (no change)
5-20
5-21
5-22
7-13 (no change)
7-14
7-25
7-26
8-11
8-12 (no change)

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MSC-G-R-66-1

GEMINI PROGRAM MISSION REPORT
GEMINI VII

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MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

JANUARY 1966

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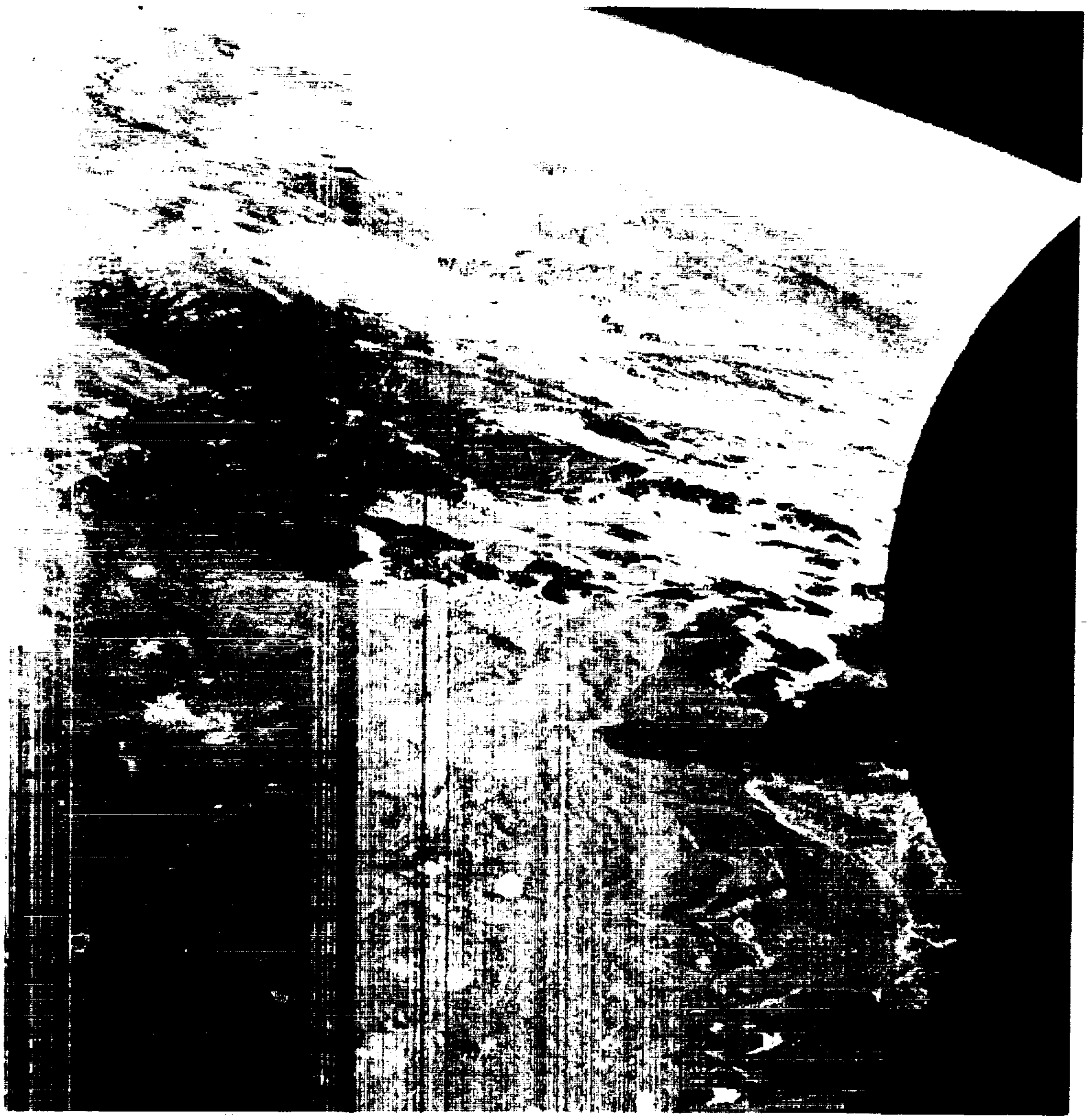

Photograph of Algeria, taken during the 49th revolution showing the area between Ahaggar Uplift and Plateau du Tademait.

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1.0 MISSION SUMMARY

The fourth manned mission of the Gemini Program, designated Gemini VII, was launched from Complex 19, Cape Kennedy, Florida, at 2:30 p.m. e.s.t., on December 4, 1965. The flight was successfully concluded on December 18, 1965, with the recovery of the spacecraft at 25° 21.9' N. latitude, 70° 8.8' W. longitude by the prime recovery ship (U.S.S. Wasp), approximately 1 hour and 5 minutes after landing. The 14-day long-duration flight was launched less than 6 weeks after the cancellation of the Gemini VI mission. The spacecraft was manned by Astronaut Frank Borman, command pilot, and Astronaut James A. Lovell, Jr., pilot. The crew completed the flight in good physical condition and demonstrated full control of the spacecraft and competent management of all aspects of the mission.

The primary objectives of the Gemini VII mission were to demonstrate manned orbital flight for approximately 14 days and to evaluate the physiological effects of long-duration flight on the crew members. The secondary objectives were to circularize the spacecraft orbit and provide a passive target for the spacecraft 6 rendezvous, conduct station keeping with the expended Gemini launch vehicle second stage, conduct 20 experiments, wear a lightweight pressure suit, demonstrate controlled reentry, and conduct systems tests. All primary and secondary objectives of the Gemini VII mission were successfully accomplished.

The Gemini launch vehicle performed satisfactorily in all respects. The countdown was nominal, resulting in a launch within 3.7 seconds of the scheduled time. The first-stage flight was normal with all planned events occurring within allowable limits. Staging was nominal. The crew reported that the flame front caused by staging had some effect on the visibility through the spacecraft windows. The second-stage flight was also normal and resulted in the nearest-to-nominal orbital-insertion conditions yet achieved in the Gemini Program. Immediately after the spacecraft separated from the launch vehicle, the crew turned the spacecraft around and began maneuvering back toward the expended Gemini launch vehicle second stage. They then successfully conducted station-keeping maneuvers, maintaining distances from 60 to 150 feet for about a 15-minute period. During station keeping, the crew reported profuse second-stage fuel venting which was apparently causing it to tumble at rates of approximately 2 rpm. The crew reported no difficulty in station keeping with the second stage; however, a minimum distance of 60 feet between vehicles was maintained because of the high tumble rates of the launch vehicle. At the completion of station keeping, a separation maneuver was performed and the spacecraft was powered down in preparation for the 14-day mission.

The crew performed five maneuvers during the course of the mission to increase the orbital lifetime and to place the spacecraft in the planned orbit for rendezvous with spacecraft 6. The crew elected to perform the first two by using a star for attitude reference, leaving the spacecraft in the powered-down configuration. According to the crew, these maneuvers were performed with no difficulty and ground-tracking verified that they placed the spacecraft in the desired orbit. The three remaining maneuvers were performed with the spacecraft in the powered-up configuration, and the crew used the spacecraft guidance system for attitude reference. All maneuvers were performed accurately, and each resulted in a new orbit which was very close to the planned one.

The spacecraft and its systems performed nominally throughout the 14-day mission, except for the delayed-time telemetry playback recorder which malfunctioned approximately 201 hours after lift-off, the two fuel-cell stacks which showed excessive degradation late in the flight, and the yaw-right orbital-attitude thrusters which exhibited poor performance after 283 hours of flight. The recorder malfunction resulted in the loss of all delayed-time telemetry data for the remainder of the mission. The fuel-cell system provided all planned electrical requirements for the 14-day mission; however, during the latter portion of the mission, the operation of fuel-cell stacks 2A and 2C became degraded and at 286:57 ground elapsed time (g.e.t.), these stacks were taken off line because they were producing considerably less than the minimum specified level of current. The remaining four stacks (1A, 1B, 1C, and 2B) of the fuel cell continued to furnish the necessary electrical requirements until preparations were started for retrofire and reentry. The main batteries were placed on line at that time, as planned, to supplement power from the fuel cells. The poor performance of the yaw-right thrusters caused the crew to eliminate the tracking and photography task associated with the retrofire of spacecraft 6 and required them to use the pulse mode of control during the platform alignment prior to retrofire.

During the fifth day, the crew maneuvered the spacecraft into a favorable orbit to become a passive target for rendezvous with spacecraft 6 on the eighth day of the spacecraft 7 flight. The crew's preciseness in placing the spacecraft in the planned orbit during this maneuver was demonstrated when it was not required to make any further adjustments for rendezvous. The crew powered up spacecraft 7 early in the eleventh day and began maintaining the required attitudes for pointing the onboard radar transponder at the approaching spacecraft. The rendezvous of spacecraft 6 with spacecraft 7 was accomplished at 263:58 g.e.t. Station keeping of the two vehicles was conducted for about three and one-half orbits. During this period, each spacecraft 7 crew member spent approximately 5 minutes conducting station keeping with spacecraft 6 as the passive target vehicle.

During the course of the mission, 18 of the planned 20 experiments were partially or entirely executed. A failure in equipment for the D-5 and MSC-12 experiments caused the loss of these two experiments. A high percentage of the desired data was obtained on the 18 experiments conducted and is being analyzed by the experimenters.

At approximately 45 hours g.e.t., the pilot removed his lightweight pressure suit. At approximately 148 hours g.e.t., the pilot donned his suit and the command pilot removed his suit. The pilot again removed his suit approximately 40 hours later, and for the remainder of the mission, except for the rendezvous and reentry phases, the crew did not wear pressure suits. The crew reported that their comfort and mobility were increased greatly while the suits were removed. Medical observers on the ground noted that the crew condition was good at all times during the flight and that trends of a gradually lower heart rate did not develop in this crew as was the case in the Gemini V mission. Initial postflight medical evaluation of the crew reveals that their condition was generally better than that observed in some crew men after shorter missions.

The flight progressed nominally to its 14-day duration. Early in the fourteenth day, the crew began preparations for retrofire and reentry. The reentry control system was activated during the last orbit and all checklists were completed for retrofire. Retrofire occurred exactly on time at 329:58:04 g.e.t. for a landing in the West Atlantic recovery area. The reentry and landing were nominal, and the landing point achieved was 6.4 nautical miles short and 0.5 nautical mile to the left along the spacecraft trajectory toward the planned landing point. The crew was returned to the recovery ship by helicopter approximately 30 minutes after landing.

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2.0 INTRODUCTION

A description of the Gemini VII mission, as well as a discussion of the evaluation results, is contained in this report. The evaluation covers the time from the start of the final countdown to the date of publication of this report.

Detailed discussions are found in the major sections related to each major area of effort. Some redundancy is found in various sections where it is required for a logical presentation of the subject matter.

All of the data was not reduced and evaluated because of the large amount of telemetry data received and recorded during the mission. Data were reduced only in the areas of known interest from telemetry data, onboard recorded biomedical data, and ground-based radar tracking data. In evaluating the launch vehicle performance, all available data were processed. The evaluation of the spacecraft and launch vehicle consisted of analyzing the flight results and comparing these results with results from ground tests and from previous missions.

Section 6.1, FLIGHT CONTROL, is based on observations and evaluations made in real time, and, therefore, may not coincide with the results obtained from the detailed postflight analysis. Brief descriptions of the experiments flown on this mission are presented in section 8.0 with preliminary results and any conclusions that could be drawn at the time of publication of this report.

The following objectives, as set forth in the Mission Directive, formed the basis for evaluation of the flight and were of paramount consideration during the preparation of this report. The primary mission objectives were to:

(a) Conduct a 14-day mission

(b) Evaluate the effects of the 14-day flight on the crew

The secondary objectives for the Gemini VII mission were to:

(a) Provide a rendezvous target for the Gemini VI-A spacecraft

(b) Conduct station keeping with spacecraft 6

(c) Conduct station keeping with the second stage of the launch vehicle

(d) Conduct 20 scheduled experiments

(e) Conduct the mission in a lightweight pressure suit

(f) Evaluate the spacecraft reentry guidance capability

(g) Conduct spacecraft systems tests.

At the time of publication of this report, more detailed analyses of data on the performances of the launch vehicle and the radio guidance system were continuing. Analyses of the spacecraft inertial guidance and high-frequency voice communication systems were also continuing. In addition, the physiological aspects of a pressure suit versus "shirt-sleeve" environment in a spacecraft were being studied, and an overall biomedical analysis of the effects of extended Gemini flights on the crew was being made. Supplemental reports, listed in section 12.4, will be issued to provide documented results of these analyses.

The results of other Gemini missions are reported in references 1 to 7.

3.0 GEMINI VII VEHICLE DESCRIPTION

The space vehicle for the Gemini VII mission consisted of spacecraft 7 and Gemini launch vehicle 7 (GLV-7). The Gemini VII lift-off general arrangement and major reference coordinates are shown in figure 3.1-1.

3.1 GEMINI SPACECRAFT

A detailed description of the basic structure and major systems of the first complete production Gemini spacecraft (spacecraft 2) is provided in reference 2. All spacecraft flown subsequently are similar, with the exceptions noted herein and in references 3, 4, 5, and 7. Because the spacecraft 7 configuration closely resembles that of spacecraft 5 (ref. 5), only the significant differences between these two spacecraft are included in this report. These differences are summarized in table 3.1-I. The general arrangement of the spacecraft assemblies is illustrated in figure 3.1-2.

3.1.1 Spacecraft Structure

The primary load-bearing structure of spacecraft 7 was essentially the same as that of spacecraft 5. The major changes made for equipment installation were as follows.

3.1.1.1 Reentry assembly.- Structural provisions were made for the installation of an L-band radar transponder in the rendezvous and recovery (R and R) section of spacecraft 7 instead of the regular rendezvous radar installation required for spacecraft 5 and 6. Another change in spacecraft 7 was the installation of redesigned hatch-latching mechanisms (effective with spacecraft 6) as a result of the difficulty in closing the right-hand hatch after extravehicular operation on the Gemini IV mission.

3.1.1.2 Adapter assembly.- The supports for modules and cryogenic bottles within the spacecraft 7 adapter were the same as those of spacecraft 5 except for the following:

(a) The rendezvous evaluation pod mount installed on the blast shield access door of spacecraft 5 was not installed.

(b) Two acquisition-light installations were provided at the base of the adapter.

(c) A water-bottle installation was added to the adapter retrograde section (see section 3.1.2.3).

(d) A reserve propellant tank was added to the orbital attitude and maneuver system (OAMS) module (see section 3.1.2.7).

(e) The fuel-cell module was provided with new fiberglass trunnion supports to reduce heat transfer into the cryogenic containers.

3.1.2 Major Systems

3.1.2.1 Communications system.- The spacecraft 7 communications equipment was like that installed in spacecraft 5 with the following exceptions.

(a) The adapter C-band transponder code spacing was changed from 5 microseconds to 3 microseconds.

(b) A redesigned input circuit compatible with the urine flowmeter (see section 3.1.2.3) was installed in the voice tape recorder for spacecraft 7.

(c) The telemetry transmitter initially provided for experiment D-4/D-7 (244.3 megacycles) was interchanged with the regular delayed-time telemetry transmitter (246.3 megacycles). (In the spacecraft 7 arrangement, the 244.3 megacycle transmitter was used for delayed-time telemetry transmission, and the 246.3 megacycle transmitter was used to transmit D-4/D-7 experiment data.)

3.1.2.2 Instrumentation and recording system.- The instrumentation and recording system was essentially the same as the spacecraft 5 system except for the addition of electroencephalograph (EEG) sensors and signal conditioners to obtain data for experiment M-8 (inflight sleep analysis).

3.1.2.3 Environmental control system.- The spacecraft 7 environmental control system (ECS) configuration was the same as that of spacecraft 5 except for the modifications noted in the following paragraphs:

(a) A cryogenic oxygen crossover line from the downstream side of the ECS launch cooling heat exchanger to the downstream side of the reactant supply system (RSS) heat exchanger was added to provide the capability of pressurizing the RSS oxygen tank from the ECS oxygen tank, or vice versa, in the event of a heater failure in either tank (see fig. 3.1-3).

(b) The B coolant pump power supplies were modified to lower the power consumption in the powered-down configuration.

(c) Egress-kit bypass hoses were installed to eliminate heat transfer between the suit outlet and inlet gas in the egress kits. This modification was designed to reduce water condensation in the lithium hydroxide (LiOH) charge by delivering higher temperatures, thus extending the life of the LiOH charge (and providing additional cooling for the crew.

(d) The cabin vent valve was modified to incorporate a "stopper", providing a redundant seal in the event of a failed-open vent valve. The "stopper" was opened by means of a cable terminated with a pull-ring, and was designed for one-time operation. The pull-ring was located on the left side of the ECS quadrant.

(e) The water management system of spacecraft 7 included two 150-pound storage tanks installed in the adapter equipment section (tanks A and B in fig. 3.1-4), and a cabin tank with a capacity of approximately 15 pounds, as in the spacecraft 5 configuration. In addition to these, however, spacecraft 7 contained one 42-pound tank (tank C in fig. 3.1-4) in the adapter retrograde section.

Prior to launch, tank A was serviced with gaseous nitrogen at 19.0 psia. During the flight, fuel-cell product water was transferred into tank A, replacing the nitrogen. Tank B was serviced prior to launch with 149 pounds of drinking water and was pressurized during flight by fuel-cell product water. Tank C was serviced with 25 pounds of drinking water and then pressurized with oxygen at 18.0 psia prior to launch.

In the normal mode of operation, the cabin tank is referenced to cabin pressure (nominally 5.0 psia) causing drinking water to flow from the adapter tanks into the cabin tank, keeping it filled. (A schematic diagram of the water management system is presented in fig. 3.1-5.)

(f) The spacecraft 7 urine disposal equipment was like that of spacecraft 5 except for the incorporation of a urine sampling system for experiment M-5 (bioassays of body fluids) and experiment M-7 (calcium balance study). Also, a filter and flowmeter were connected downstream of the M-5/M-7 experiment equipment. The flowmeter output was recorded on the voice tape recorder for postflight analysis.

(g) The self-contained oxygen supply originally used in conjunction with experiment M-1 (cardiovascular conditioning) on spacecraft 5 was not installed on spacecraft 7. Instead, the primary oxygen supply was utilized by providing a quick disconnect on the cabin repressurization valve outlet.

(h) In accordance with the long-duration flight planned for Gemini VII, the carbon dioxide (CO_2) and odor absorber canister in the reentry assembly ECS package contained an insulated LiOH cartridge having greater CO_2 absorption capacity than the spacecraft 5 cartridge. In addition, the spacecraft 7 ECS canister incorporated an insulated lid.

3.1.2.4 Guidance and control system.- The guidance and control system of spacecraft 7 was not changed from the spacecraft 5 configuration, except as noted in the following paragraphs:

(a) Rendezvous radar equipment such as that installed in the R and R sections of spacecraft 5 and spacecraft 6 was not required in spacecraft 7. In its place, an L-band radar transponder, a boost regulator, and a single spiral antenna similar to equipment included in the rendezvous evaluation pod of spacecraft 5 (ref. 5) and the Agena target vehicle (ref. 6) were installed.

(b) Two acquisition lights, like those used on the rendezvous evaluation pod and the Agena target vehicle, were installed on opposite sides of the equipment adapter section to assist the crew of spacecraft 6 in visually locating spacecraft 7 during the terminal phase of the rendezvous. The acquisition lights were turned on and off by the ACQ LT circuit breaker on the right switch/circuit breaker panel, and the lights were automatically controlled to flash at a frequency of approximately 65 flashes per minute.

(c) The encoder, supplied on spacecraft 5 and 6 to provide the capability to transmit commands to an Agena target vehicle, was not installed on spacecraft 7.

(d) Modified aerodynamic coefficients were incorporated in the computer program for reentry prediction.

(e) Provisions were made for the transmission of computer discrete "autopilot scale factor" (gain change) at LO + 110 seconds instead of at LO + 105 seconds, the time used on the Gemini V flight.

3.1.2.5 Time reference system.- The time reference system was like the spacecraft 5 system except for the addition of a digital ground-elapsed-time (g.e.t.) clock in the center instrument panel in place of the flight plan roller (see paragraph 3.1.2.9.1). The locations of the time reference system components are shown in figure 3.1-6.

3.1.2.6 Electrical system.- The electrical system of spacecraft 7 (fig. 3.1-7) was essentially the same as the spacecraft 5 system. The major changes consisted of the addition of an auxiliary set of heaters on OAMS thrust chamber assemblies 1 through 10, and modifications to the fuel-cell product water and reactant supply systems.

3.1.2.6.1 Fuel-cell product-water system: A standpipe was added to the lower end of the fuel-cell product-water line to prevent high differential pressures within the fuel-cell sections under launch acceleration.

3.1.2.6.2 Reactant supply system: A crossover line was added between the RSS fuel-cell oxygen supply and the ECS breathing oxygen supply (see section 3.1.2.3). The RSS hydrogen supply tank installation was modified as follows.

(a) Fifty layers of aluminized mylar were added to the outer surface.

(b) Insulated mounts were incorporated.

(c) The hydrogen outlet line was routed around the bottle to provide regenerative cooling.

(d) A pyrotechnic cutter was installed on the pinch-off tube used to evacuate the annulus during manufacture. (If an excessive amount of gas had built up between the inner and outer walls of the bottle, the tube could have been severed to vent the gas.)

A sketch showing these modifications is included as figure 3.1-8.

3.1.2.7 Propulsion systems.- The spacecraft 7 reentry control system (RCS) was essentially the same as the spacecraft 5 system (see fig. 3.1-9). The following change was made in the OAMS, effective with spacecraft 7. A reserve fuel tank was added to the OAMS of spacecraft 7 to supply a known quantity of fuel to the system upon depletion of the primary fuel tank. Figure 3.1-10 shows the location of the reserve fuel tank. Additionally, an "F" package was provided (shown schematically in fig. 3.1-11) to isolate pressure from the reserve fuel tank until primary tank depletion. The reserve fuel was made available by operation of the OAMS RESV switch, located on the Agena control panel, to the SQUIB position. Operation of the switch resulted in the initiation of dual squibs, opening a normally closed pyrotechnic valve in the "F" package. Operation of the valve resulted in pressurization of the reserve fuel tank.

3.1.2.8 Pyrotechnic system.- The pyrotechnic system of spacecraft 7 was like the spacecraft 5 system, with the following exceptions:

(a) Mild detonating fuse (MDF) interconnects of a new part number were installed in the hatch actuator initiation system and the Z100 separation assembly of spacecraft 7.

(b) The MDF interconnect attached to the Z69 tube-cutter detonator assembly was modified to provide a greater detonation output than that of the previously used design.

(c) The crank mechanism in the nose-fairing ejector assembly was modified for easier installation.

(d) Rendezvous evaluation pod ejection devices were not installed in spacecraft 7.

(e) A pyrotechnic cutter was added to the RSS hydrogen bottle vent tube to allow exposure of the evacuated space between the inner and outer walls of the bottle to the orbital environment.

(f) The escape system aneroids (personnel parachute and ballute) incorporated a redesigned adjustment screw to assure adequate thread engagement.

3.1.2.9 Crew station furnishings and equipment.- The crew station furnishings and equipment for spacecraft 7 were basically the same as those of spacecraft 5. The more important differences are described in the following paragraphs:

3.1.2.9.1 Instrument panels and controls: The configuration of the instrument panels and controls is shown in figure 3.1-12. The main differences between this configuration and that of spacecraft 5 are described in the following paragraphs.

(a) A digital clock was incorporated in the center instrument panel to display ground elapsed time. The clock interfaced with the electronic timer and started at lift-off. The total elapsed time read-out capability of the clock was 999 hours, 59 minutes, and 59 seconds. Provisions were included for starting and stopping, or resetting the clock.

(b) The radar range and range-rate indicator was deleted.

(c) The HF ANT switch was changed, effective with spacecraft 6, to a three-position (extend-off-retract) toggle switch, spring-loaded to the center position. The switch controls the extension and retraction of the two HF whip antennas through the landing squib arm switch. When the landing squib arm switch is placed in the SAFE position, the HF ANT switch controls the adapter HF whip antenna. When the landing squib arm switch is placed in the ARM position, the HF ANT switch controls the reentry assembly HF whip antenna.

(d) The RADAR switch, located on the pedestal panel, was used to control the L-band transponder on spacecraft 7. The radar LOCK-ON light was not operational.

(e) The computer manual sequencing switch was not provided in spacecraft 7.

(f) A cabin vent valve pull-ring was installed on the left side of the ECS quadrant.

(g) Switch function and nomenclature changes in the Agena control panel resulted from the different experiment and operational equipment installed in spacecraft 7.

(1) The ENCDR switch was replaced by the oxygen CROSS FEED switch.

(2) The lower position of the DOCK LT switch was used to apply power to the auxiliary OAMS heaters. The upper position was used to turn on the docking light as well as apply power to the auxiliary heaters. The center position was "off".

(3) The docking EMERG REL switch was replaced by a spectrometer-magnetometer (SPT-MAG) switch to turn the experiment MSC-2 (proton-electron spectrometer) and MSC-3 (tri-axis magnetometer) equipment on and off.

(4) The INDEX EXTEND - POD EJECT switch was replaced by a BOOM EXT-RET switch to control the extension and retraction of the magnetometer boom for experiment MSC-3.

(5) The ENGINE ARM switch was replaced by the OAMS RESV SQUIB switch, used to pressurize the OAMS reserve fuel tank.

3.1.2.9.2 Space suits: A G5C lightweight pressure suit was developed by the NASA Manned Spacecraft Center for the Gemini VII mission. The G5C suit was designed for comfort during long-duration flight. It was made using G4C pressure-suit materials and technology, except that the restraint layer and inner liner were eliminated. The helmet was soft with an integral visor and no neck ring. When not required, the pressure helmet was unzipped at the neck and folded up behind the head. An aircraft-type crash helmet was worn inside the suit helmet to provide protection to the head and to provide a means to mount the earphones and microphones. These communication items were of the same design as those used with the G4C suit.

In addition to the G5C pressure suits, the crew were supplied with orbital flight suits. These garments were tailored HT-1 nylon two-piece suits which provided additional warmth if required when the pressure suits were removed.

3.1.2.9.3 Drinking water and urine disposal provisions: A new design water-metering device (see fig. 3.1-13) replaced the water dispenser used on spacecraft 5. The measuring device was a pistol-configured water dispenser capable of measuring and dispensing water in $\frac{1}{2}$-ounce increments. A trigger-operated bellows was used to measure and dispense the increments of water, and a mechanical counter was used to tabulate the number of cycles on the trigger.

Two chemical urine volume measuring systems were carried on spacecraft 7. These chemical systems utilized tracer cartridges which injected 0.1 milliliter of tracer chemical into each collection of urine. The basic design function of the chemical urine receiver was the same as the system flown on spacecraft 5. Urine sample bags were carried for experiments M-5 (bioassays of body fluids) and M-7 (calcium balance study) to permit sampling each voiding of urine before it was dumped overboard. Two additional items, a filter and a flowmeter, were incorporated in the spacecraft 7 urine system. These were carried as loose items to be connected into the system by the crew. The flowmeter electrical output was recorded on the voice tape recorder by means of special wiring to the recorder.

3.1.2.9.4 Stowage facilities: The basic crew equipment stowage configuration of spacecraft 7 was similar to that of spacecraft 5. Although the aft and center stowage containers were slightly different in size and shape, the utilization was the same. The aft boxes were filled with food, and the centerline containers were stowed with photographic, experiment, and operational equipment. An auxiliary food pouch was added to the left side of the right footwell to carry additional food and equipment. An additional dry-waste stowage area was provided behind the pilot's seat. Containers for stowage of the flight-crew equipment are shown in figure 3.1-14. Table 3.1-II lists the major items of equipment stowed in the containers at launch.

3.1.2.9.5 Ejection seats: The ejection seats of spacecraft 7 were identical to those of spacecraft 5.

3.1.2.10 Landing system.- The landing system was the same as the spacecraft 5 system.

3.1.2.11 Postlanding and recovery systems.- The postlanding and recovery equipment was the same as that used on spacecraft 5.

TABLE 3.1-I.- SPACECRAFT 7 MODIFICATIONS

System	Significant differences between the spacecraft 7 and spacecraft 5 configurations.
Reentry assembly structure	(a) Provision was made for the installation of an L-band transponder in the R and R section. (b) A new-design hatch-latching mechanism was used.
Adapter assembly structure	(a) Insulated cryogenic bottle and fuel-cell-module supports were installed. (b) A drinking water storage tank was installed in the retro adapter. (c) A reserve fuel tank was installed on the OAMS module. (d) Provision was made for the installation of two acquisition lights at the base of the equipment adapter. (e) The rendezvous evaluation pod installation was not required.
Communications	(a) The normal delayed-time telemetry transmitter was interchanged with the D-4/D-7 experiment telemetry transmitter. (b) The adapter C-band transponder code spacing was changed from 5 microseconds to 3 microseconds.
Instrumentation	Biomedical sensors were added to obtain electroencephalograms.

TABLE 3.1-I.- SPACECRAFT 7 MODIFICATIONS - Continued

System	Significant differences between the spacecraft 7 and spacecraft 5 configurations.
Environmental control	(a) A cryogenic oxygen crossover line was added between the ECS primary breathing oxygen supply and the fuel-cell oxygen supply. (b) Modified power supplies for the B coolant pump were installed. (c) A "stopper" was added to the cabin vent valve to provide redundancy in the event of a failed-open valve. (d) Egress kit bypass lines were added to extend the life of the LiOH charge. (e) The LiOH canister was insulated. (f) The water management system was modified to include one 42-pound tank in the retro adapter in addition to two 150-pound tanks located in the equipment adapter. One of the 150-pound tanks carried 149 pounds of drinking water, while the 42-pound tank carried 25 pounds of drinking water. Fuel-cell product water was stored in both 150-pound tanks. (g) The urine system incorporated a urine sampling system, a filter, and a flowmeter. The output of the flowmeter was recorded on the voice tape recorder.

TABLE 3.1-I.- SPACECRAFT 7 MODIFICATIONS - Continued

System	Significant differences between the spacecraft 7 and spacecraft 5 configurations.
Guidance and control system	(a) An L-band transponder, boost regulator and spiral antenna were installed in the R and R section (no rendezvous radar was provided). (b) Two flashing acquisition lights were installed on opposite sides at the base of the equipment adapter section. (c) Modified aerodynamic coefficients were used for reentry prediction. (d) Computer discrete "autopilot scale factor" was sent at LO + 110 seconds instead of at LO + 105 seconds.
Time reference system	A digital ground-elapsed-time clock was installed in the center instrument panel.
Electrical system and reactant supply system	(a) Auxiliary heaters were added to OAMS TCA's 1 through 10. (b) A standpipe was added to the lower end of the fuel-cell product water line. (c) The RSS hydrogen bottle was provided with added insulation.
Propulsion systems	A reserve fuel tank was added to the OAMS.

TABLE 3.1-I.- SPACECRAFT 7 MODIFICATIONS - Continued

System	Significant differences between the spacecraft 7 and spacecraft 5 configurations.
Pyrotechnic system	(a) MDF interconnects used in the escape system and the retro adapter separation assembly were of a new part number.
	(b) The station Z69 explosive interconnect was modified.
	(c) A pyrotechnic cutter was added to the RSS hydrogen bottle evacuation tube.
	(d) The REP ejection system was not installed.
	(e) Escape system aneroids incorporated a redesigned adjustment screw.
	(f) The crank mechanism in the nose fairing ejector assembly was modified.
Crew station furnishings and equipment	(a) A digital elapsed-time clock was installed in the center instrument panel (see time reference system).
	(b) The radar range and range-rate indicator was deleted.
	(c) Minor variations in switch functions and nomenclature were incorporated, primarily because of different experiment equipment installed on spacecraft 7.

TABLE 3.1-I.- SPACECRAFT 7 MODIFICATIONS - Concluded

System	Significant differences between the spacecraft 7 and spacecraft 5 configurations.
Crew station furnishings and equipment - concluded	(d) Lightweight G5C space suits were used in place of the standard G4C suits. (e) Nylon two-piece orbital flight suits were provided for crew use while the G5C space suits were removed. (f) The drinking water dispenser was redesigned to provide a measurement of the water consumed. (g) A urine sampling system was provided for use in conjunction with experiments M-5 and M-7. (h) Additional stowage spaces were provided.

TABLE 3.1-II.- CREW STATION STOWAGE LIST

Stowage area (See fig. 3.1-12)	Item	Quantity
Centerline stowage container	70-mm camera (with 250-mm lens and ring sight assembly)	1
	70-mm camera filter adapter	1
	70-mm camera interference filters	3
	70-mm film magazines	8
	16-mm camera lens (25mm)	1
	16-mm camera lens (75mm)	1
	16-mm film magazines	7
	Plastic zipper bags	21
	Telescope, body	1
	Blood pressure reprogramming adapter	1
	UCD clamps	4
	Personal hygiene towels	6
	Suit repair kit	1
	Dew point hygrometer sensor	1
	Dew point hygrometer sensor cable	1
	Dew point hygrometer sensor control unit	1
	Tape cartridges for voice tape recorder	19
	Medical accessory kit	1

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

Stowage area (See fig. 3.1-12)	Item	Quantity
Centerline stowage contained - concluded	Star occultation photometer	1
	Tissue dispensers	5
	CO_2 tapes (in bottom of tissue dispenser)	28
	Bag, urine measuring system	1
	Tracer cartridge, urine measuring system	2
	Sextant	1
	Laser transmitter assembly	1
	Inflight exerciser	1
	Vision tester data cards (14 cards per set)	2 sets (in sextant box)
	Head-brace strut	1
	Vision tester bite board	2
Left-hand aft stowage container	Food	(a)
Left-hand sidewall stowage containers	Pilot's preference kit	1
	Telescope eyecups	1
	Postlanding kit assembly	1

[a]Total quantity of $14\frac{1}{3}$ crew days stowed in left-hand and right-hand aft stowage containers and footwell pouch.

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

Stowage area (See fig. 3.1-12)	Item	Quantity
Left-hand sidewall stowage containers - concluded	Personal hygiene towels	2
	Waste containers	2
	Defecation devices	17
	Lightweight head set	1
	Glare shield for optical sight	1
	Chemical urine volume measuring system (with urine receiver)	1
	Additional urine receivers (urine measuring system)	2
	Latex roll-on cuffs (urine measuring system)	10
	Inflight medical kit	1
Right-hand aft stowage container	Food	(a)
Right-hand sidewall stowage containers	Pilot's preference kit	1
	Personal hygiene towels	4
	Defecation devices	16
	Water dispenser adapter	1
	Dual utility cord (one installed)	2
	Cable adapter, voltage regulator	1

[a]Total quantity of $14\frac{1}{3}$ crew days stowed in left-hand and right-hand aft stowage containers and footwell pouch.

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

Stowage area (See fig. 3.1-12)	Item	Quantity
Right-hand sidewall stowage containers - concluded	Lightweight headset	1
	Inflator, manual blood pressure assembly	1
	Single-end crescent wrench	1
	Urine filter assembly	1
	16-mm camera	1
	Mirror mounting bracket assembly for 16-mm camera	1
	16-mm camera lens (18-mm lens mounted on camera)	1
	16-mm film magazine loaded in camera (additional 16-mm film magazine in pocket of pressure suit)	1
	16-mm camera bracket	1
	Waste containers	2
Pedestal wall (left side)	Orbital path display assembly	1
	Celestial display (polar)	1
	Celestial display (Mercator)	1
	Flight data booklets (in plotboard pouch)	3
	Auxiliary window shade (left window)	1
Pedestal wall (right side)	Auxiliary window shade (right window)	1

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

Stowage area (See fig. 3.1-12)	Item	Quantity
Footwells	70-mm film magazines	2
	Orbital flight suits (stowed in footwell pouches)	2
	Waste disposal pouches (stowed in footwell pouches)	4
	Footwell pouches	2
Orbital utility pouch	Tape ($\frac{3}{4}$ inch width)	30 ft
	Urine hose assembly	1
	Reticle assembly	1
Under pilot's instrument panel	Cap assemblies (oxygen hose screen)	2
Under command pilot's instrument panel	Optical sight	1
Left-hand hatch	Vision tester (with one set of data cards)	1
Right-hand hatch	Photometer and battery	1
Hatch pouches	Urine sample bags	120
Water management panel	Chemical urine-volume measuring system with urine receiver	1

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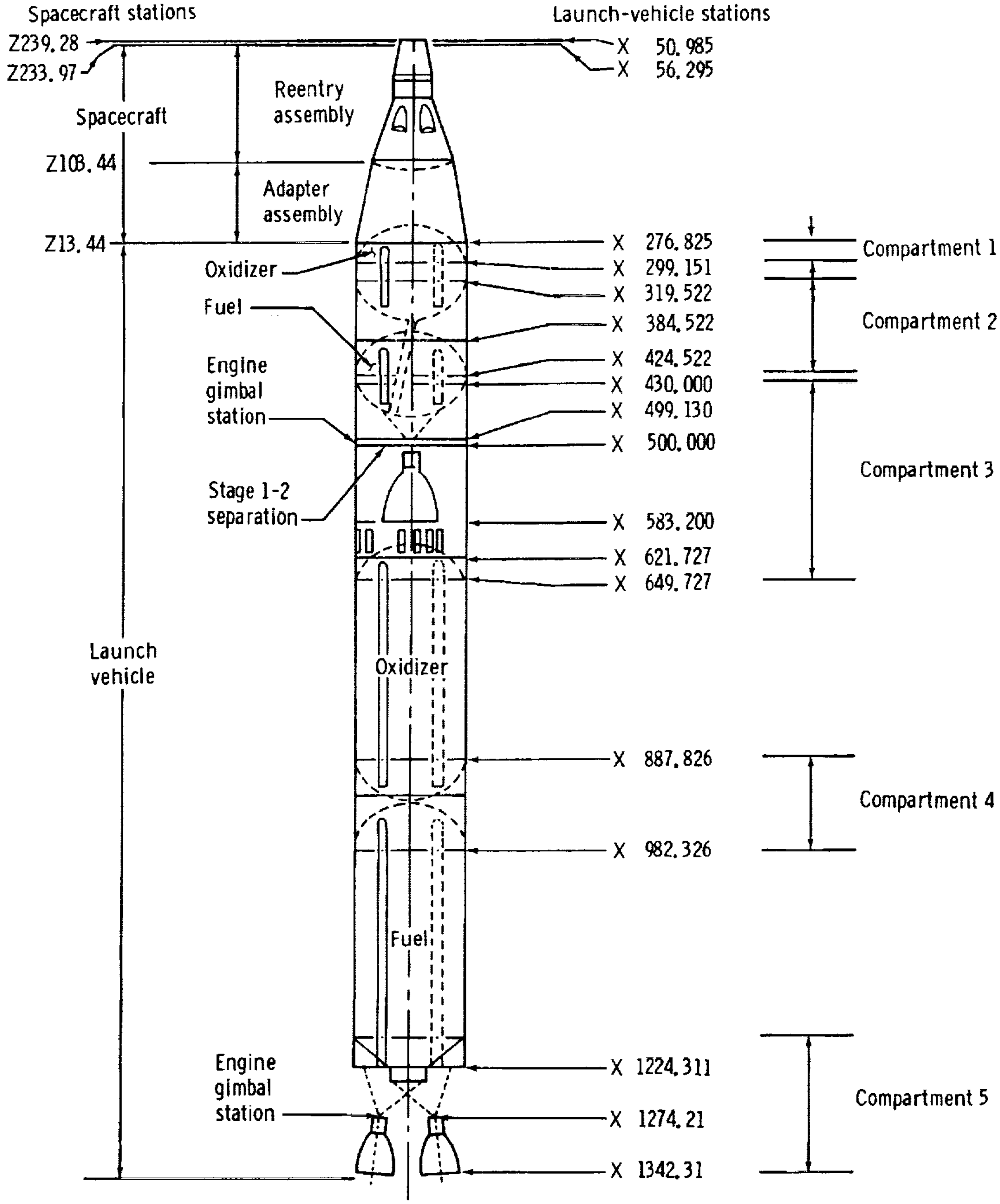

(a) Launch configuration.

Figure 3.1-1. - GLV - spacecraft relationships.

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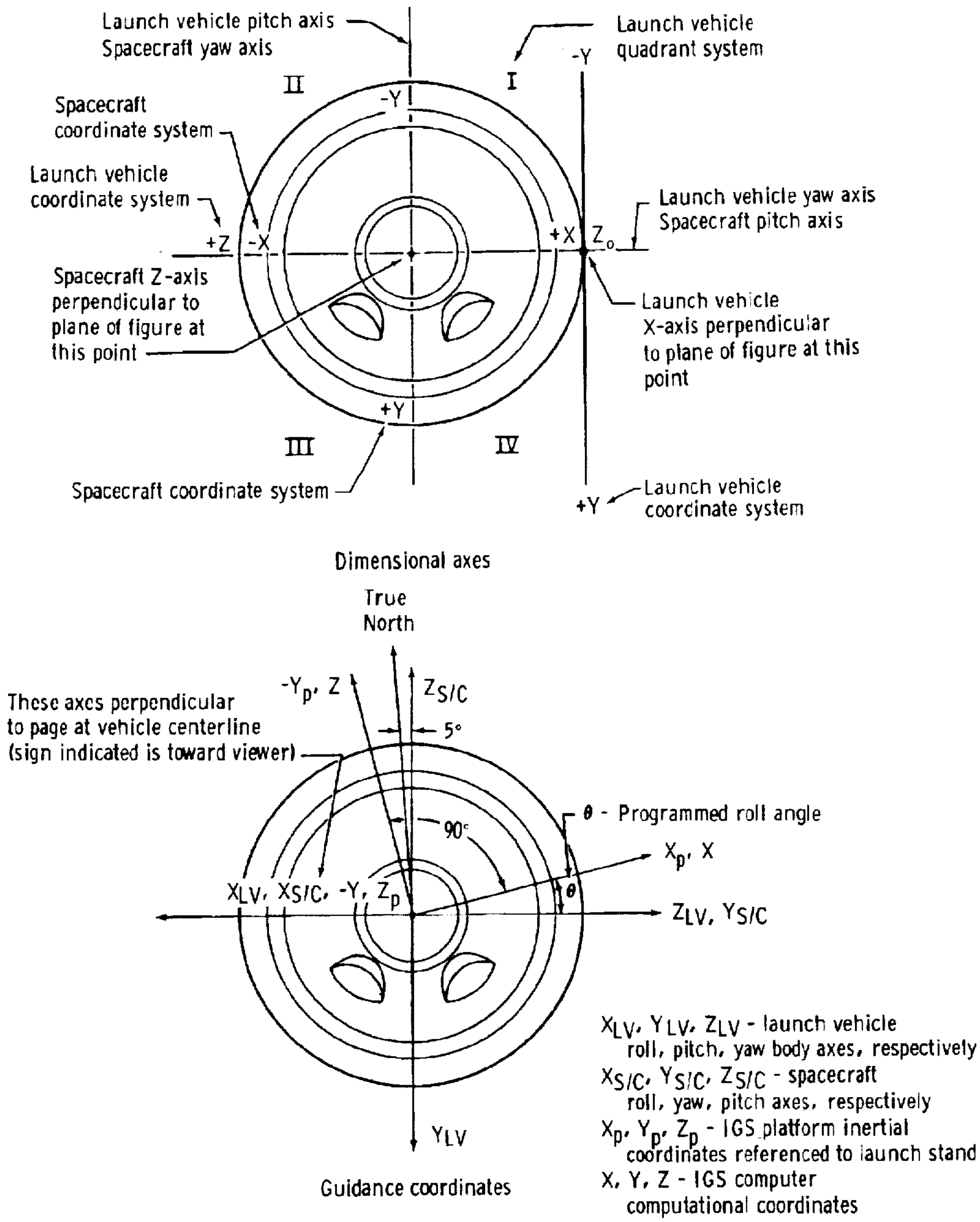

(b) Dimensional axes and guidance coordinates.

Figure 3.1-1. - Concluded.

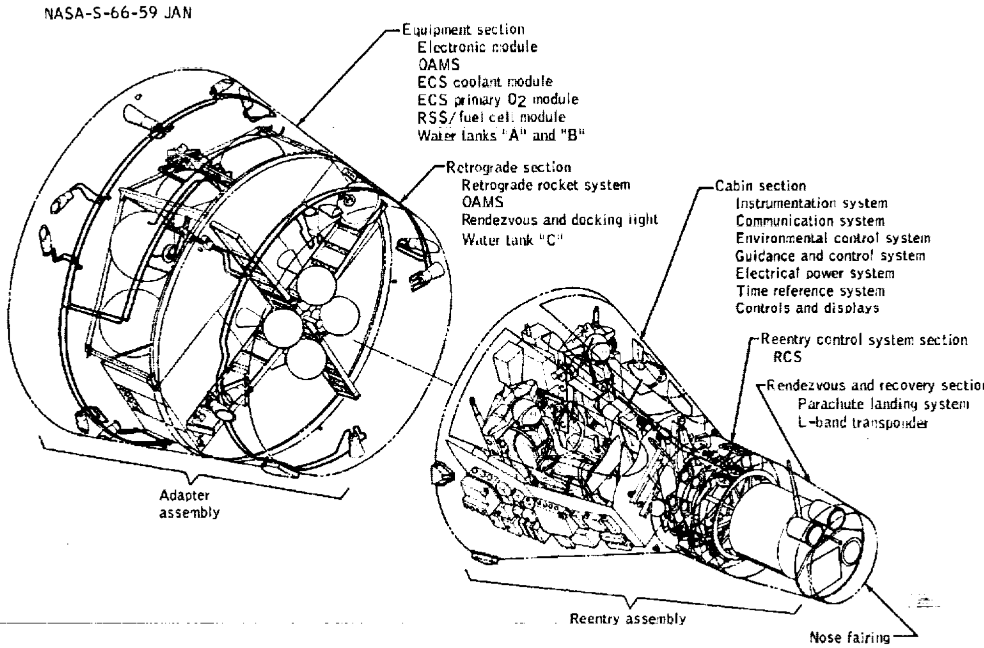

Figure 3.1-2. - Spacecraft arrangement and nomenclature.

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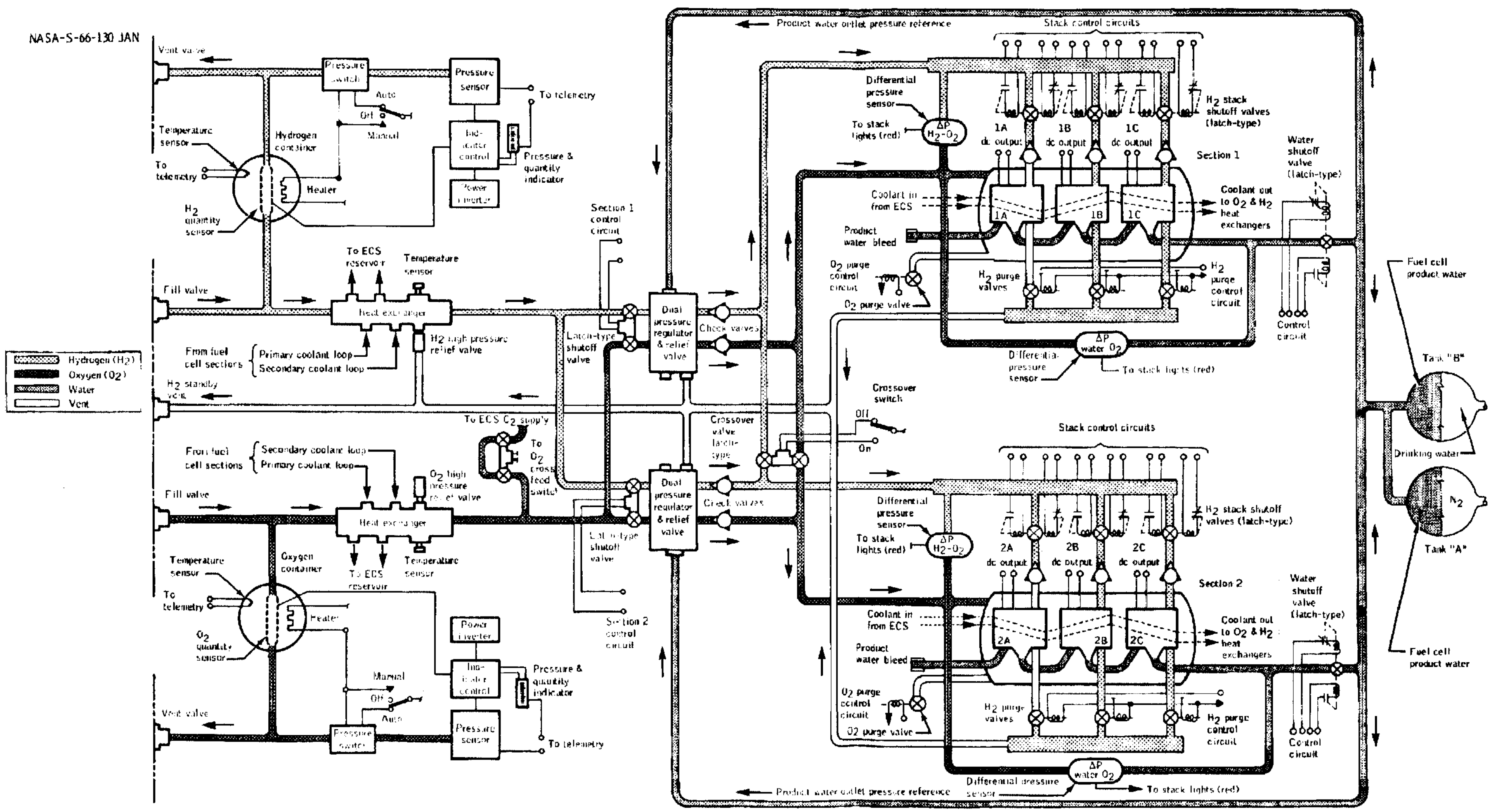

Figure 3.1-3. - RSS/fuel cell system functional diagram.

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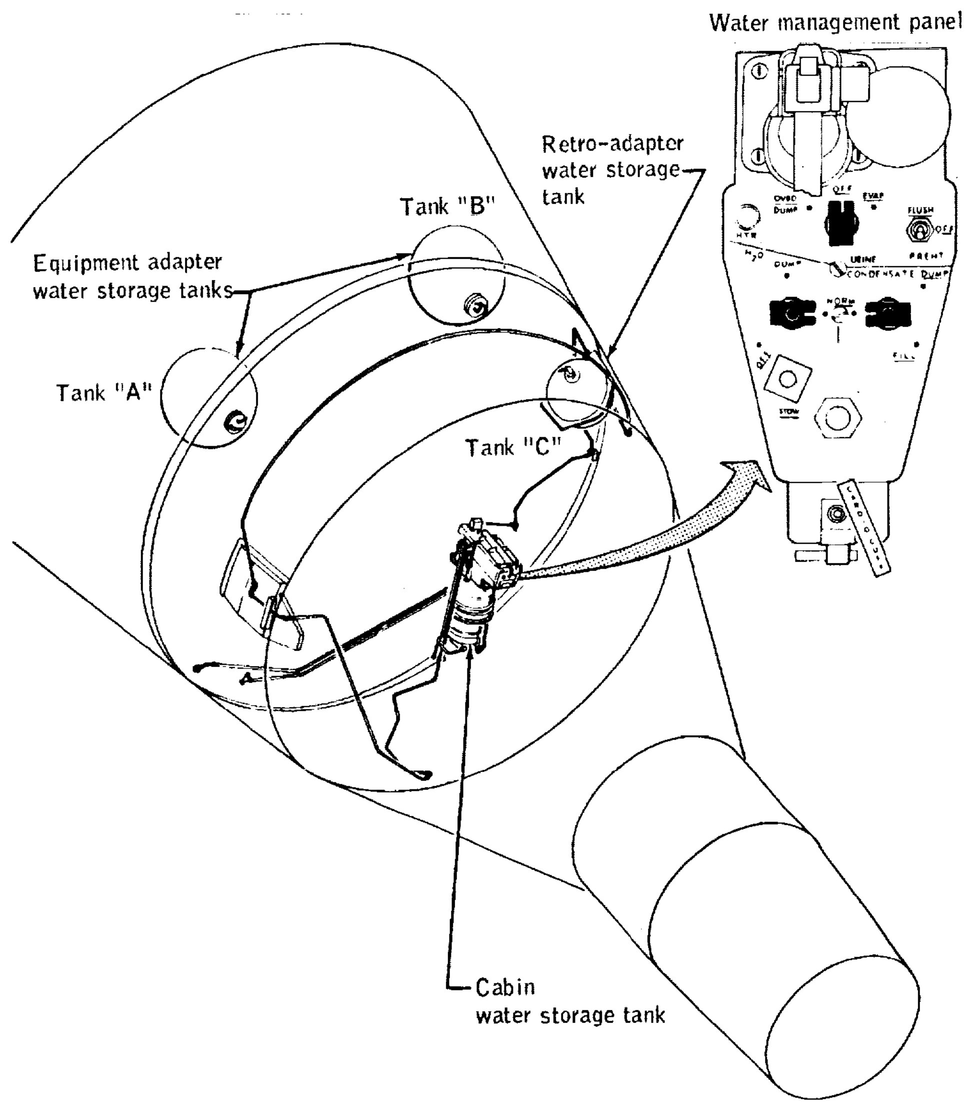

Figure 3.1-4. - Water management system components.

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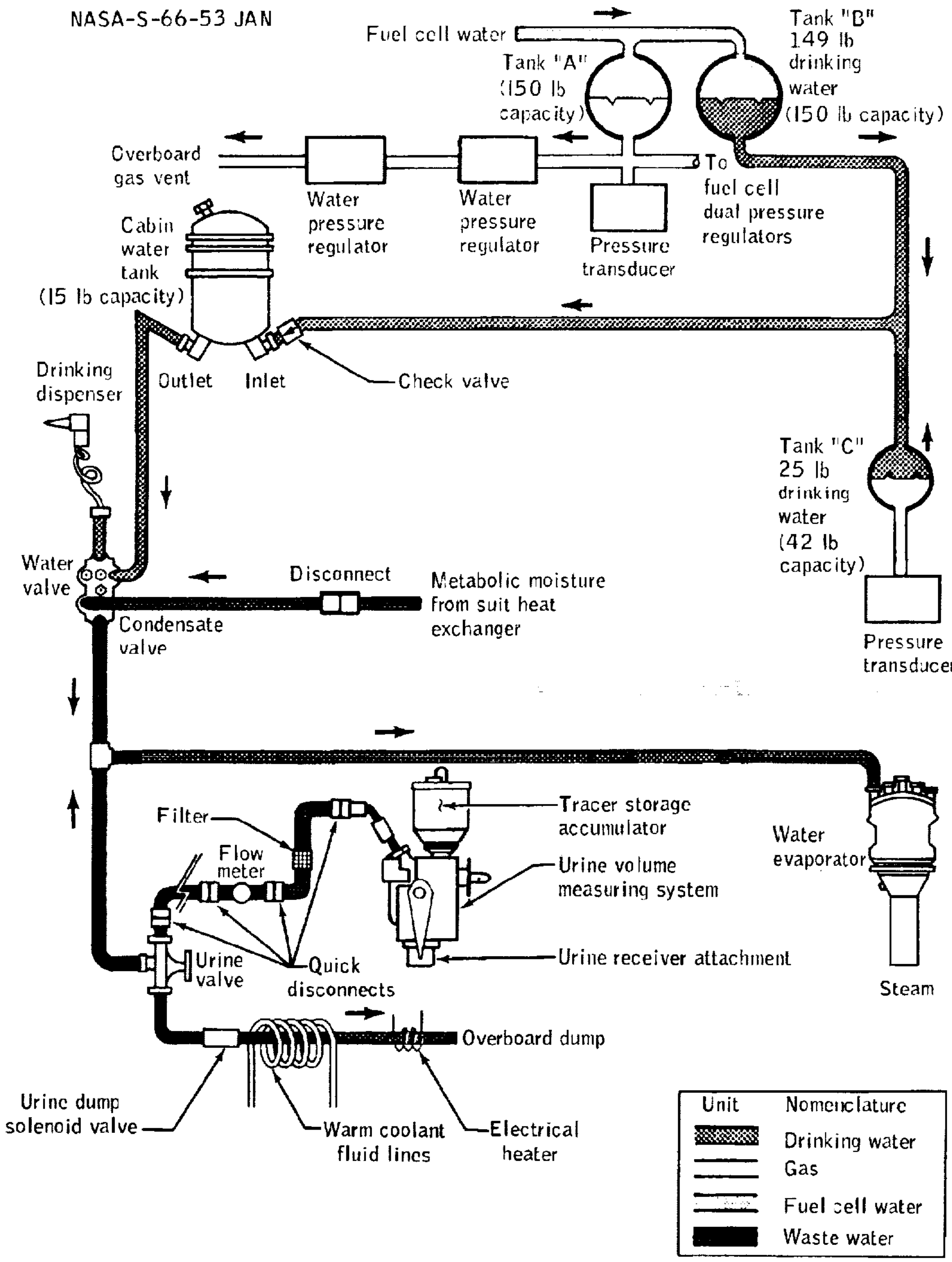

Figure 3.1-5. - Water management system schematic.

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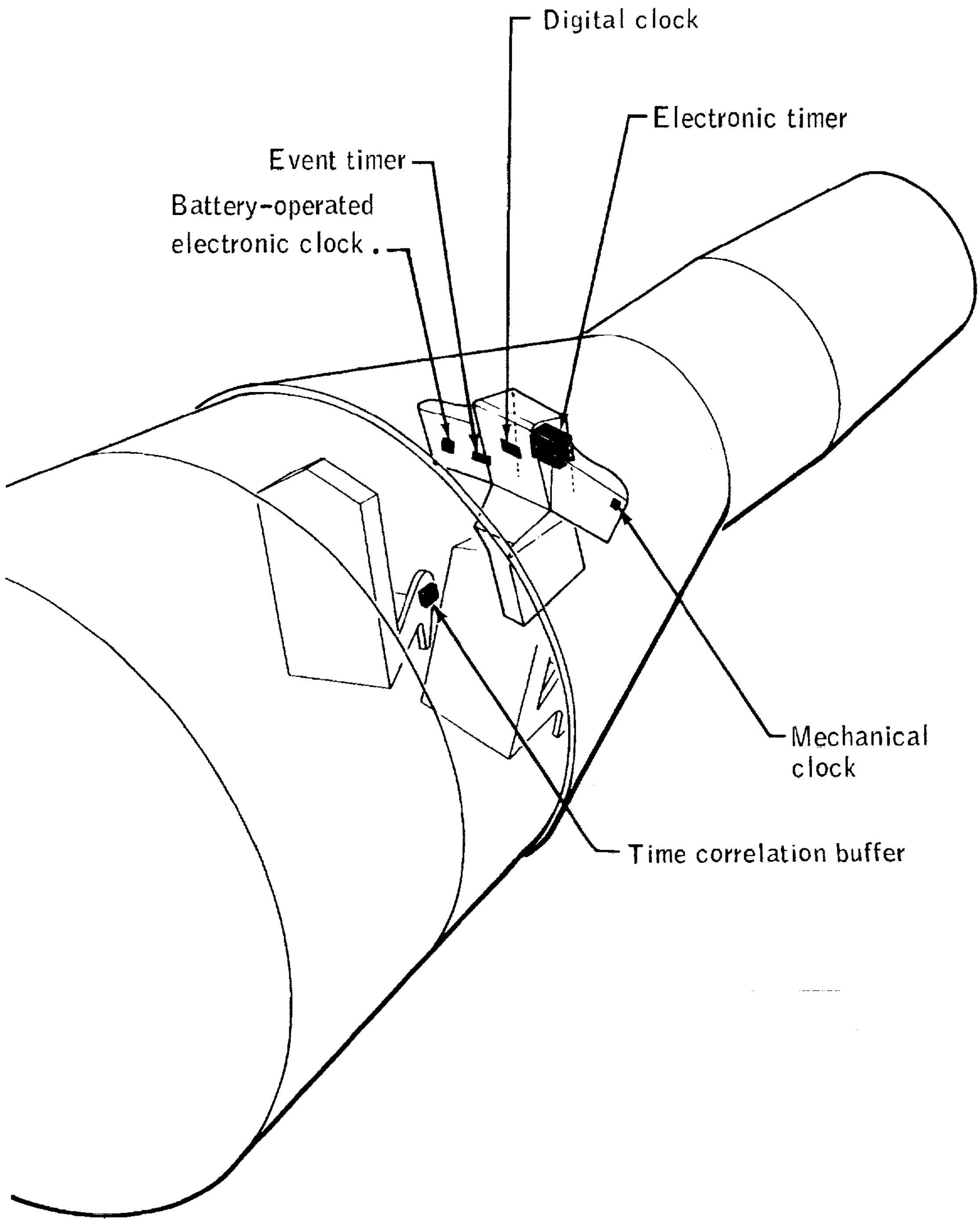

Figure 3.1-6. - Time reference system equipment locations.

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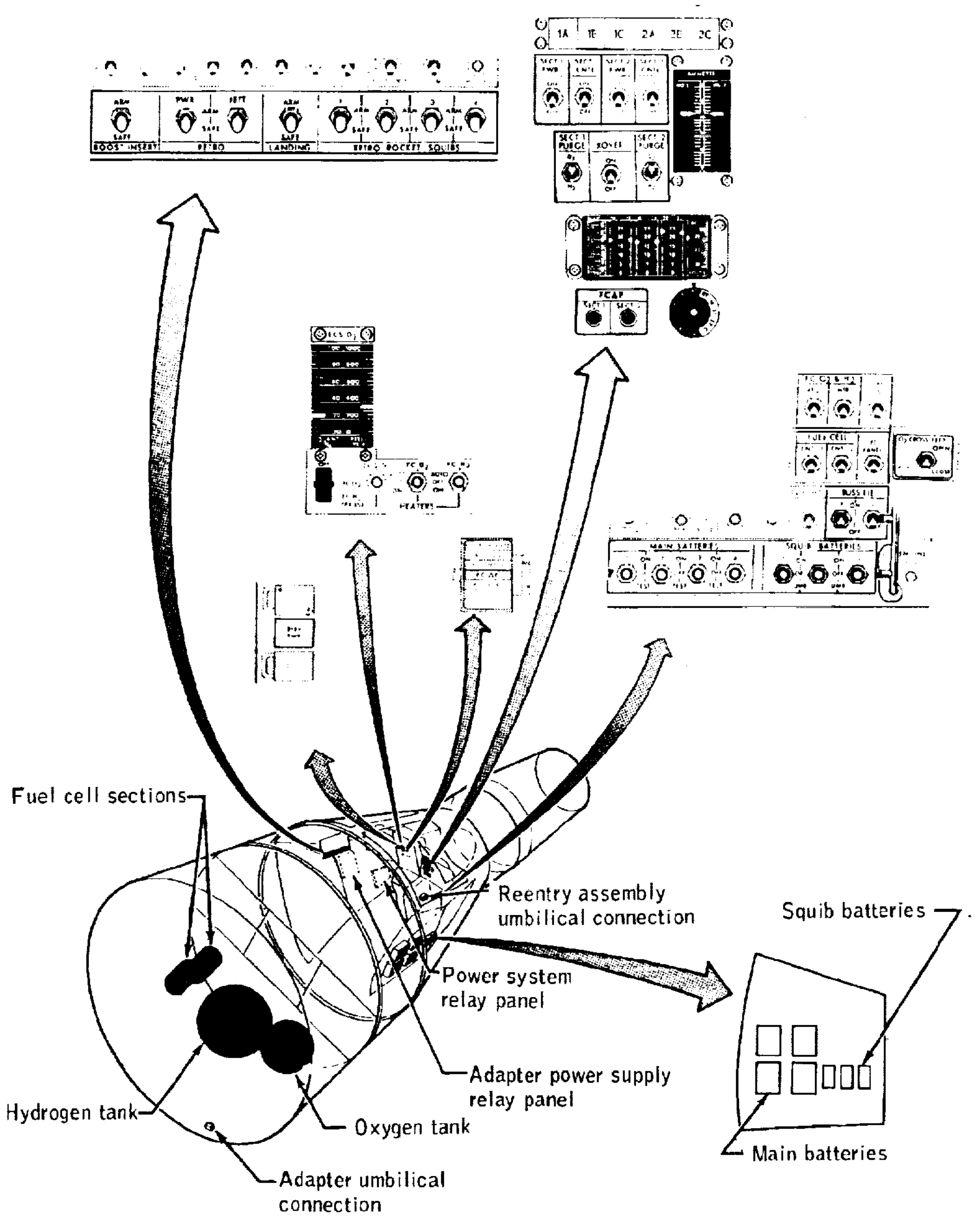

Figure 3.1-7. - Electrical power system installation.

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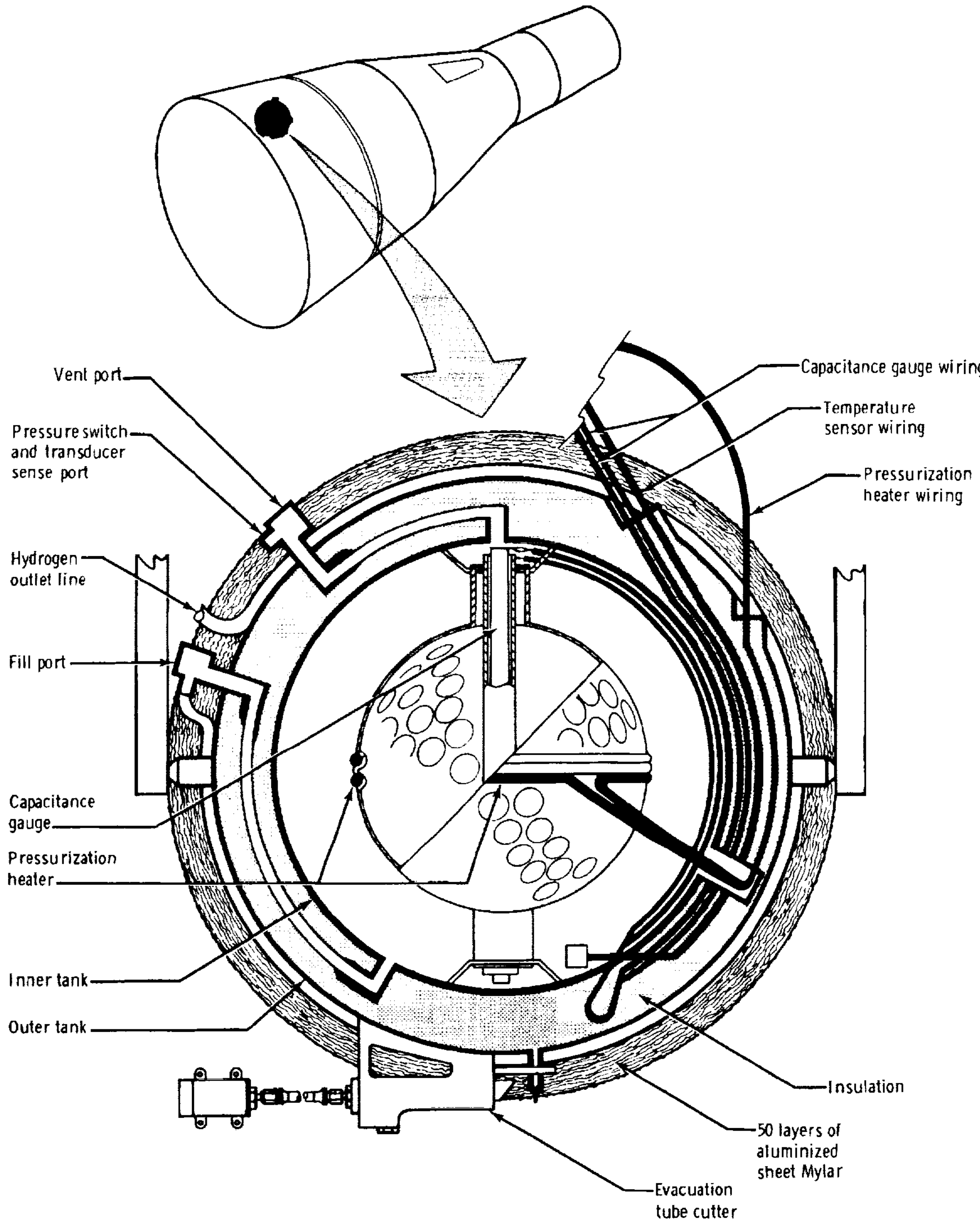

Figure 3.1-8. - RSS cryogenic hydrogen tank.

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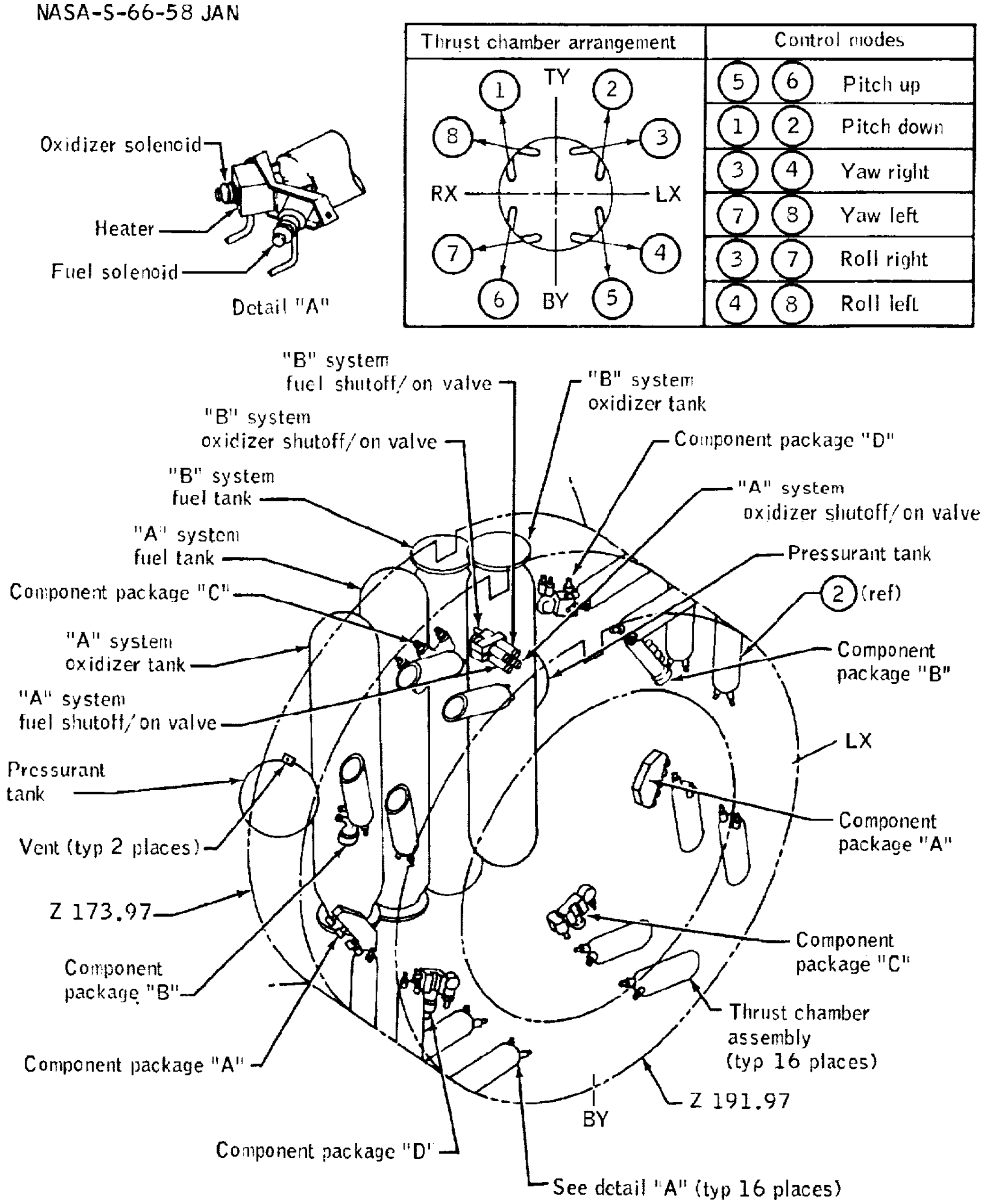

Figure 3.1-9. - Reentry control system.

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OAMS thrusters	
5 6	Pitch up
1 2	Pitch down
3 4	Yaw right
7 8	Yaw left
3 7	Roll clockwise
4 8	Roll counterclockwise
9 10	Translate forward
11 12	Translate aft
13	Translate right
14	Translate left
15	Translate up
16	Translate down

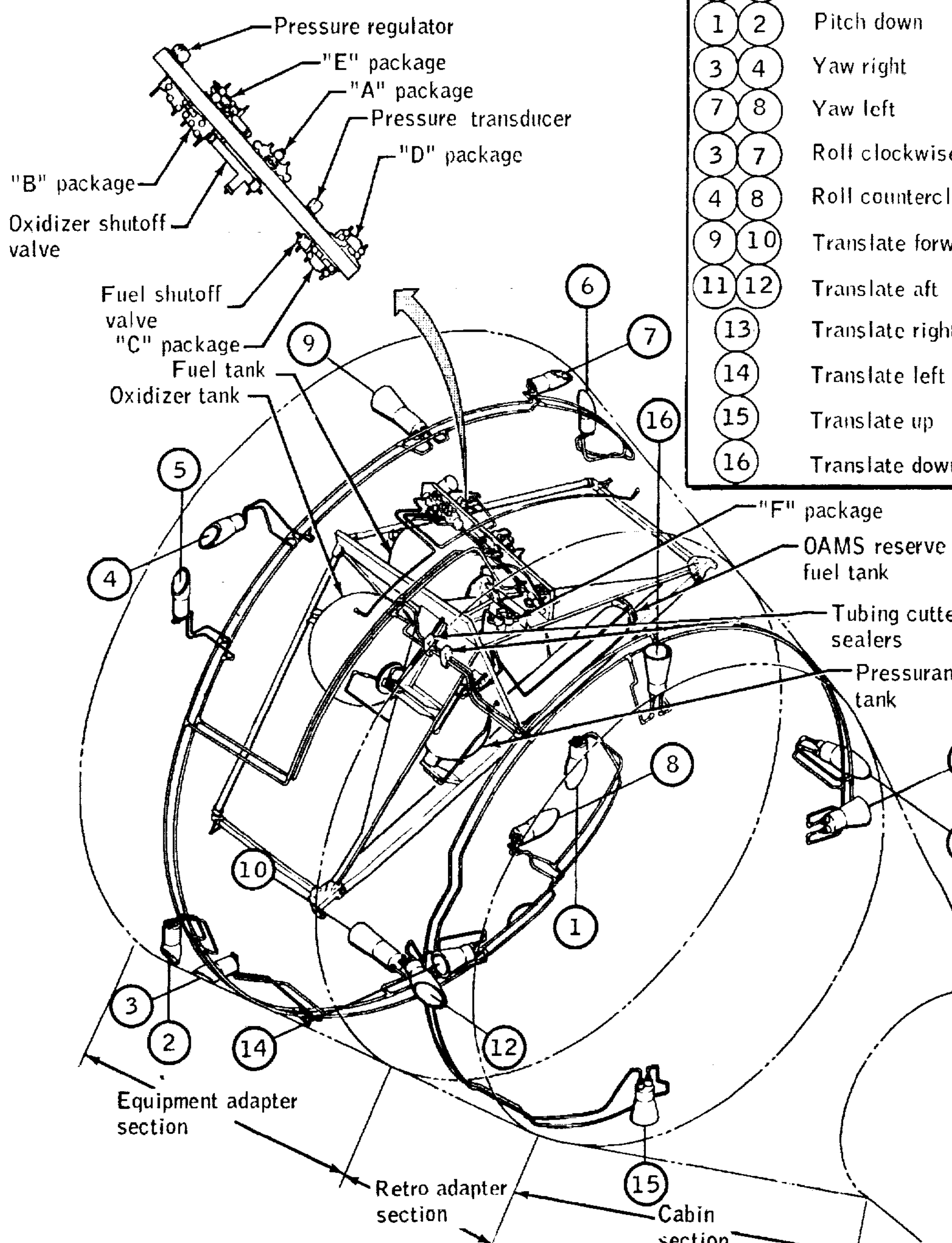

Figure 3.1-10. - Orbital attitude and maneuver system.

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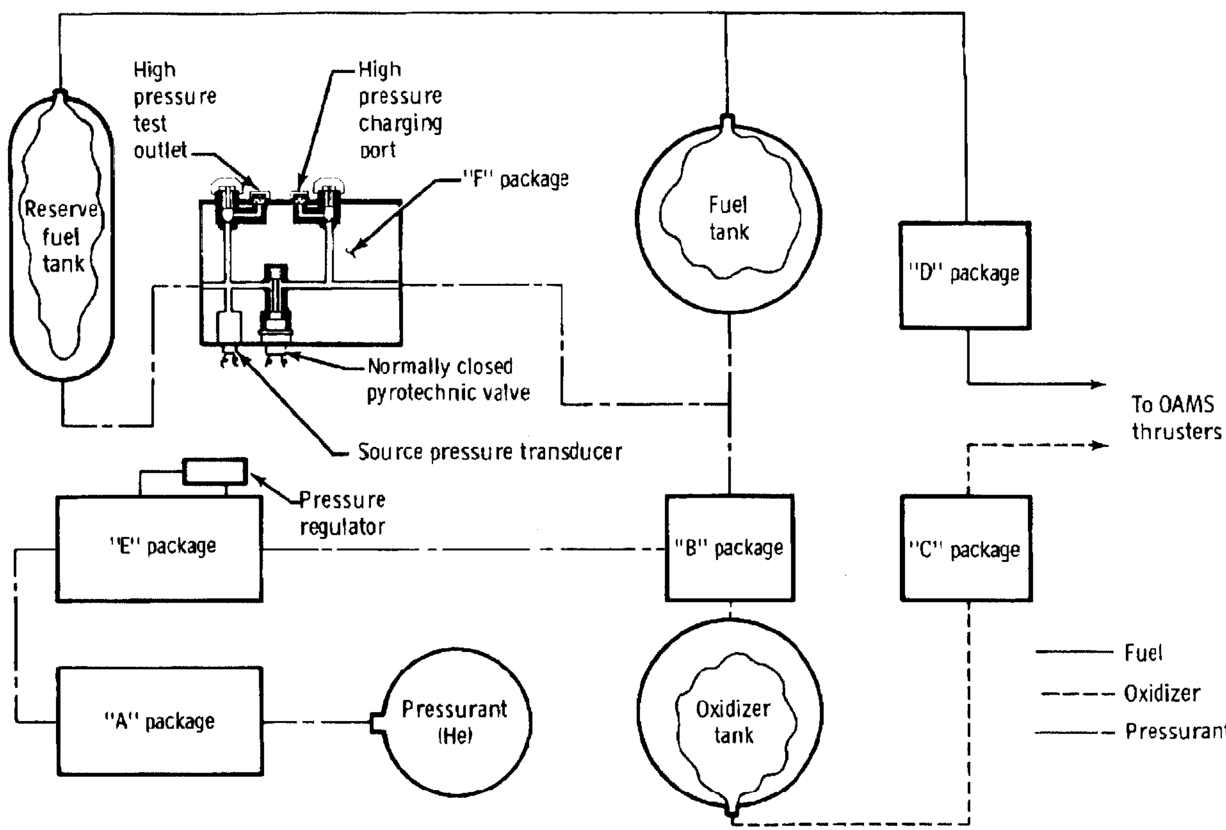

Figure 3.1-11. - Orbital attitude and maneuver system schematic.

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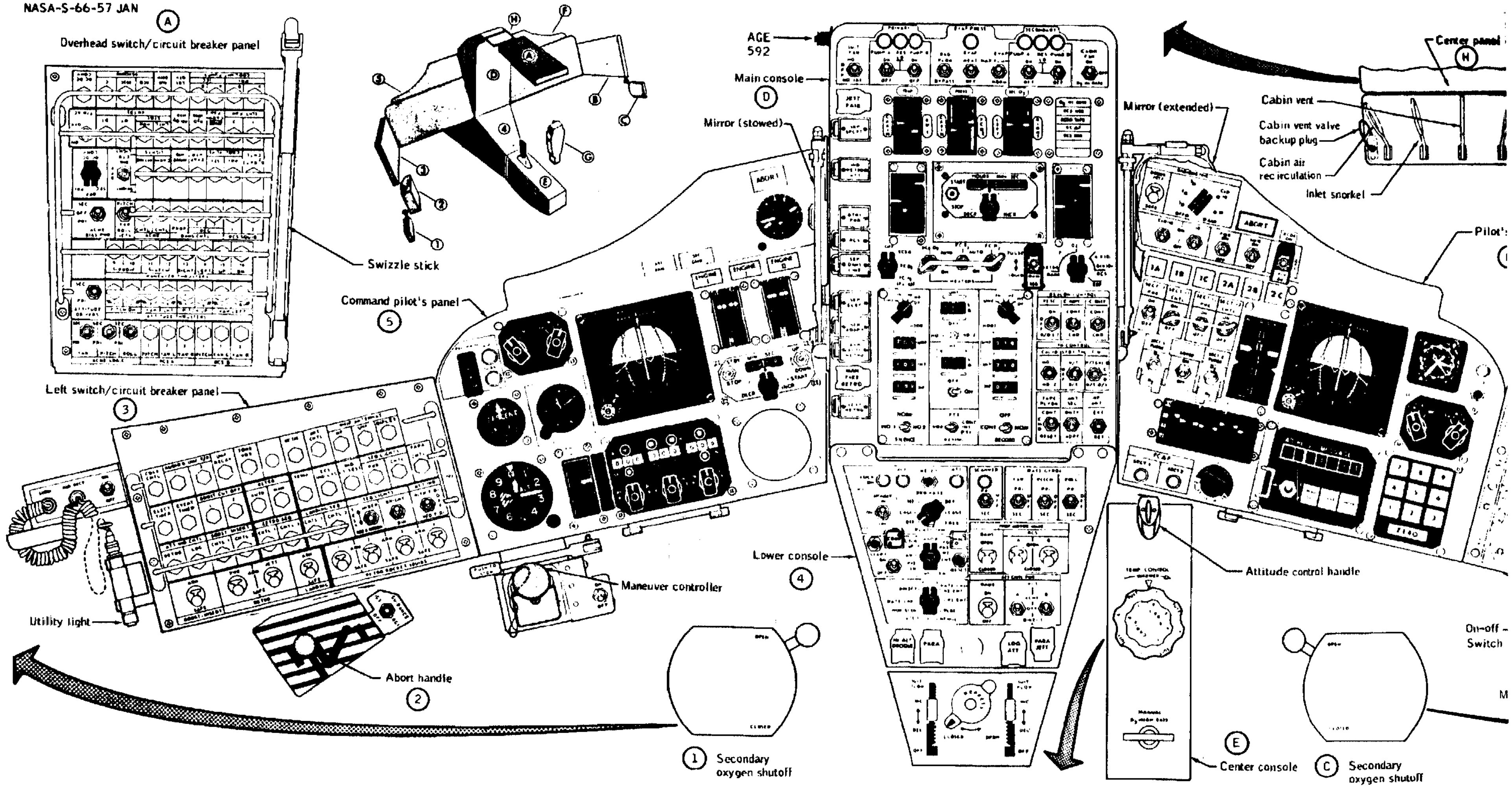

3-31-a

3-31 a

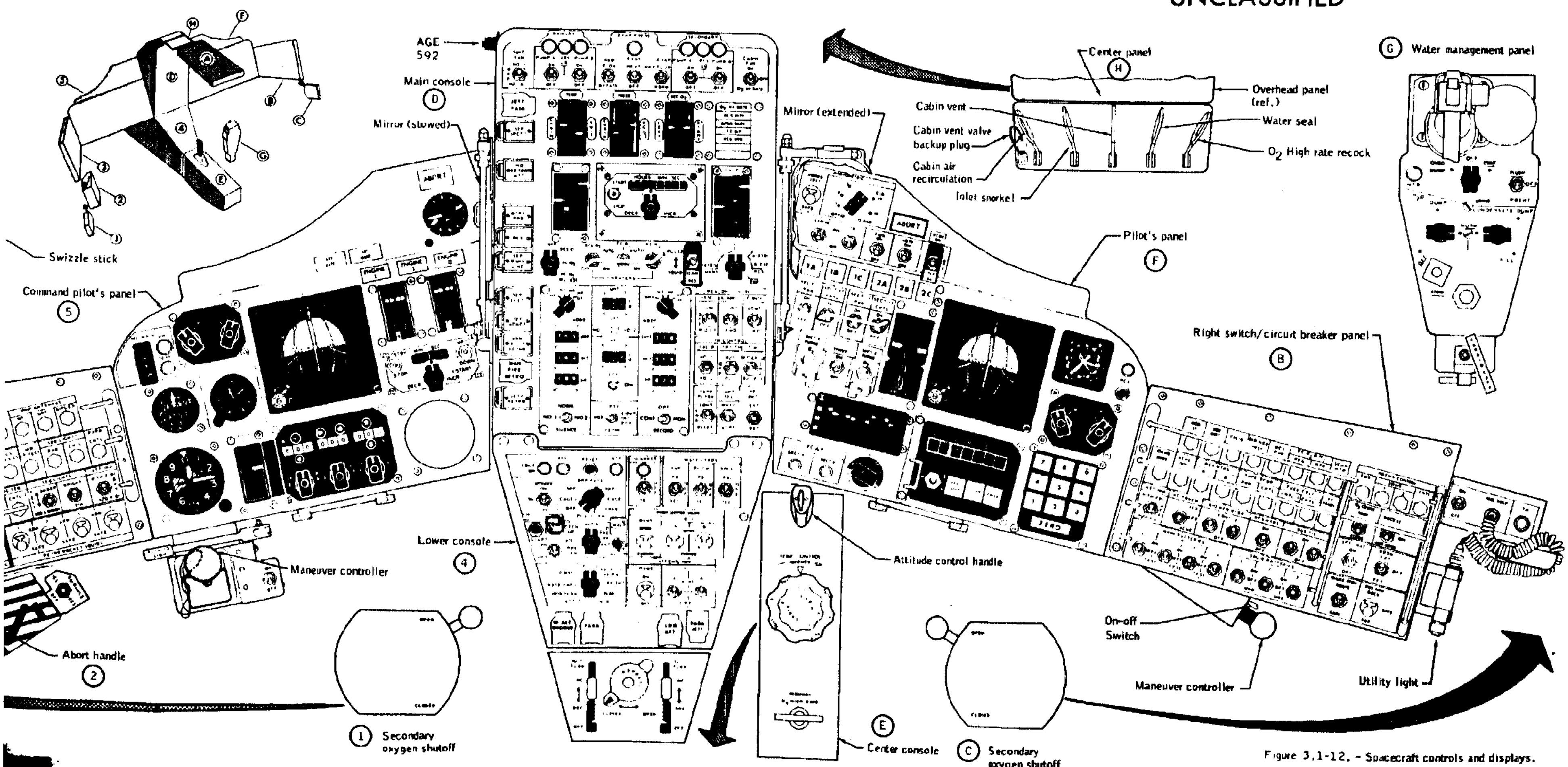

Figure 3.1-12. - Spacecraft controls and displays.

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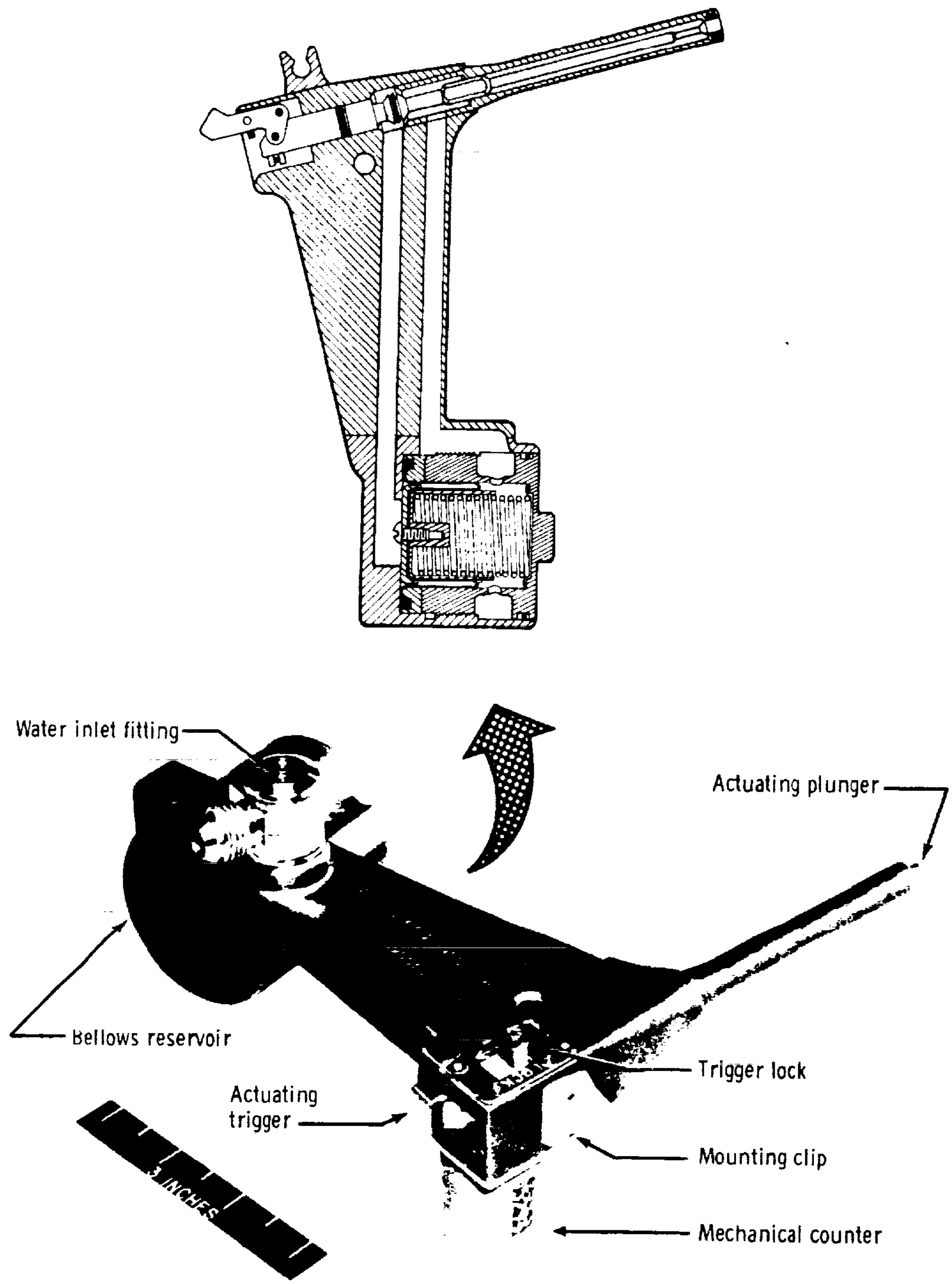

Figure 3. 1-13. - Metering water dispenser.

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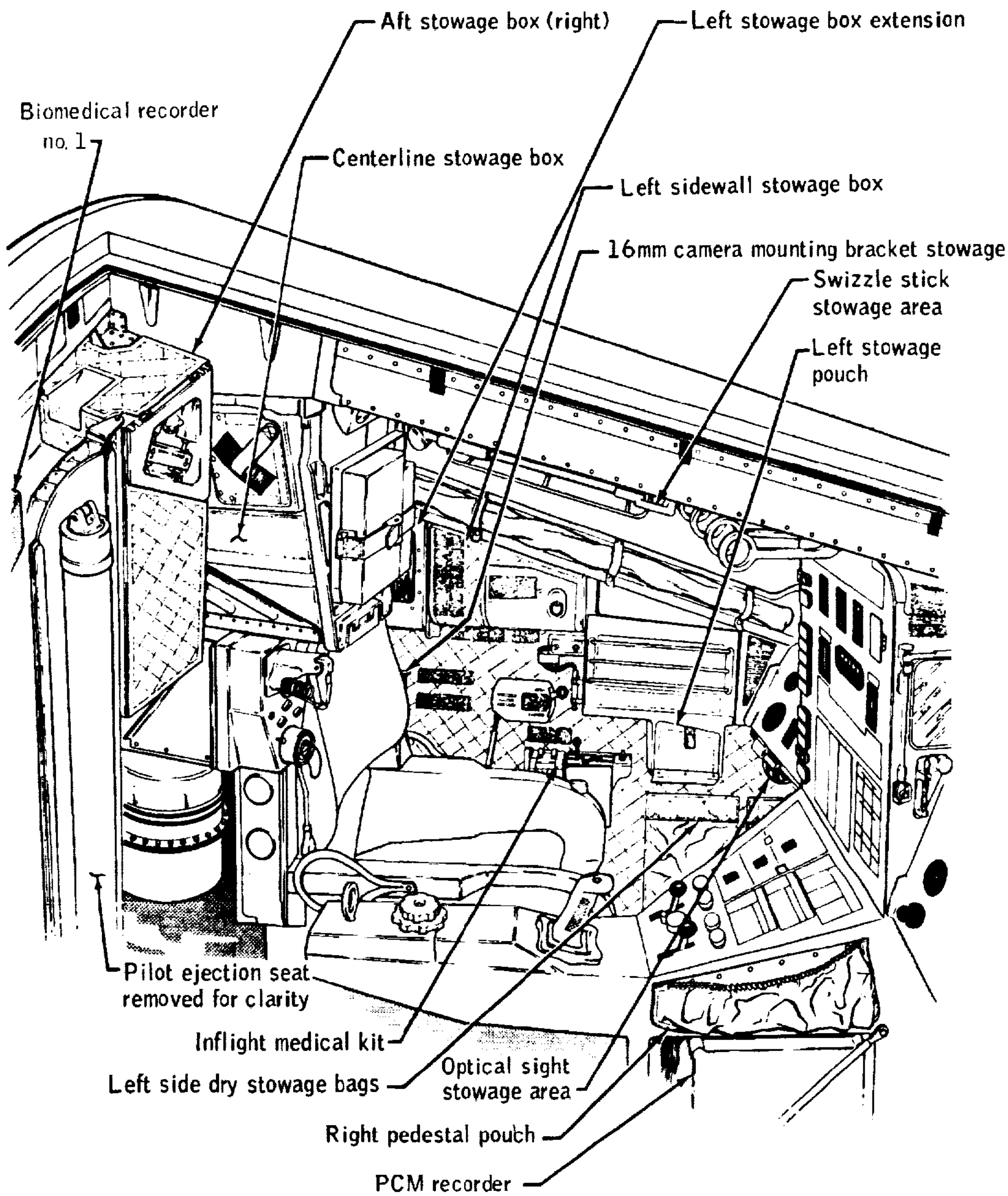

(a) View looking into command pilot's side

Figure 3.1-14. - Spacecraft interior stowage areas.

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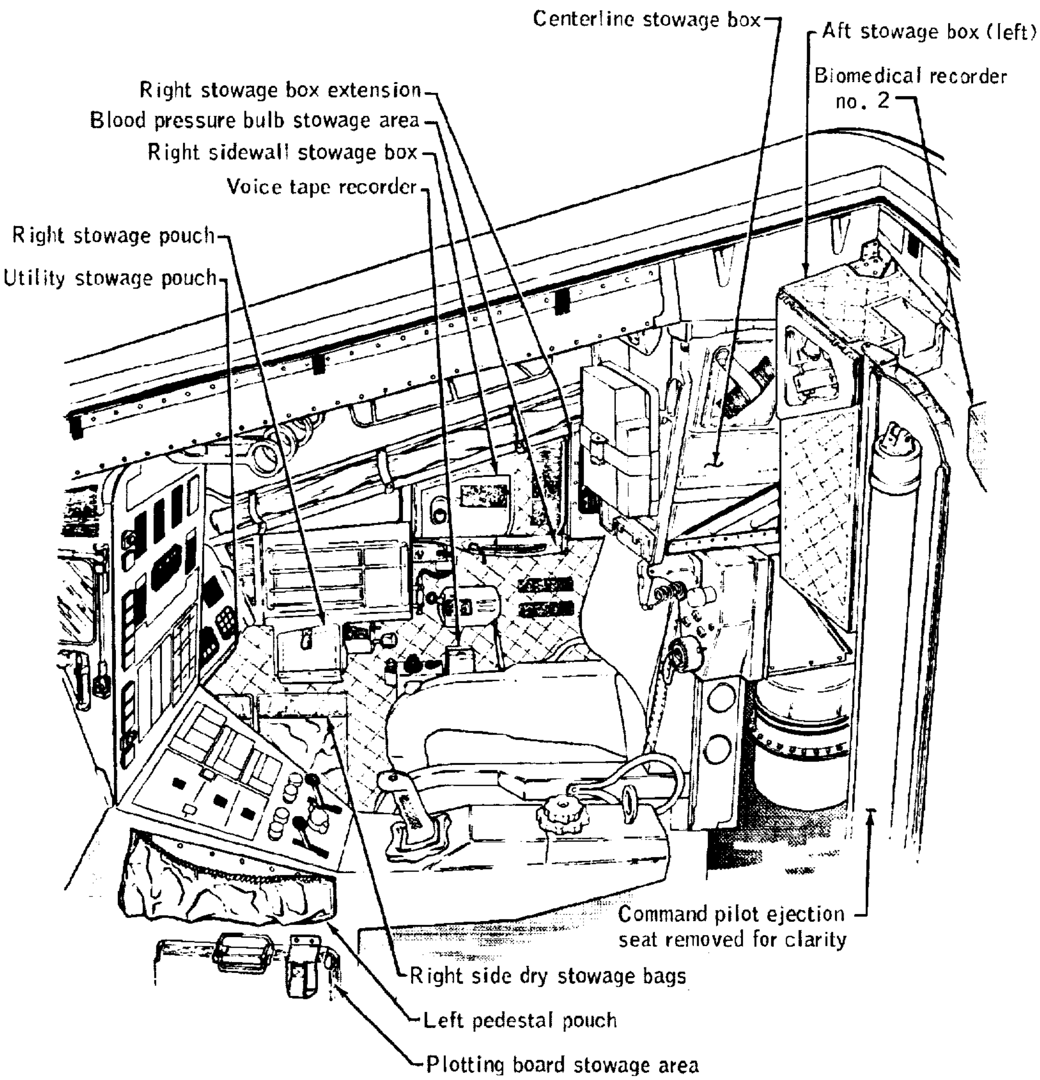

(b) View looking into pilot's side.

Figure 3.1-14. - Concluded.

3.2 GEMINI LAUNCH VEHICLE

Except for minor changes, Gemini launch vehicle 7 (GLV-7) was of the same configuration as GLV-6 (see refs. 6 and 7). Table 3.2-I lists the significant differences between the two vehicles.

3.2.1 Structure

On GLV-2 through GLV-6, cover plates were installed on two of four cutouts for telemetry antennas. On GLV-7 the cutouts were reduced from four to two.

3.2.2 Major Systems

3.2.2.1 Propulsion system.- The GLV-7 propulsion system was the same as the GLV-6 system except that the back-pressure orifice on GLV-6 was reduced from 0.50 inch to 0.46 inch to reduce the possibility of an inadvertent shutdown because of late actuation of the oxidizer pressurant pressure switch (OPPS).

3.2.2.2 Flight control system.- The flight control system was the same as the GLV-6 system.

3.2.2.3 Radio guidance system.- The radio guidance system was the same as the GLV-6 system.

3.2.2.4 Hydraulic system.- The hydraulic system was the same as the GLV-6 system.

3.2.2.5 Electrical system.- A flashing beacon light system similar to that used on GLV-4 was installed on GLV-7. The same type of lights were used on both vehicles; however, the number and arrangement differed. On GLV-4, two lights were installed near the center, and on diametrically opposite sides of the second stage. On GLV-7, four lights were installed near the center, and spaced 90° apart around the circumference. The GLV-7 electrical system was the same as that of GLV-6 in all other respects with the exception of a modification incorporated in GLV-6 subsequent to the attempted Gemini VI-A launch on December 12, 1965. That modification to GLV-6 consisted of a breakwire added to the pad disconnect tail plugs to prevent premature dropout.

3.2.2.6 Malfunction detection system.- The malfunction detection system was the same as the GLV-6 system.

3.2.2.7 Instrumentation.- The instrumentation system was the same as that of GLV-6.

3.2.2.8 Range safety and ordnance systems.- These systems were the same as the GLV-6 systems.

TABLE 3.2-I.- GLV-7 MODIFICATIONS

System	Significant changes incorporated in GLV-7 from GLV-6 configuration
Structure	No significant change.
Propulsion	Modification of back-pressure orifice from 0.50 inch to 0.46 inch on GLV-6 was not accomplished on GLV-7.
Flight controls	No significant change.
Guidance	No significant change.
Hydraulics	No significant change.
Electrical	A flashing beacon light system similar to that used on GLV-4 was added to stage II of GLV-7; however, the number of lights was increased from two to four. Modification of pad disconnect tail plugs on GLV-6 to prevent premature dropout was not accomplished on GLV-7.
Malfunction detection	No significant change.
Instrumentation	No significant change.
Range safety and ordnance	No significant change.

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3.3 GEMINI VII WEIGHT AND BALANCE DATA

Weight and balance data for the Gemini VII space vehicle are as follows:

Condition	Weight (including spacecraft), lb (a)	Center-of-gravity location, in. (a),(b)		
		X	Y	Z
Ignition	346 228	775.2	0.0	59.9
Lift-off	342 569	775.5	0.0	59.9
Stage I burnout (BECO)	84 664	441.4	-.2	59.9
Stage II start of steady-state combustion	73 587	343.7	-.1	59.9
Stage II engine shutdown (SECO)	14 372	292.3	-.6	59.5

[a]Weights and center-of-gravity data were obtained from Aerospace Corporation.

[b]Refer to figure 3.1-1 for GLV 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 location is referenced to water-line 0.00 (60 inches below the horizontal centerline of the horizontal vehicle).

Spacecraft 7 weight and balance data are as follows:

Condition	Weight, lb	Center-of-gravity location, in. (a)		
		X	Y	Z
Launch, gross weight	8076.10	-0.71	0.86	105.12
Retrograde	5648.73	.26	-1.50	128.84
Reentry (0.05g)	4824.33	.10	-1.50	135.54
Main parachute deployment	4427.95	.08	-1.67	129.27
Touchdown (no parachute)	4317.14	.08	-1.73	127.21

[a]The X- and Y-axes are referenced to the centerline of the vehicle. The Z-axis reference is located 13.44 inches aft of the launch vehicle - spacecraft mating plane (GLV station 290.265).

4.0 MISSION DESCRIPTION

4.1 ACTUAL MISSION

A comparison of the planned and actual mission is shown in figure 4.1-1. Lift-off of the Gemini VII vehicle occurred on December 4, 1965, at 19:30:03:702 G.m.t. Lift-off was expected to occur at 19:30:00 G.m.t., but the range sequencer, which times the ignition signal to the launch vehicle, was not properly synchronized with the range countdown clock. For precision lift-off timing, it had been planned that the sequencer would be synchronized 3 seconds ahead of the range clock and the range clock would count toward a T-0 at the desired G.m.t. of lift-off. For a nominal Gemini launch vehicle, this 3 seconds is the time span, to the nearest second, between transmission of the ignition signal and lift-off. Instead, the range sequencer and countdown were exactly synchronized and, with the addition of the uncertainties involved in ignition timing and thrust-chamber pressure buildup, the lift-off of the Gemini VII space vehicle occurred 3.702 seconds later than the planned G.m.t. The vehicle was rolled to the planned azimuth, as confirmed by the Cape Kennedy Range Safety and Mission Control Center plotboards. Unlike all earlier Gemini flights which had lofted flight profiles, the first stage of Gemini VII flew a slightly depressed profile. The Gemini VII launch profile was closer to the predicted nominal trajectory than that of any other Gemini flight, indicating good preflight trajectory predictions. Thrust levels for the first-stage and second-stage engines were nominal. Vehicle steering rates during ground guided flight experienced a slight oscillation in pitch and yaw because of noise in the radar data (see section 5.2.5).

After second stage engine cutoff (SECO), the angular rates were so small that no attitude control was required. A spacecraft separation thrust was applied for approximately 2 seconds, followed by a 180° turnaround. When the launch vehicle second stage came into view, the command pilot thrusted toward it for 5 seconds, resulting in the spacecraft being in close proximity to the second stage. Station keeping started at that time. Several times during powered flight and throughout the mission the fuel-cell differential pressure warning lights were on, indicating a potential problem.

During the initial phase of station keeping, the second stage was venting rather heavily, which apparently imparted both a translation and a rotation to it. This condition, coupled with the high level of action during this period, somewhat complicated the station keeping. After trying several control modes, the command pilot decided on the pulse mode, using the reticle aligned with the horizon. Orbital attitude and maneuver system (OAMS) propellant was used at a greater rate than planned during the station keeping because of the magnitude of second-stage venting and the resulting motions. It was near the end of daylight and the crew experienced difficulty in photographing the second stage because it was directly in line with the sun. As a result of the spacecraft propellant usage, the separation maneuver planned for experiment D-4/D-7 was made earlier and was of shorter duration than originally planned. This maneuver occurred in darkness with thrust being directed downward. Following separation, experiment D-4/D-7 observations were made of the second stage, the space void, and selected stars. The use of the launch vehicle flashing beacon lights to determine separation distance between the spacecraft and the second stage did not prove to be satisfactory.

At 03:47:59 ground elapsed time (g.e.t.), a perigee adjust maneuver was performed using aft thrusters. In performing this maneuver, a star reference was used for yaw attitude rather than using the platform, and pitch and roll attitudes were held at zero degrees with respect to the horizon. The pilot applied the thrust and maintained the correct attitudes while the command pilot timed the maneuver. The resulting orbit was 120 by 174 nautical miles. A set of prepared charts showed the required altitudes for 15 days orbital lifetime at various apogees, as well as phasing with relation to Cape Kennedy to realize an optimum orbit for starting the later rendezvous circularization maneuvers. The chart indicated that a perigee of 120 nautical miles was required instead of the preflight-planned 108 nautical miles because of the 6 nautical mile lower apogee achieved at insertion. In achieving this higher perigee and the desired phasing, this maneuver required the use of approximately 20 pounds of fuel more than planned prior to lift-off; however, this extra fuel usage was somewhat offset by the larger intermediate orbit. After completion of the perigee adjust maneuver, the spacecraft was powered down. The crew then conducted housekeeping activities and commenced the necessary recurring flight plan activities such as: crew status reports, tape dumps, experiments, real-time updates of experiments, fuel cell purges, eating, and sleeping. Routine activities continued until about 22:20:00 g.e.t. at which time a transponder test was performed followed by a D-4/D-7 experiment sequence.

Early in the second day of the flight (Dec. 5), failure of the photometer used in connection with the D-5 (star occultation) experiment was encountered. Several unsuccessful attempts were made during the mission to try to determine the cause of the failure and effect a repair. (See section 8.2 for additional details.) At the end of revolution 27, a successful S-8/D-13 experiment run was made, with the crew achieving visual readings of the ground targets. The MSC-2 and MSC-3 experiments were begun at 27:20:00 g.e.t. and continued for approximately 2 hours. This activity was followed by a fuel-cell purge at about 28:42:00 g.e.t. and a flight-plan update for experiment S-6 to obtain photographs of a storm in the Indian Ocean. A flight plan report was made over the Coastal Sentry Quebec (CSQ) in revolution 20 followed by a planned landing area (PLA) update which was made over Hawaii.

Up to this point in the flight, the command pilot had tried to sleep from about 9 hours g.e.t. to about 14 hours g.e.t. The pilot then tried sleeping from about 14 hours g.e.t. to about 20 hours g.e.t. The alternating sleep period was planned in order to assure that the spacecraft was monitored during the first 24 hours of the mission. After this time, sleep periods were scheduled so that both crewmen would sleep simultaneously on their normal day-night schedule. The ground station was required to monitor the flight during these simultaneous sleep periods during the rest of the mission. Another transponder test was performed at about 43:10:00 g.e.t., during a Cape Kennedy pass, and was followed by S-8/D-13 and M-9 experiment runs. The pilot began removing his pressure suit at 45:03:00 g.e.t., with the complete removal plus donning of the orbital flight suit, including all biomedical instrumentation, requiring approximately 30 minutes. After completion of the suit removal, the pilot executed several experiment S-5 sequences over Mexico and an experiment D-4/D-7 sequence on the star Betelgeuse at 46:41:35 g.e.t. An attempt was made to obtain an experiment D-5 measurement on the same star and equipment problems were again encountered. (See section 8.2.) A very successful experiment D-4/D-7 sequence was obtained of a Polaris launch from a submarine at 47:55:00 g.e.t. Tracking was performed using the pulse mode. This mode was used almost exclusively during the tracking tasks, with very good results. The tracking of a Minuteman missile reentry later in the mission was one of the few times when more response was required than the pulse mode could provide. In that case, the direct mode was used.

An experiment MSC-2/MSC-3 run was made early in the third day of the mission (Dec. 6) without using attitude control. OAMS propellant was being conserved in order to shift the usage rate closer to the premission predicted values. At 51:13:00 g.e.t. an experiment D-9 observation was made using the sextant. In the zero-g condition, handling the sextant did not present a problem; however, the crew did experience problems with the sextant due to light reflection and window glare. The use of the green filter in conjunction with this experiment was not successful because the horizon could not be seen through it. Beginning at approximately 54:25:00 g.e.t., the crew conducted their daily housekeeping activity, followed by periods of eating and sleeping. In preparation for the sleep period, the crew placed aluminum foil over the windows, in addition to the polaroid filters, to keep out all of the light.

A posigrade maneuver was performed during revolution 44 at 69:43:19 g.e.t. to adjust the phase of the orbit. In performing the maneuver, the reticle and a star reference were used for alignment and no particular problem was encountered with this technique. This phase adjustment provided the necessary flexibility so that the orbital altitude could be optimized on the fifth day for a Gemini VI-A launch and rendezvous on either the eighth or ninth day of the Gemini VII flight. The maneuver resulted in a velocity change of 12.6 ft/sec and was made using the aft-firing thrusters for 16.5 seconds.

An experiment S-8/D-13 run was attempted near the end of revolution 46 on the fourth day (Dec. 7), but clouds prevented complete success. At 74:30:00 g.e.t., an experiment S-6 sequence was made of jet-stream clouds over the Pacific Ocean. This was followed by an experiment S-5 sequence obtained while over Southern Mexico. An experiment D-9 run was attempted at 74:56:00 g.e.t., but measurement was difficult because the brightness of the moon tended to dim the stars being used. An experiment D-4/D-7 run was made while over Africa during revolution 49. Tracking of a large fire was accomplished and infrared measurements were obtained. Beginning at 77:37:00 g.e.t., housekeeping was performed, followed by a sleep period that lasted until 88:06:00 g.e.t. An experiment S-5 sequence followed the sleep period, and experiment D-4/D-7 data were obtained of the moon and of land and water at night. Optical communication (experiment MSC-4) runs were attempted while over the White Sands Test Facility near the end of revolution 60, but these were unsuccessful because of a cloud cover.

Early in the fifth day of the mission (Dec. 8), another attempt was made to repair the experiment D-5 photometer, but was not successful. A high frequency (HF) radio test was made during revolution 63, but the spacecraft was unable to receive any transmission. The crew rested or slept from approximately 104 hours through 112 hours g.e.t. The platform and computer were powered up during revolution 74 in preparation for circularization maneuvers. These maneuvers occurred at 119:11:55 and 119:55:01 g.e.t. The first was a posigrade perigee adjust maneuver using the aft-firing thrusters and having a duration of 75.6 seconds with a velocity change of 60 ft/sec. The second was a retrograde apogee adjust maneuver having a 15-second thrust duration, and a 12.1 ft/sec velocity change. These maneuvers resulted in an orbit of 160.5 by 162.8 nautical miles. The OAMS propellant remaining after the two maneuvers was approximately 33 percent of that loaded before the flight.

During the sixth day of the flight (Dec. 9), an experiment S-6 sequence was performed over Mexico. During revolution 79 over Hawaii, an attempt was made to accomplish the MSC-4 (optical communications) experiment. However, clouds prevented acquisition or visual contact from being made. At this point in the mission, the OAMS propellant usage was approximately 6.5 pounds more than predicted.

An experiment S-6 sequence was performed at approximately 145:27 g.e.t. on the seventh day of the flight (Dec. 10), followed by an experiment D-9 run which consisted of measurements of two stars at 145:50 g.e.t. The pilot donned his pressure suit at 148 hours g.e.t. after which the command pilot removed his. After completing housekeeping and eating, the crew powered down the spacecraft and went to sleep at approximately 151:30 g.e.t. During the sleep period, the spacecraft tumbling rate increased to a higher level than had been previously experienced during this mission, and the cabin wall temperatures decreased approximately 20° more than during previous sleep periods. At 163:12 g.e.t., experiment MSC-12 sequence was attempted, but problems with the photometer prevented attaining the desired results. An experiment D-4/D-7 run was completed at 165:50 g.e.t. Several minutes of tracking over both land and water were accomplished. During the pass over Hawaii at 167:45 g.e.t. in revolution 105, the crew acquired the laser beacon with the unaided eye but an attempt to acquire it with the telescope was unsuccessful. There was a tendency for the view to fade when using the green filter in the telescope.

On the eighth day of the mission (Dec. 11), rates began building up as a result of water-boiler venting, necessitating higher OAMS propellant usage to keep the rates low. The decision was made to assume drifting flight in order to conserve fuel. Experiments and other tasks had to be planned around this mode of flight, and many experiment sequences had to be canceled or postponed because the spacecraft attitude was not satisfactory at the time the sequence was planned. Because a large amount of film remained at this time, and because it was difficult to accomplish some experiment sequences while in drifting flight, the crew began taking pictures of terrain and weather patterns considered to be of importance. The command pilot observed several blinks from the ground laser during the pass over the White Sands Test Facility in revolution 119, but no acquisition was made with the telescope. At about 191 hours g.e.t., when the command pilot was in his orbital flight suit and the pilot was in his pressure suit, the crew was given the option to continue the mission with the suit configuration they desired to use. They elected to fly with both pressure suits removed until rendezvous.

Several Apollo landmark photographs were taken early in the ninth day of the flight (Dec. 12), but most of the photographs were taken without using the infrared filter. Flight planners began budgeting 3 pounds of fuel per day for experiments, compared to an earlier budget of 6 pounds per day. As many as possible of the minimum fuel experiment sequences were scheduled.

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On the 10th day of the mission (Dec. 13), the MSC-2/MSC-3 equipment was turned on and a 10-minute sequence was initiated at 216:27 g.e.t. This equipment was turned on again at 218:07 g.e.t. and left on for the remainder of the mission. Activities consisted of flight plan updates, status reports, PLA updates, and fuel-cell purges. In addition, one important experiment sequence performed on this day was a D-4/D-7 sequence of a rocket sled firing. Several D-4/D-7 runs were also made at 238:18 g.e.t. of a Minuteman missile reentry. Tracking was performed in the direct mode for the missile reentry, because there was not enough response in the pulse mode to accomplish this task. After completion of the D-4/D-7 tracking tasks, a decision was made to conserve fuel because the OAMS propellant quantity was just above the cutoff point for the planned rendezvous with spacecraft 6.

Onboard activity was centered around the necessary operational tasks during most of the 11th day (Dec. 14 and 15), with a minimum of fuel allotted for use. An observation was made at the Mission Control Center in Houston, Texas (MCC-H) that the fuel-cell excessive differential pressure which had been a concern since second-stage powered flight, was possibly being caused by the large withdrawal of drinking water each morning. The crew was asked to stagger their drinking and not to withdraw large amounts of water for reconstituting food at the same time.

Gemini VI-A was launched at 13:37:26.47 G.m.t. (258:07:22.77 g.e.t. of Gemini VII) on the 12th day (Dec. 15) of the Gemini VII mission, and was observed by the Gemini VII crew. The actual lift-off was not seen from spacecraft 7, but tracking of powered flight was achieved both visually and with experiment D-4/D-7 equipment. At approximately 259:00 g.e.t. both pilots put their pressure suits back on for rendezvous. Spacecraft 7 played a passive part during the rendezvous, having only the responsibility of maintaining the correct attitude. This was accomplished in the pulse mode. During the rendezvous terminal phase, the initial sighting of spacecraft 6 occurred at a separation distance of approximately 2 miles. After closing to approximately 1/2 mile, the actual thruster firings of spacecraft 6 could be seen by the Gemini VII crew. After completion of the terminal phase of the rendezvous and after station keeping by the Gemini VI-A crew, station keeping was performed by the Gemini VII crew. No difficulties were encountered during this exercise. At approximately 269:30 g.e.t., the Gemini VI-A crew performed a separation maneuver, and the Gemini VII crew obtained a D-4/D-7 experiment sequence of this maneuver. At 281:20 g.e.t., the Gemini VII crew gave a status report and performed S-8/D-13 and M-9 runs. Both crew members removed their pressure suit following these experiment runs at 282 hours g.e.t.

The planned photography of the Gemini VI-A reentry on the 12th day (Dec. 16) was deleted because of the degradation of spacecraft 7 attitude thrusters 3 and 4. These thrusters had been used extensively to control the yaw rates caused by venting during much of the mission. (See section 5.1.8 for a detailed discussion of the thruster problem.)

Because of the drifting mode of flight during the 13th day (Dec. 17), many of the activities were curtailed and the conduct of experiments was limited. The crew was advised to use other thrusters to reduce excessive yaw rates because of the degraded condition of thrusters 3 and 4. One technique was to turn all maneuver-thruster circuit breakers off except no. 12, and all attitude-thruster circuit breakers on except nos. 3 and 4. (See section 5.1.8.) Another problem that continued to warrant attention was the warning light indications of abnormal differential fuel-cell pressures. This situation had been monitored for some time, with performance continuing to degrade in fuel cell section 2. (See section 5.1.7.) Early in revolution 195, stowage for reentry was reported to be progressing with an estimate of about 1 hour needed for completion. Because of the limited amount of fuel remaining which dictated a drifting mode of flight, the only experiments accomplished on the 13th day were an S-5 sequence over North Africa, a D-4/D-7 calibration of the sun, and an S-8/D-13 window measurement.

The final sleep cycle occurred early in the 14th day (Dec. 17) from about 316 hours to 322:30 g.e.t. After the sleep period, the crew began preparing for retrofire; the pressure suits were put back on, and final stowage was accomplished. Platform power up and the alignment checklist were started at approximately 327 hours g.e.t. Attitude thrusters 3 and 4 were tested over Bermuda in preparation for the platform alignment, and proved to be capable of the task. However, because of the degraded condition of the thrusters, the alignment was made manually instead of using the platform mode. A nominal retrofire sequence was performed in darkness at 329:58:04 g.e.t. Attitude control during retrofire was accomplished in the rate command mode.

The spacecraft was rolled to a heads-down attitude following retrofire, and the crew began looking for the horizon. At an altitude of approximately 350K ft, the pilot was able to locate the horizon and provide a description to the command pilot. Approximately 34 seconds before guidance initiate, an update on the bank-angle command was sent by MCC-H. The spacecraft was rolled left 55° after passing 400K ft, and was controlled in the pulse mode until guidance initiate. After guidance initiate, the control was switched to the direct mode and the spacecraft was controlled in the direct mode until yaw oscillations began to build up. The command pilot then switched to single-ring rate command mode, and was able to control very well in this mode until after the acceleration began to fall off. An oscillation increase at that time caused the command pilot to switch to two RCS rings. The parachute sequence was nominal and recovery occurred in a minimum amount of time without incident. The touchdown point (from final Grand Turk Island radar data) was at 70°6.7' west longitude and 25°25.1' north latitude or approximately 6.4 nautical miles uprange of the planned point and 0.5 nautical miles to the left of track.

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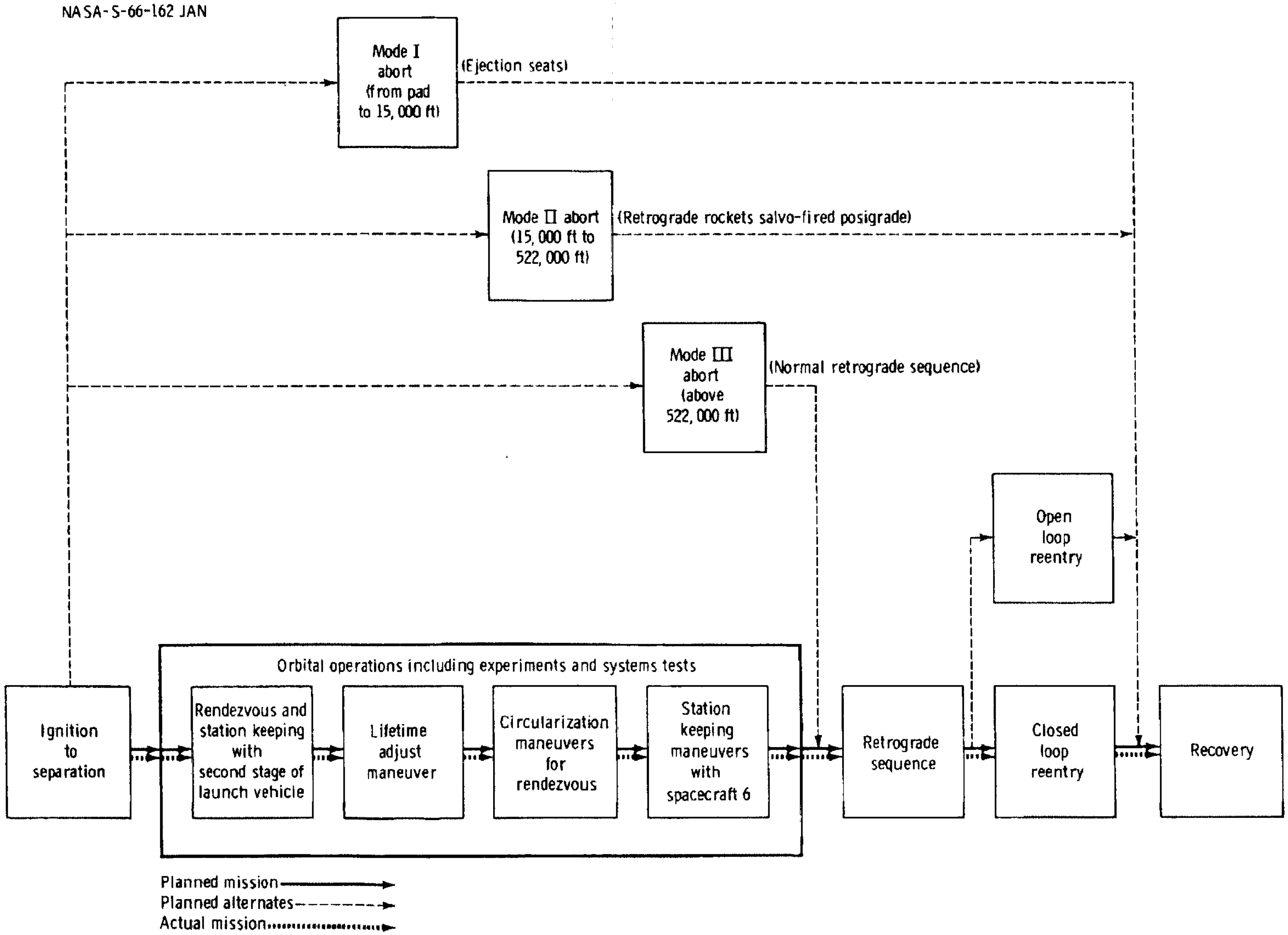

Figure 4.1-1. - Planned and actual mission with planned alternates included.

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4.2 SEQUENCE OF EVENTS

The times at which major events were planned and executed are presented in table 4.2-I. All events were completed as scheduled or within the expected tolerances, indicating a satisfactory flight.

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TABLE 4.2-I.- SEQUENCE OF EVENTS

Event	Planned time, g.e.t.	Actual time, g.e.t.	Difference, sec
Launch phase, sec			
Stage I engine ignition signal (87FS1)	-3.40	-3.51	-0.11
Stage I MDTCPS makes subassembly 1	-2.30	-2.57	-0.27
Stage I MDTCPS makes subassembly 2	-2.30	-2.43	-0.13
TCPS subassembly 1 and subassembly 2 make	-2.20	-2.30	-0.10
Shutdown lockout (back-up)	-0.10	-0.10	0
Lift-off (pad disconnect separation) (19:30:03.702 G.m.t.)	0	0	0
Roll program start	19.44	19.35	-0.09
Roll program end	20.48	20.39	-0.09
Pitch program rate no. 1 start	23.04	22.94	-0.10
Pitch program rate no. 1 end, no. 2 start	88.32	88.04	-0.28
First IGS update sent	105.00	105.00	0
Control system gain change no. 1	109.96	109.60	-0.36
Pitch program rate no. 2 end, no. 3 start	119.04	118.66	-0.38
Second IGS update sent	145.00	145.00	0
Stage I engine shutdown circuitry armed	144.64	144.15	-0.49
Stage I MDTCPS unmake	155.27	155.57	+0.30
BECO (stage I engine shutdown (87FS2))	155.35	155.61	+0.26
Staging switches actuate	155.35	155.61	+0.26
Signals from stage I rate gyro package to flight control system discontinued	155.35	155.61	+0.26
Hydraulic switchover lockout	155.35	155.61	+0.26
Telemetry ceases, stage I	155.35	155.61	+0.26
Staging nuts detonate	155.35	155.61	+0.26
Stage II engine ignition signal (91FS1)	155.35	155.61	+0.26
Control system gain change no. 2	155.35	155.61	+0.26
Stage separation begin	156.05	156.25	+0.20
Stage II engine MDFJPS make	156.25	156.30	+0.05

TABLE 4.2-I.- SEQUENCE OF EVENTS - Concluded

Event	Planned time, g.e.t.	Actual time, g.e.t.	Difference, sec
Launch phase, sec			
Pitch program rate no. 3 ends	162.56	162.02	-0.54
Radio guidance enable	162.56	161.99	-0.57
First guidance command signal recieved by TARS	169.00	168.60	-0.40
Stage II engine shutdown circuitry armed	317.44	316.33	-1.11
SECO (stage II engine shutdown (91FS2))	338.61	337.01	-1.60
Redundant stage II shutdown	338.61	337.04	-1.57
Stage II MDFJPS break	338.91	337.17	-1.74
Spacecraft separation (shaped charge fire)	368.61	368.79	+0.18
Spacecraft – launch vehicle separation	368.75	368.90	+0.15
OAMS on	368.61	367.62	-0.99
OAMS off	370.61	(a)	[illegible]
Orbital phase, hr:min:sec			
D-4/D-7 experiment maneuver	00:22:17	00:21:17	-60
Perigee adjust maneuver	03:47:59	03:47:59	0
Phasing maneuver	69:43:19	69:43:21	+2
Circularization maneuver	119:11:55	119:11:55	0
Circularization maneuver	119:55:01	119:55:01	0
Reentry phase, hr:min:sec			
Retrofire initiation	329:58:04	329:58:04	0
Begin blackout	330:22:08	330:21:43	-25
End blackout	330:27:34	330:27:32	-2
Drogue parachute deployment	330:29:26	330:29:30	+4
Drogue parachute release		330:31:02	
Pilot parachute deployment/ main parachute initiation	330:31:04	330:31:03	-1
Landing	330:35:20	330:35:01	-19
Main parachute jettison	--	330:35:02	--

[a]A telemetry false reset at 368.44 seconds from lift-off resulted in a loss of data between that time and 370.63 seconds; TCA's 9 and 10 were indicating on at the start of this period and off when the data returned to normal.

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4.3 FLIGHT TRAJECTORIES

The launch and orbital trajectories referred to as planned are either preflight calculated nominal trajectories from references 8 and 9 or trajectories based on nominal outputs from the real-time computer complex (RTCC) and planned attitudes and sequences as determined in real time by the auxiliary computer room (ACR). The actual trajectories are based on the Manned Space Flight Network tracking data and actual attitude and sequences as determined by airborne instrumentation. 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 for all trajectories except the actual launch phase which was measured up to an altitude of 25 nautical miles at the time of launch. The earth model for all trajectories contained geodetic and gravitational constants representing the Fischer ellipsoid. Ground tracks of the first four revolutions and from retrofire to landing are shown in figure 4.3-1. The launch trajectory, orbital attitudes, and the reentry trajectory curves are presented in figures 4.3-2 to 4.3-4.

4.3.1 Gemini Space Vehicle

4.3.1.1 Launch.- 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 utilized data from the missile trajectory measurement system (MISTRAM), FPQ-6, and TPQ-18 radars. The GMCF utilized data from the GE Mod III radar. Data from these tracking facilities were used during the time periods listed in the following table:

Facility	Time from lift-off, sec
IP 3600 (FPQ-6 and TPQ-18),[(a)] GMCF (GE Mod III)	0 to 52
IP 3600 (MISTRAM),[(a)] GMCF (GE Mod III)	52 to 261
GMCF (GE Mod III)	261 to 418

(a) The automatic data select program alternated between the radar sources listed.

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The actual launch trajectory, as compared with the planned launch trajectory in figure 4.3-2, was essentially nominal in altitude, slightly high in velocity, and low in flight-path angle during stage I powered flight. After BECO, very little correction was required from the radio guidance system (RGS) to guide stage II to a near nominal insertion. At BECO, the altitude and velocity were high by 2016 ft and 132 ft/sec, respectively; and flight-path angle was low by 0.14°. At SECO, the altitude was 175 ft high, the velocity was 7 ft/sec low, and the flight-path angle was 0.04° high. Actual SECO conditions were based on inertial guidance system (IGS) corrected data. At spacecraft separation, the altitude was 280 ft high, velocity was 11 ft/sec low, and flight-path angle was 0.03° high. Table 4.3-I contains a comparison of planned and actual conditions at BECO, SECO, and spacecraft separation. The preliminary conditions at spacecraft separation were obtained by integrating the Bermuda vector after insertion back to the time of separation, and it was assumed that there was no overall velocity change as a result of station-keeping maneuvers. The final conditions were obtained by generating an orbital ephemeris using Bermuda, Grand Bahama, Grand Turk, and Canary Island tracking data from SECO through station keeping, and fitting a trajectory through the velocity changes that resulted from station keeping. It can be seen, however, that the preliminary solution agrees with the final solution.

The GE Mod III and MISTRAM tracking radar 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 condition obtained from GE Mod III showed the velocity and flight-path angle to be low by 7 ft/sec and 0.01°, respectively, when compared to the more accurate orbital ephemeris data. The conditions obtained from MISTRAM showed velocity to be high by 3 ft/sec and the flight-path angle to be low by 0.09°. All of these indications were well within the "go" conditions for this flight.

4.3.1.2 Orbit.- The Gemini crew performed station keeping with the launch vehicle second stage for 15 minutes after insertion during which time they effectively brought the relative velocity to zero. At 00:21:17 g.e.t., a radial maneuver was performed in order to fly in-plane around the launch vehicle second stage, a requirement for the D-4/D-7 experiment. Table 4.3-II contains a comparison of the planned and actual maneuvers performed during the mission. Table 4.3-III shows the planned and actual orbital elements after each maneuver and table 4.3-IV shows the orbital elements for every 16th revolution. A comparison of planned and actual apogees and perigees is shown in figure 4.3-3. These planned and actual elements were obtained from orbital ephemerides generated by using the sequences in reference 9 and by integrating the Gemini tracking network vectors, respectively.

The gradual rise in perigee altitude (measured as height above a spherical earth), which was observed during the flights of Gemini V and Gemini VII, may be attributed to the combined perturbative effects of the earth's equatorial bulge and the excessive mass in its southern hemisphere (the bottom of the pear). The equatorial bulge caused the Gemini VII perigee to advance about 12° per day. As the perigee point approached the southern hemisphere, the effect of the increasing earth mass was to cause the perigee radius to lengthen by about 0.2 nautical mile per day. The apogee radius shortened by the same amount. Thus, the semimajor axis or the orbit was remaining unchanged, but its eccentricity was gradually decreasing. This long-term periodic variation in orbital eccentricity is represented mathematically by the equation

$$\Delta e = \frac{-2}{3} \frac{J_3}{J_2} \frac{r_e}{P} \left(1 - e^2\right)^{\frac{1}{2}} \sin I \sin \left(\omega_o + \dot{\omega} t\right)$$

where:

J_2 = second zonal harmonic

J_3 = third zonal harmonic

r_e = earth equatorial radius

P = semilatus rectum

e = eccentricity

I = inclination

ω_o = initial value of perigee

$\dot{\omega}$ = secular advance of ω

The second harmonic J_2 represents the effects of the earth's equatorial bulge. The third harmonic J_3 represents the effects of the excessive mass in the southern hemisphere. The period of the long-term effect is about 30 days, or the length of time for the perigee point to make a complete cycle around the earth. The variation in the Gemini VII perigee height would have been 2.5 miles over one cycle, where its maximum altitude would have been achieved in the southern hemisphere and its minimum altitude in the northern hemisphere. An empirical formula for the change in perigee height is:

$$\Delta r_p = - 1.25 \sin \omega$$

where Δr_p, in nautical miles, represents the deviation in perigee height from its value when perigee is at the equator.

The phenomenon of apsidal "shift" may be explained as well from the energy standpoint. The total energy of an orbit undergoing very little atmospheric drag remains virtually fixed.

total energy = kinetic energy + potential energy

or

$$E_T = \frac{1}{2} mv^2 - \frac{GMm}{r}$$

where:

G = universal gravitational constant

M = mass of earth

m = mass of spacecraft

The equation has a constant value. As perigee moves southward, then, the total energy of this point remains fixed; but, the potential energy of the vehicle increases because of the increasing mass below, and the kinetic energy and velocity of the vehicle decreases accordingly. The relationship between perigee radius and velocity as given by the following equation shows that, as the velocity at perigee decreases, the perigee radius must increase.

$$r_P = \frac{2a}{\left(1 + \frac{aV_P{}^2}{\mu}\right)}$$

where:

a = semimajor axis

V_P = velocity at perigee

μ = gravitational constant of earth

During the Gemini VII mission, the circularization maneuvers were performed at the start of the 6th day and about 1 and 1/2 days before perigee crossed over the equator toward the southern hemisphere. Perigee was approximately 1.2 nautical miles lower than apogee after the maneuver but, by the time it had traversed to a position over the equator, the orbit was very close to circular and essentially had no apogee or perigee. However, the forces explained in the preceding paragraphs continued to raise the point in the orbit which had been perigee, making it, by definition, apogee.

After circularization, the perigee (changing to apogee) increased from 161.6 nautical miles at circularization to 164.3 nautical miles in the last orbit before retrofire and, over the same period of 8 days, the apogee (changing to perigee) decreased from 162.8 to 158.2 nautical miles. The larger change in apogee (perigee) than in perigee (apogee) resulted in a lower average orbital height due to the small drag force acting on the spacecraft. It is interesting to note that, if the flight had continued for several days, the orbit would have returned to circular after perigee (apogee) had traversed back into the northern hemisphere.

The $C_D A\rho$ term uncertainty was investigated after the Gemini V mission. The major problem appears to be the density ρ discrepancy between the 1959 ARDC atmosphere, which was obtained during a high cycle of solar activity, and the current atmosphere, which is now in a low cycle of solar activity. The 1959 atmosphere deviates from the current atmosphere by about 50 percent at the orbital altitude of this mission. Based on tracking data, the RTCC and ACR computed a K factor of 0.5 to apply against the C_D which agreed with the atmosphere discrepancy of 50 percent.

4.3.1.3 Reentry.- The planned and actual reentry phase of the trajectory is shown in figure 4.3-4. The planned trajectory was determined by integrating the Woomera vector taken during revolution 205 through planned retrofire sequences determined by the RTCC, and simulating a 53° bank-angle lifting reentry according to Math Flow 6 described in reference 10. The Woomera vector was selected one revolution before retrofire because the retrofire setting in the spacecraft was based on that solution. The reentry trajectory in figure 4.3-4 is a simulated reentry required to achieve the actual landing point. It was obtained by integrating the White Sands vector after retrofire back to the end of retrofire, then forward to landing through bank and reverse bank angles of 48.8°. An actual reentry trajectory could not be obtained because the real-time telemetry containing reentry attitudes was lost during communications blackout period and the onboard telemetry recorder had failed before reentry. The crew stated that they flew the instruments (cross-range and down-range error indicators) after guidance initiate, and reversed bank four or five times as required to null out cross-range dispersions. The crew stated that reentry was accomplished at about 35° roll. They reported a maximum g of 3.9, compared to 4.5g obtained with both the simulated reentry trajectory and the real-time telemetry obtained after blackout. It is believed that the simulated reentry trajectory is reasonable because the blackout times agree within 17.0 seconds of actual blackout, maximum g loads agree with telemetry at the analogous times, and parachute deployment altitudes at recorded sequence times agree with those reported in section 5.1.11. Table 4.3-I contains a comparison of reentry dynamic parameters and landing points. The final landing point, as determined by Grand Turk Island tracking, was 6.4 nautical miles uprange from the planned point.

4.3.2 Gemini Launch Vehicle Second Stage

The second stage of the Gemini launch vehicle was inserted into an orbit with apogee and perigee altitudes of 176.8 and 87.2 nautical miles.

The Gemini network tracking radars and the North American Air Defense Command (NORAD) network tracking sensors were able to skin-track the second stage during the ensuing 3-day orbit lifetime. NORAD tracked the second stage prior to reentry in revolution 44, during the final orbit, and predicted an impact point of latitude 14° S. and longitude 118° W. in the South Pacific.

TABLE 4.3-I.- COMPARISON OF PLANNED AND ACTUAL TRAJECTORY PARAMETERS

Condition	Planned	Actual	
		Preliminary	Final
BECO			
Time from lift-off, sec	155.35	Not computed	155.61
Geodetic latitude, deg North	28.60		28.60
Longitude, deg West	79.61		79.57
Altitude, ft	205 084		207 100
Altitude, n.mi.	33.8		34
Range, n.mi.	50.3		52.3
Space-fixed velocity, ft/sec	9 910		10 042
Space-fixed flight-path angle, deg	18.76		18.62
Space-fixed heading angle, deg E of N	85.14		84.87
SECO			
Time from lift-off, sec	338.61	Not computed	337.01
Geodetic latitude, deg North	29.01		29.02
Longitude, deg West	71.84		71.82
Altitude, ft	529 265		529 440
Altitude, n.mi.	87.1		86.9
Range, n.mi.	460.5		461.8
Space-fixed velocity, ft/sec	25 721		25 714
Space-fixed flight-path angle, deg	0.0		0.04
Space-fixed heading angle, deg E of N	88.68		88.67
Spacecraft separation			
Time from lift-off, sec	368.61	368.79	368.79
Geodetic latitude, deg North	29.03	29.05	29.05
Longitude, deg West	69.60	69.45	69.45
Altitude, ft	529 242	529 761	529 978
Altitude, n.mi.	87.1	87.2	87.2
Range, n.mi.	578.0	585.5	585.4
Space-fixed velocity, ft/sec	25 804	25 793	25 793
Space-fixed flight-path angle, deg	0.01	0.06	0.05
Space-fixed heading angle, deg E of N	89.82	89.88	89.88

TABLE 4.3-I.- COMPARISON OF PLANNED AND ACTUAL TRAJECTORY PARAMETERS - Concluded

Condition	Planned	Actual	
		Preliminary	Final
Maximum conditions			
Altitude, statute miles	210.7	203.7	203.7
Altitude, n.mi.	183.1	177.1	177.1
Space-fixed velocity, ft/sec	25 804	25 793	25 795
Earth-fixed velocity, ft/sec	24 435	24 424	24 426
Exit acceleration, g	7.3	7.3	7.3
Exit dynamic pressure, lb/sq ft	756	703	703
Reentry deceleration, g (tracking data)	4.7	4.5	4.5
Reentry deceleration, g (telemetry data)	N/A	4.5	4.5
Reentry dynamic pressure, lb/sq ft	311	302	302
Landing point			
Latitude	25°23' N.	[a]25°22' N.	[b]25°25.1' N.
Longitude	70°00' W.	[a]70°00' W.	[b]70°06.7' W.

[a]Based on recovery ship position data taken at spacecraft retrieval.

[b]Based on final Grand Turk Island radar tracking data.

TABLE 4.3-II.- GEMINI VII MANEUVERS

Condition	Planned (a)	Actual
D-4/D-7 experiment		
Maneuver initiate, hr:min:sec, g.e.t.	0:22:17	0:21:17
ΔV, ft/sec	7.5	8.8
Δt, sec	20	21.2
Pitch, deg	-25.2	-41.5
Yaw, deg	0	49
Thruster	up	up
Perigee adjust		
Maneuver initiate, hr:min:sec, g.e.t.	3:47:59	[b]3:47:59
ΔV, ft/sec	59	58.1
Δt, sec	77	76.2
Pitch, deg	0	-5.6
Yaw, deg	0	4.2
Thruster	aft	aft
Phase adjust		
Maneuver initiate, hr:min:sec, g.e.t.	69:43:19	[b]69:43:19
ΔV, ft/sec	12.4	12.6
Δt, sec	16.5	16.5
Pitch, deg	0	-5.5
Yaw, deg	0	-3.3
Thruster	aft	aft

[a]Planned maneuvers are those computed by the RTCC and transmitted to the crew during the mission.

[b]Maneuvers obtained from orbital Gemini Network tracking data.

TABLE 4.3-II.- GEMINI VII MANEUVERS - Concluded

Condition	Planned (a)	Actual
Circular perigee adjust		
Maneuver initiate, hr:min:sec, g.e.t.	119:11:55	119:11:55
ΔV, ft/sec	61.2	60.0
Δt, sec	78	75.6
Pitch, deg	0	-1.3
Yaw, deg	0	0
Thruster	aft	aft
Circular apogee adjust		
Maneuver initiate, hr:min:sec, g.e.t.	119:55:01	119:55:01
ΔV, ft/sec	12.1	12.1
Δt, sec	15	15
Pitch, deg	0	1.2
Yaw, deg	180	178.1
Thruster	aft	aft

[a]Planned maneuvers are those computed by the RTCC and transmitted to the crew during the mission.

TABLE 4.3-III.- COMPARISON OF ORBITAL ELEMENTS FOR MANEUVERS

Maneuver	Condition	Before maneuver			After maneuver		
		Planned	Actual		Planned	Actual	
			Preliminary (a)	Final		Preliminary (a)	Final
Station keeping and D-4/D-7 experiment	Apogee, n. mi. . . .	183.1	176.9	177.1	180.1	174.4	174.4
	Perigee, n. mi. . . .	87.1	86.9	87.2	87.1	88.1	88.2
	Inclination, deg. . .	28.87	28.90	28.89	28.87	28.90	28.89
	Period, min	89.50	--	89.39	89.50	--	89.35
Perigee adjust revolution 3	Apogee, n. mi. . . .	180.1	174.4	174.3	180.1	174.1	174.3
	Perigee, n. mi. . . .	87.1	88.1	88.2	114.2	120.0	119.6
	Inclination, deg. . .	28.87	28.93	28.89	28.87	28.93	28.89
	Period, min	89.50	--	89.35	89.95	--	89.98
Phase adjust revolution 44	Apogee, n. mi. . . .	174.6	171.4	170.9	Not available	171.4	170.9
	Perigee, n. mi. . . .	111.8	120.2	119.5		127.2	126.5
	Inclination, deg. . .	28.87	28.90	28.89		28.90	28.89
	Period, min	89.87	--	89.93		--	90.07
Circularize revolution 75/76	Apogee, n. mi. . . .	167.6	169.8	168.2	161.0	163.2	162.8
	Perigee, n. mi. . . .	108.6	127.7	126.0	158.7	161.6	160.5
	Inclination, deg. . .	28.87	28.90	28.89	28.87	28.92	28.89
	Period, min	89.78	--	90.07	90.56	--	90.61

[a]Preliminary elements are RTCC values obtained during the mission. Period was not available.

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TABLE 4.3-IV.- COMPARISON OF ORBITAL ELEMENTS

Revolution	Condition	Planned	Actual Preliminary (a)	Actual Final
Insertion	Apogee, n. mi.	183.1	176.9	177.1
	Perigee, n. mi.	87.1	86.9	87.2
1	Inclination, deg	28.87	28.90	28.89
	Period, min	89.50	--	89.39
16	Apogee, n. mi.	178.5	173.4	172.8
	Perigee, n. mi.	113.5	120.0	120.4
	Inclination, deg	28.87	28.91	28.89
	Period, min	89.92	--	89.94
32	Apogee, n. mi.	176.3	172.4	172.2
	Perigee, n. mi.	112.6	119.9	119.8
	Inclination, deg	28.87	28.89	28.89
	Period, min	89.89	--	89.94
48	Apogee, n. mi.	174.0	171.2	170.7
	Perigee, n. mi.	111.5	127.1	126.4
	Inclination, deg	28.87	28.91	28.89
	Period, min	89.86	--	90.07
64	Apogee, n. mi.	171.6	170.5	169.2
	Perigee, n. mi.	110.4	127.4	126.1
	Inclination, deg	28.87	28.93	28.89
	Period, min	89.84	--	90.06
80	Apogee, n. mi.	169.1	162.8	162.5
	Perigee, n. mi.	109.3	161.6	159.5
	Inclination, deg	28.87	28.90	28.89
	Period, min	89.81	--	90.61
96	Apogee, n. mi.	160.9	162.4	162.1
	Perigee, n. mi.	158.6	162.0	159.4
	Inclination, deg	28.87	28.91	28.89
	Period, min	90.54	--	90.60

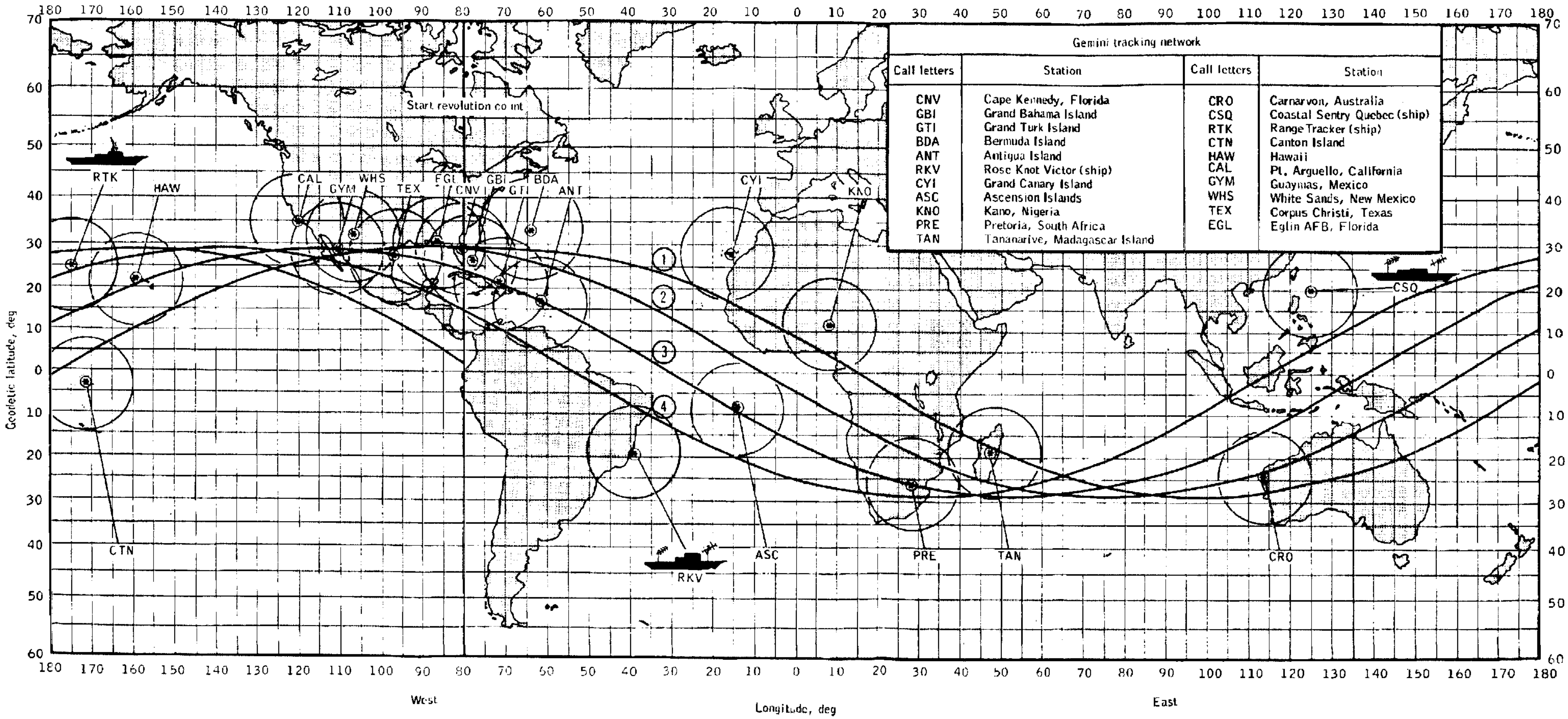
[a]Preliminary elements are RTCC values obtained during the mission. The altitude is measured above the launch complex 19 earth radius. Period was not available.

TABLE 4.3-IV.- COMPARISON OF ORBITAL ELEMENTS - Concluded

Revolution	Condition	Planned	Actual	
			Preliminary (a)	Final
112	Apogee, n. mi.	160.1	162.6	162.0
	Perigee, n. mi.	157.8	161.1	158.8
	Inclination, deg	28.87	28.90	28.89
	Period, min	90.53	--	90.59
128	Apogee, n. mi.	159.4	162.7	161.8
	Perigee, n. mi.	157.1	161.2	158.0
	Inclination, deg	28.87	28.92	28.89
	Period, min	90.51	--	90.58
144	Apogee, n. mi.	159.1	163.3	162.1
	Perigee, n. mi.	156.8	159.6	157.5
	Inclination, deg	28.87	28.93	28.89
	Period, min	90.49	--	90.57
160	Apogee, n. mi.	158.8	163.4	162.5
	Perigee, n. mi.	156.5	159.4	157.1
	Inclination, deg	28.87	28.89	28.89
	Period, min	90.46	--	90.57
176	Apogee, n. mi.	158.6	163.7	162.7
	Perigee, n. mi.	156.3	158.8	156.6
	Inclination, deg	28.87	28.93	28.89
	Period, min	90.43	--	90.57
192	Apogee, n. mi.	158.4	164.3	163.3
	Perigee, n. mi.	156.1	158.7	156.5
	Inclination, deg	28.87	28.93	28.89
	Period, min	90.40	--	90.57
206 (prior to retrofire)	Apogee, n. mi.	158.2	164.2	163.6
	Perigee, n. mi.	155.9	158.2	156.5
	Inclination, deg	28.87	28.90	28.89
	Period, min	90.38	--	90.57

[a]Preliminary elements are RTCC values obtained during the mission. The altitude is measured above the launch complex 19 earth radius. Period was not available.

NASA-S-66-80 JAN



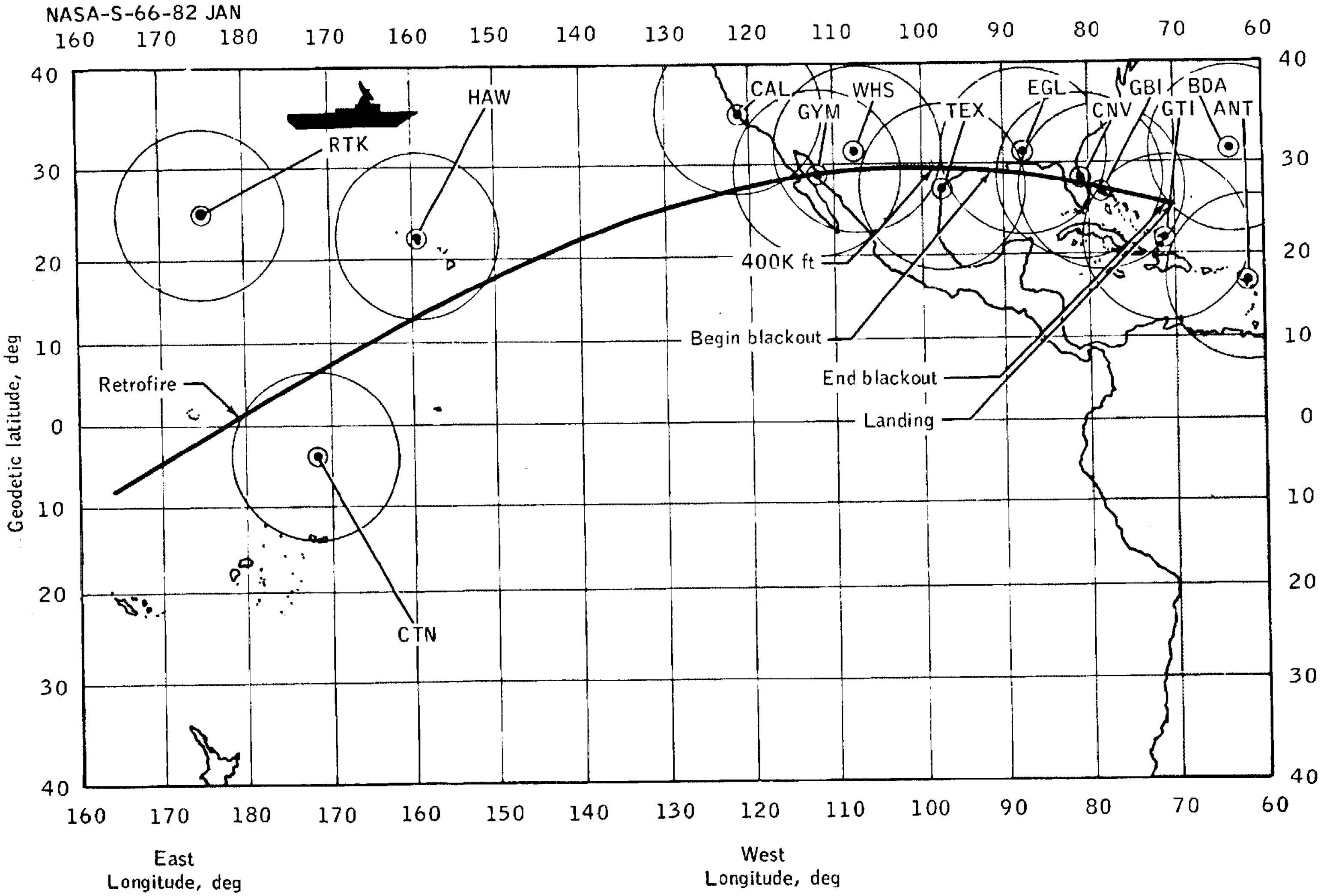
Gemini tracking network

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	RTK	Range Tracker (ship)
BDA	Bermuda Island	CTN	Canton Island
ANT	Antigua Island	HAW	Hawaii
RKV	Rose Knot Victor (ship)	CAL	Pt. Arguello, California
CYI	Grand Canary Island	GYM	Guaymas, Mexico
ASC	Ascension Islands	WHS	White Sands, New Mexico
KNO	Kano, Nigeria	TEX	Corpus Christi, Texas
PRE	Pretoria, South Africa	EGL	Eglin AFB, Florida
TAN	Tananarive, Madagascar Island		

(a) Revolutions 1 through 4
Figure 4.3-1. - Ground track for the Gemini VII orbital mission.

4-28-a

4-28-b



(b) Reentry.

Figure 4. 3-1.- Concluded.

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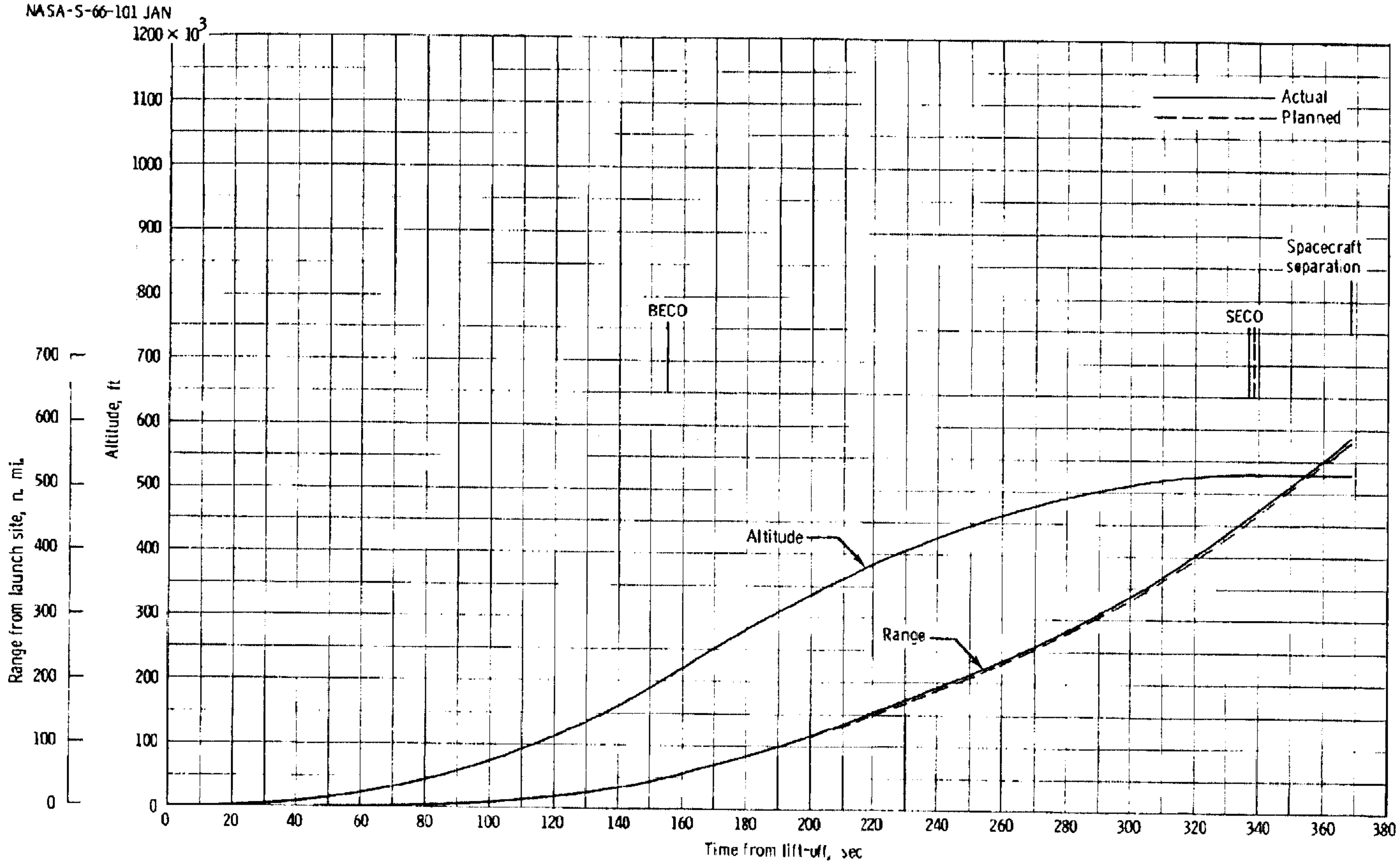

(a) Altitude and range.

Figure 4. 3-2. - Trajectory parameters for the Gemini VII mission launch phase.

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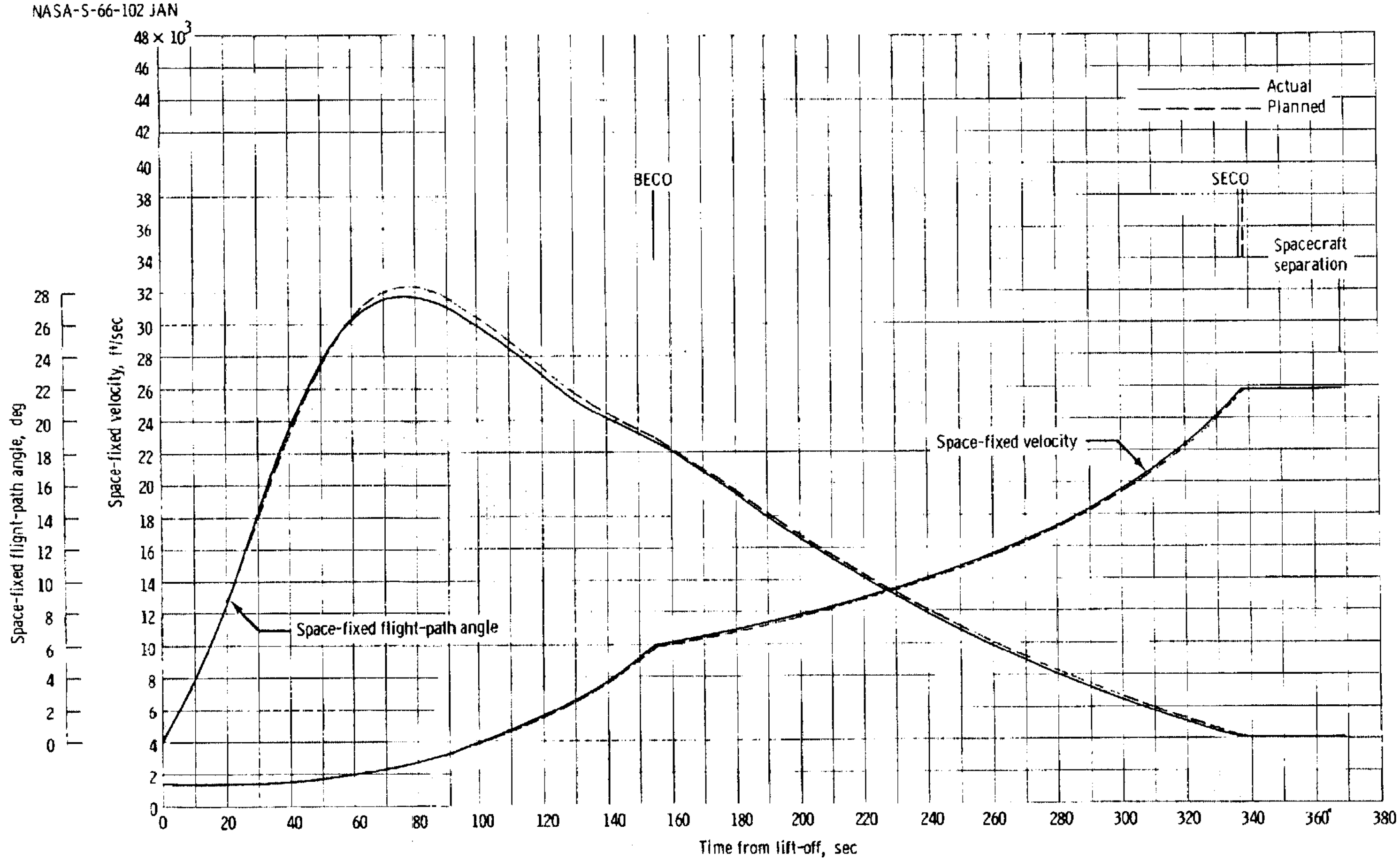
NASA-S-66-102 JAN



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

Figure 4. 3-2. - Continued.

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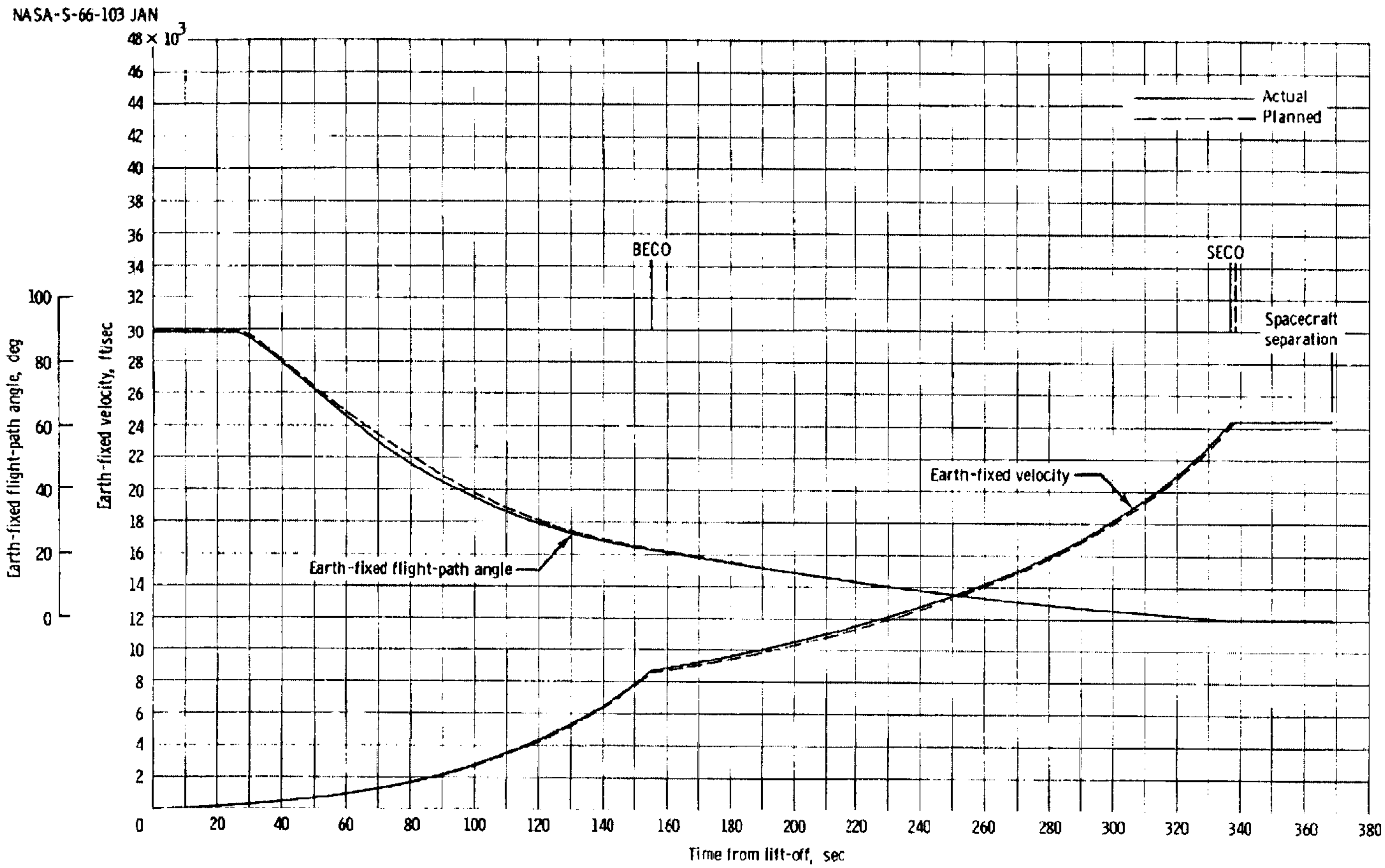

(c) Earth-fixed velocity and flight-path angle.

Figure 4. 3-2.- Continued.

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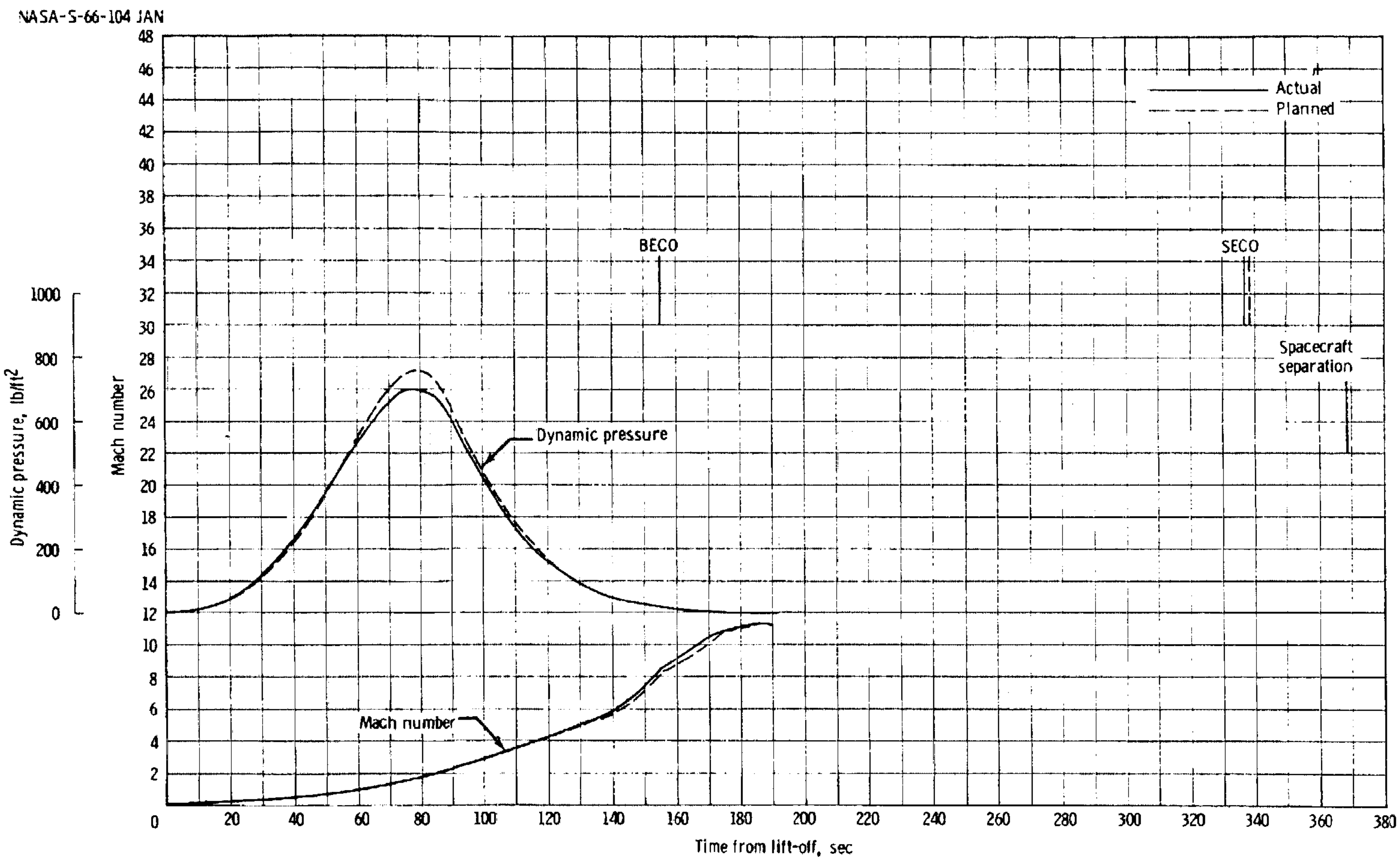

(d) Dynamic pressure and Mach number.

Figure 4. 3-2.- Continued.

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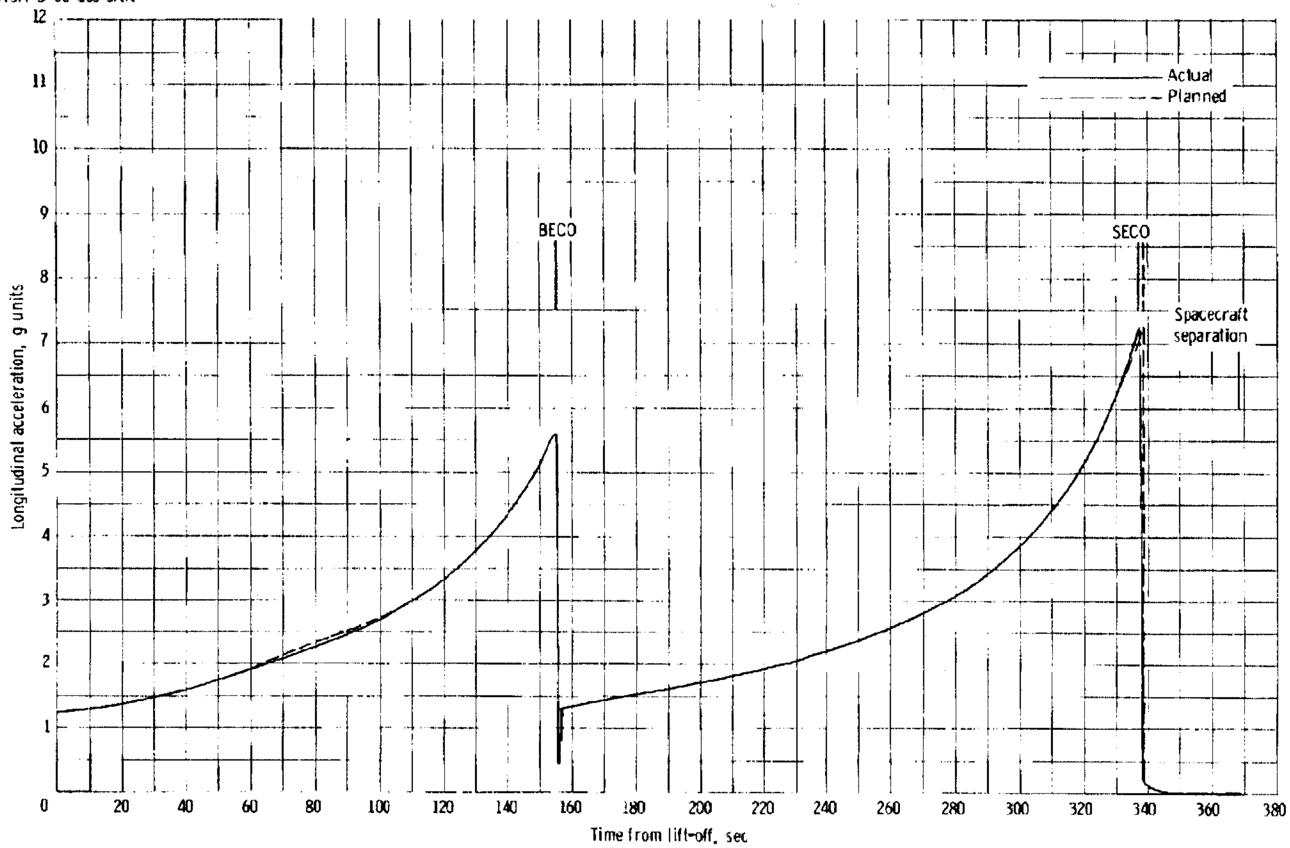
NASA-S-66-105 JAN



(e) Longitudinal acceleration.

Figure 4. 3-2. - Concluded.

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NASA-S-66-120 JAN

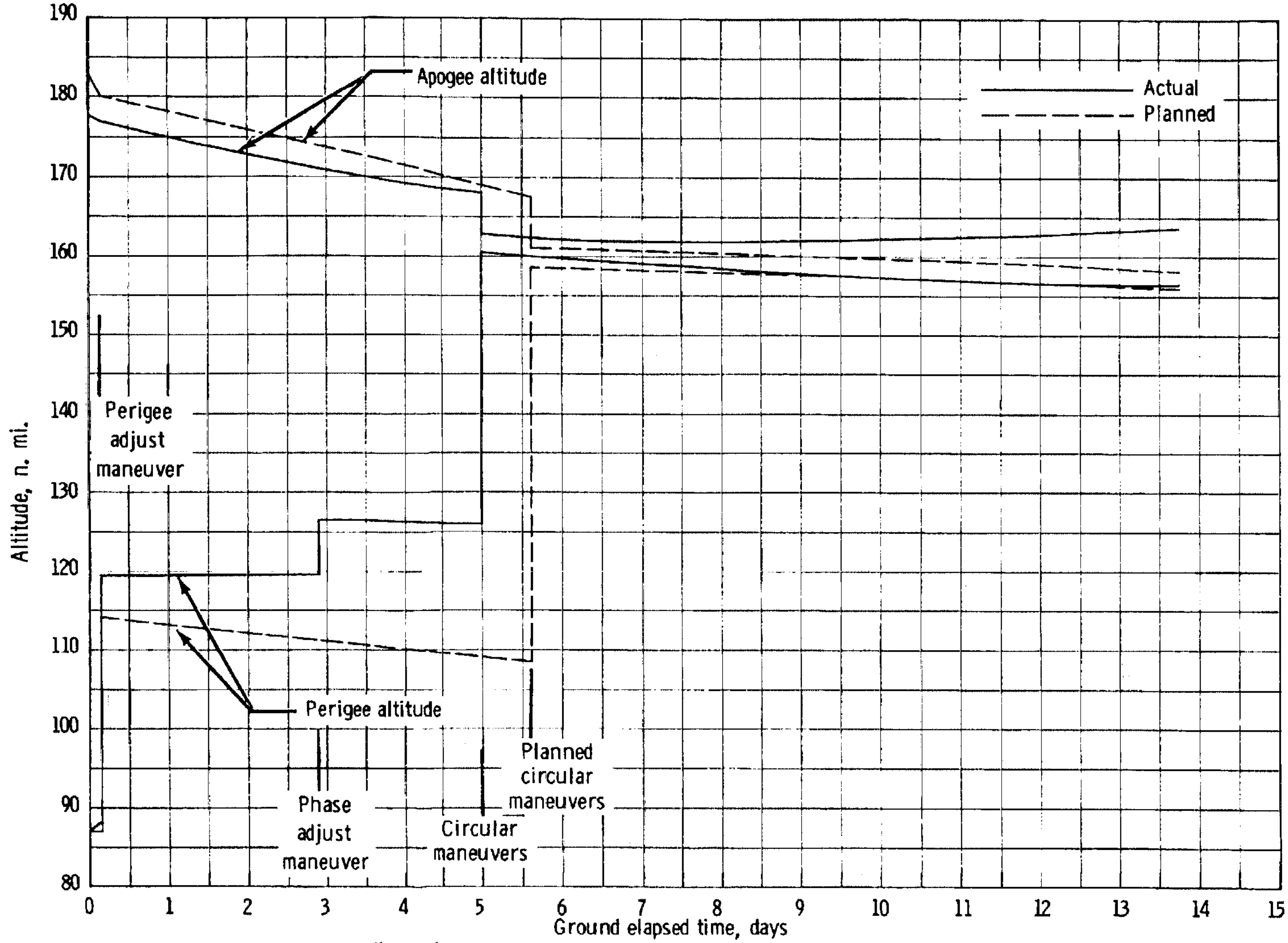

Figure 4.3-3.- Apogee and perigee altitude for Gemini VII mission.

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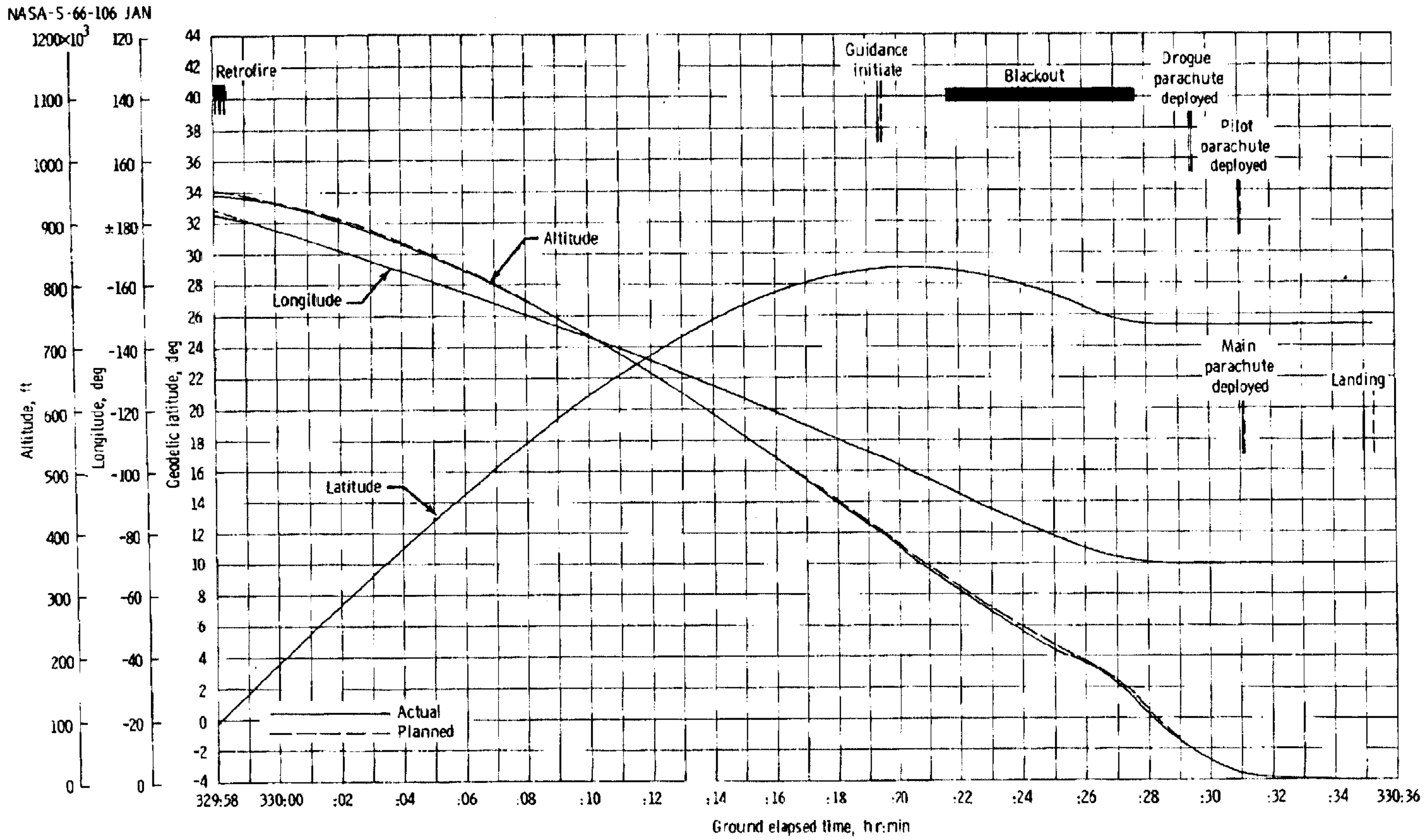

(a) Latitude, longitude, and altitude.

Figure 4.3-4. - Trajectory parameters for the Gemini VII mission reentry phase.

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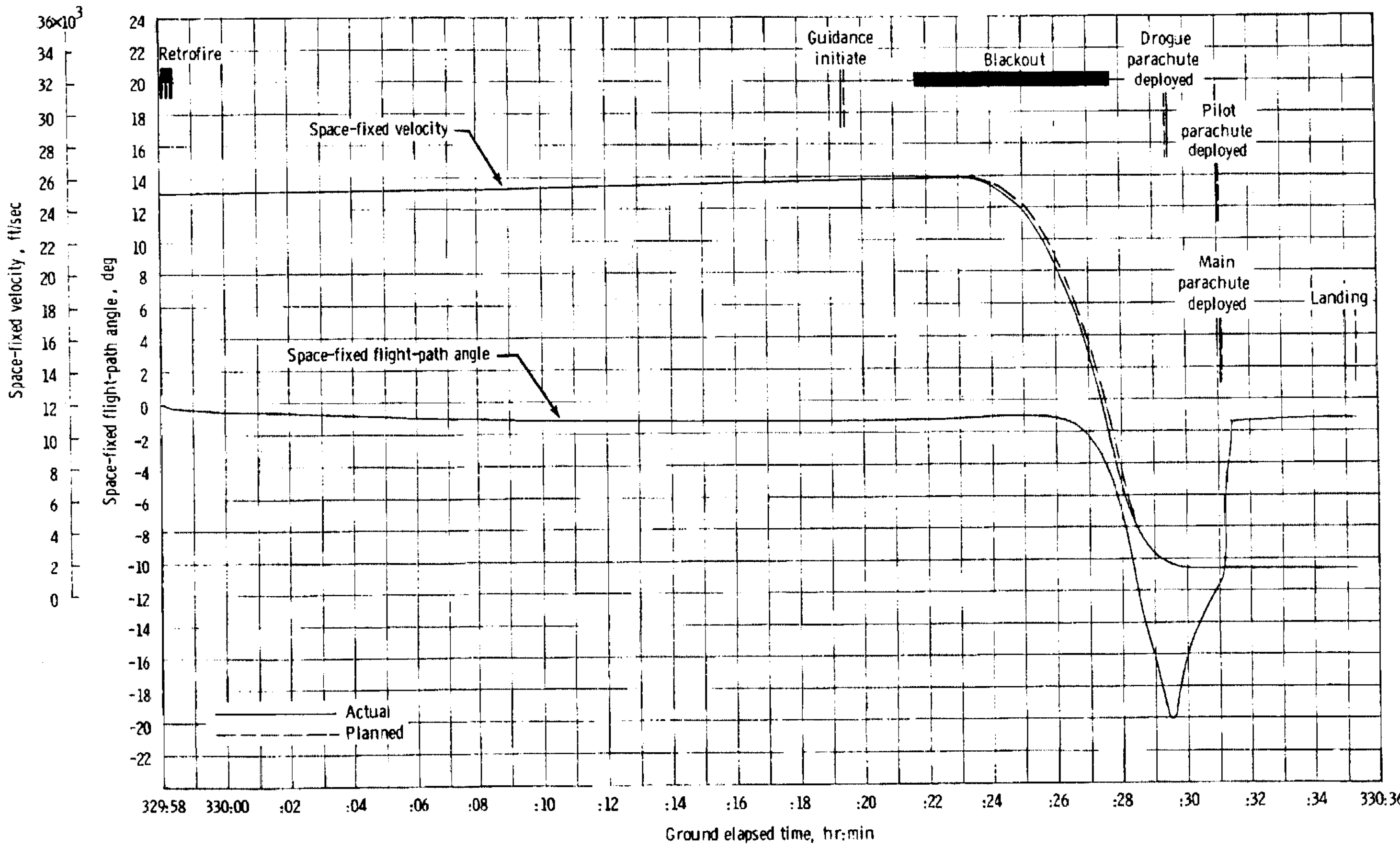
NASA-S-66-107 JAN



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

Figure 4.3-4. - Continued.

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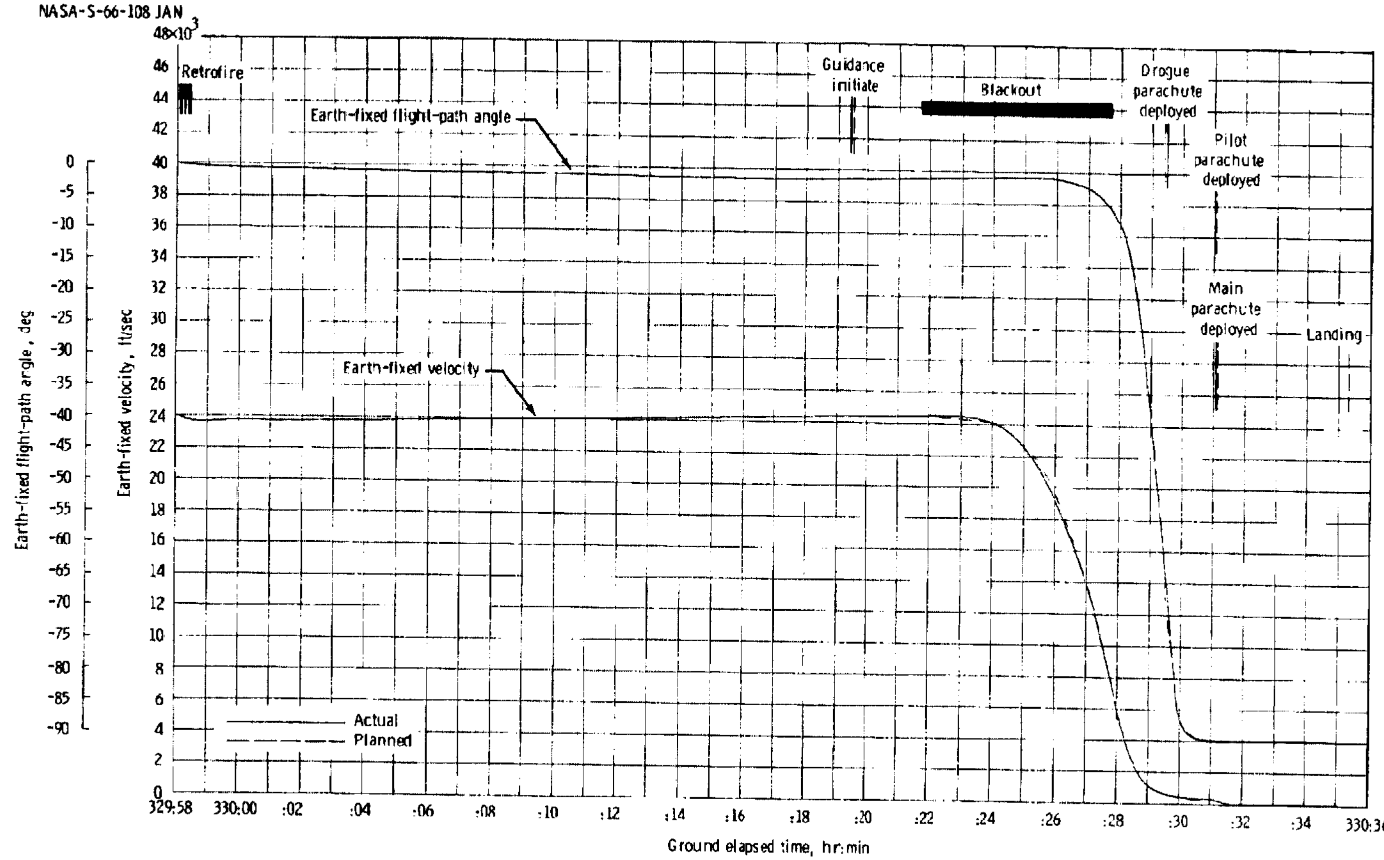

(c) Earth-fixed velocity and flight-path angle.

Figure 4.3-4. - Continued.

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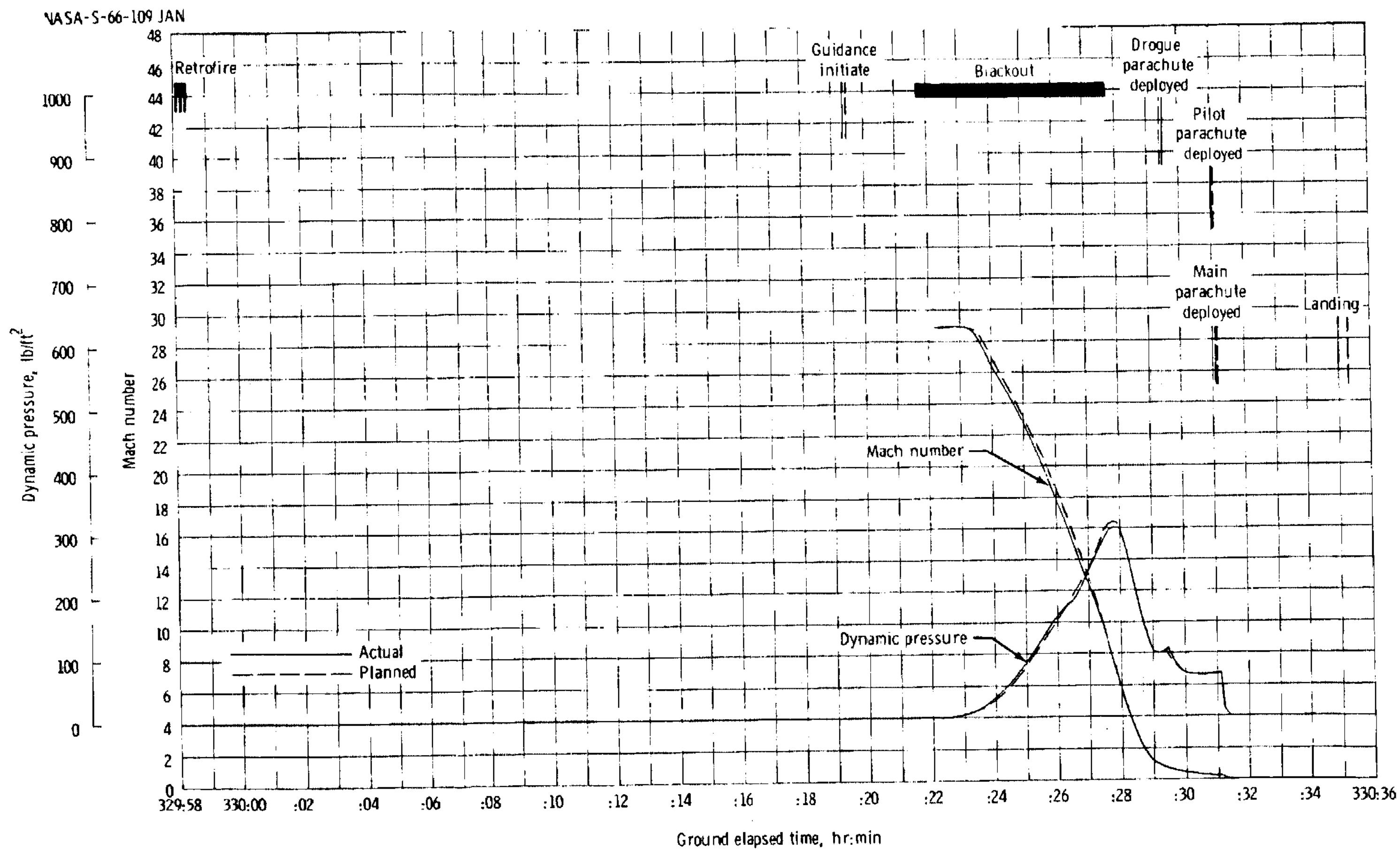

(d) Dynamic pressure and Mach number.

Figure 4.3-4. - Continued.

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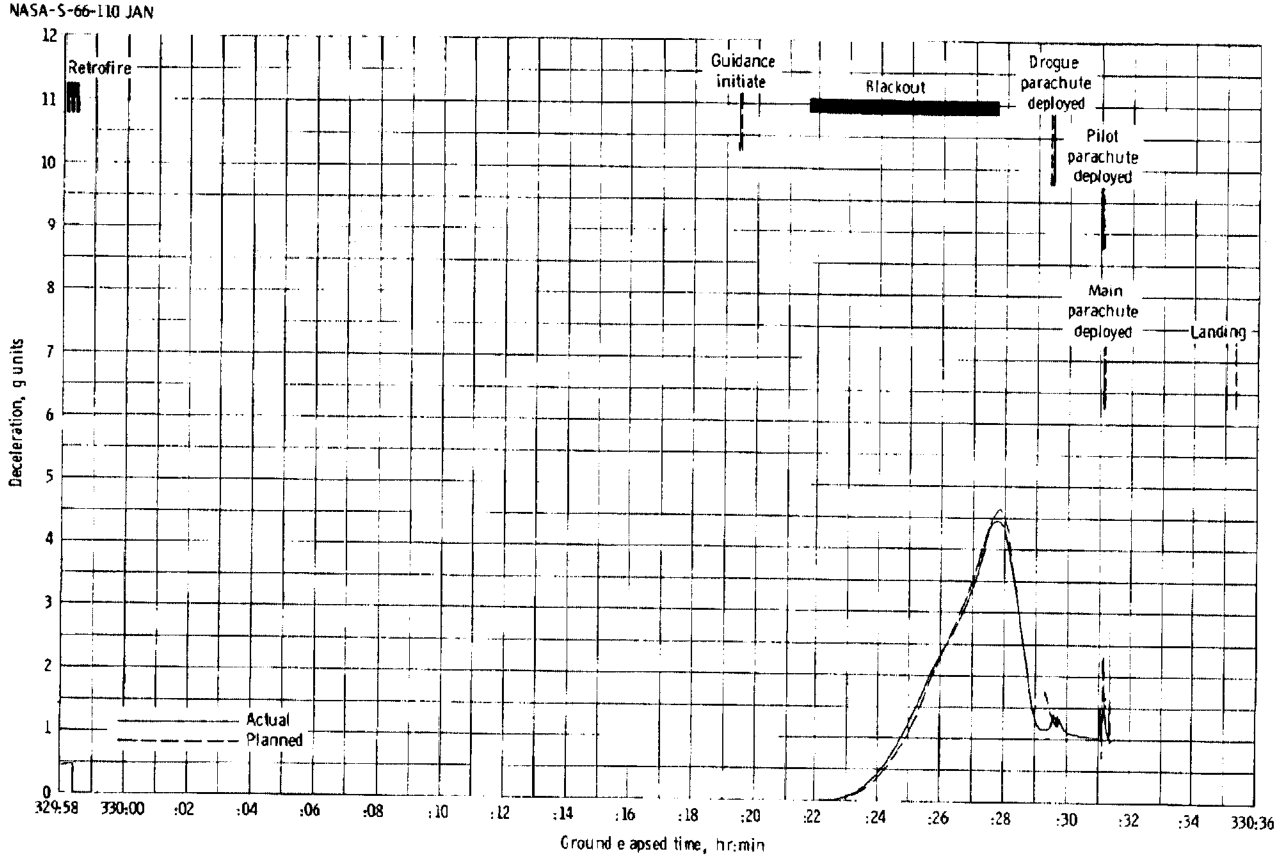

(e) Longitudinal deceleration.

Figure 4.3-4. - Concluded.

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5.0 VEHICLE PERFORMANCE

5.1 SPACECRAFT PERFORMANCE

5.1.1 Spacecraft Structure

The spacecraft structure and heat protection equipment performed satisfactorily except for the following two anomalies:

(a) The problem of residue deposits on the windows, which had been experienced on previous flights.

(b) A difficulty in closing the centerline stowage box door while in orbit.

Any formal analysis of reentry aerodynamics is precluded because of a PCM tape recorder failure and the unavailability of real-time data caused by telemetry "blackout" during the Mach 22 to Mach 8 portion of the reentry. However, the apparent stagnation point, as measured on the heat shield after recovery, was 12 inches below center which indicates that the trim angle was close to the expected trim angle of 12° at Mach 15 (achieved by Gemini V which had a postflight heat shield stagnation offset of 12.6 inches). A char depth of 0.30 to 0.31 inch was measured on the spacecraft 7 heat shield. The slightly greater charring on this reentry as compared to previous flights (0.26 to 0.29 in.) was as expected for reentry from the higher orbit of 161 nautical miles, and for the longer duration, high-lift flight path that was flown.

Spacecraft 7 was reported to have an unusually heavy residue deposited on its windows. An evaluation is being made to determine the composition and possible origin of the residue.

The centerline stowage box door was reported to be difficult to close in orbit. It functioned satisfactorily during postflight investigation with the cabin unpressurized; however, the stowage box is attached to the large pressure bulkhead in a manner such that bulkhead deformations under pressure could distort the box. This was confirmed during the altitude chamber tests of spacecraft 8, wherein the door closed properly at sea-level pressure but malfunctioned at altitude. A corrective design change is being incorporated to make the box structure more flexible thereby allowing the rigid door to be easily aligned by the tapered pins under all conditions of cabin pressurization.

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5.1.2 Communications Systems

The communications equipment for the Gemini VII spacecraft performed as designed with no known failures at the time of the preparation of this report. Voice communications were adequate to support the mission and to achieve the mission objectives. The flight crew reported that voice communications from the ground network were excellent throughout the mission. However, voice communications from the spacecraft were practically unreadable during the launch phase and there were several isolated instances of degraded voice communications during the mission. Communications reentry blackout occurred from 330:21:43 ground elapsed time (g.e.t.) to 330:27:32 g.e.t. as determined from the real-time telemetry signal strength records taken at the Texas and Grand Turk Island stations.

The flight crew reported that communications between spacecraft 7 and spacecraft 6 were satisfactory; however, they were uncertain of the distance between the two spacecraft when voice contact was first established. It is known that the distance was in excess of 235 nautical miles because rendezvous radar lock-on occurred at this distance and voice contact occurred prior to radar contact. The distance for readable ultrahigh frequency (UHF) voice contact between the spacecraft had been previously calculated to be 200 to 400 nautical miles, depending on antenna orientation.

5.1.2.1 Ultrahigh frequency voice communications.- Voice communications from the spacecraft during the launch phase were practically unreadable. This was probably because of the lightweight pressure suit with a soft helmet which the crew members were wearing on this flight. The soft helmet is not as effective in attenuating or reducing the engine noise as the hard helmet which had been used on previous missions.

Voice communications were loud and clear for the majority of the time during the orbital phase of the mission. The quality was excellent and equal or superior to that of any previous mission. However, on several occasions, communications from the spacecraft via remote stations became weak and noisy probably because of the propagation problems which existed between ground stations. Communications improved as the network personnel were able to select alternate paths for transmission.

5.1.2.2 High frequency voice communications.- The high frequency (HF) voice communications equipment is included in the Gemini spacecraft for emergency purposes during orbit and to aid in locating the spacecraft after landing. The HF equipment was not used for emergency purposes but several HF tests were performed. The HF tests consisted of two tests of one revolution each of HF air-to-ground transmissions and one revolution of HF ground-to-air transmissions from the Hawaii station. Analysis of the data for the HF air-to-ground test is incomplete at this time; however, both tests were monitored at the spacecraft contractor's facility in St. Louis, Missouri. The flight crew reported that during the HF ground-to-air test the Hawaii station could be heard only when the spacecraft was close to the Hawaii station.

Although not a part of the HF test, music was transmitted by Mission Control Center-Houston (MCC-H) on the HF voice links through Mission Control Center-Cape Kennedy (MCC-C) and Hawaii. The crew members reported that reception of the music was good only when passing over the transmitting station, and at other times the music was fading and unrecognizable.

The flight crew also stated that HF voice communications were used during several station passes but reception was good only when the spacecraft was within line-of-sight of the ground station. At all other times, reception was reported by the crew as weak and very difficult to understand.

5.1.2.3 Radar transponders.- Performance of the adapter-mounted C-band radar transponder was normal throughout the mission. Signal fading occurred as expected, and it was attributed to an unfavorable radiation pattern presented to the ground radar as a result of the spacecraft attitude. This type of fading can be as great as 30 dB, but generally does not cause degraded data or loss of track.

The reentry assembly transponder operated normally during launch and reentry, and was used several times in orbit. The signal phase shifter was suspected of being inoperative at times, but investigation revealed that either it was turned off for test purposes or the spacecraft attitude was such that phase-shifter operation was not present in the radiation lobe oriented toward the ground radar. An evaluation of data by Carnarvon radar operators on revolutions 189 and 190 revealed no effect on tracking accuracy as a result of phase-shifter action. This, of course, was known from previous missions. An evaluation by tracking stations during the period when the phase shifter was turned off indicated that there were no serious adverse effects, but that antenna pattern nulls were much deeper.

Because of the higher orbit, communications reentry plasma blackout occurred over White Sands. The predicted landing point was within 10 miles from the nominal landing point, using radar-beacon and skin-track data from White Sands, Patrick AFB, and Grand Turk Island. All Eastern Test Range radars elected to skin-track because of heavy blackout attenuation. Beacon returns were received intermittently, but as a rule were much weaker than skin-track returns.

5.1.2.4 Digital command system.- The digital command system (DCS) performance was nominal during the entire mission. On a few occasions, however, the uplinked commands were not validated by the spacecraft DCS. These nonvalidated commands were transmitted from real-time sites (Texas, Bermuda, and Eastern Test Range) and in each case the cause for nonvalidation was attributed to a ground network malfunction. A problem occurred during the Gemini V mission, wherein a series of real-time stored program commands were sent from MCC-H through the Texas station in too rapid a succession and could not be properly received by the spacecraft. This problem did not occur during the Gemini VII mission because the DCS at MCC-H was changed to repeat a command word until both a valid message acceptance pulse (MAP) and an indication of proper telemetry ground station synchronization has been received. Effective with the Gemini VIII mission, spacecraft 8 will code a MAP as eight ones rather than eight zeros. This will further avoid a recurrence of the problem.

5.1.2.5 Telemetry transmitters.- An examination of the data available at this time indicates that all telemetry transmitters operated normally throughout the mission. One ground station reported some intermittent telemetry parameters during the first HF air-to-ground transmission tests; however, no HF interference was noted by a different network station later in the test.

5.1.2.6 Antenna systems.- An examination of the performance of the communications systems indicates that the adapter, reentry, and recovery UHF antennas deployed properly and operated normally as required. The performance of the HF orbit and postlanding antennas was satisfactory as evidenced by the transmission and reception of HF signals. The radar transponder antennas operated normally as evidenced by radar tracking data from the ground stations.

5.1.2.7 Recovery aids.- The communications recovery aids for the Gemini VII mission operated normally. The UHF recovery beacon was turned on after two-point suspension on the main parachute. The recovery aircraft received CW and pulse transmissions from the UHF recovery beacon at distances up to 180 nautical miles. The recovery aircraft also established voice communications with the spacecraft while the spacecraft was on the main parachute. Operation of spacecraft recovery aids is further described in section 6.3.3. The flashing light extended normally, but was not necessary and was not turned on by the crew. The external intercommunications jack provided good communications between the crew and rescue personnel before the hatches were opened.

The HF postlanding antenna was deployed after landing. Reports at this time are that HF was received at Cape Kennedy and at St. Louis, Missouri. Figure 6.3-7 shows other stations which received HF-DF signals from the spacecraft after it landed. The HF antenna was retracted by the crew members before leaving the spacecraft in order to prevent damage during hoisting aboard the recovery ship.

5.1.3 Instrumentation and Recording System

The instrumentation and recording system performed in a satisfactory manner except for the anomalies listed below:

(a) The pulse code modulation (PCM) delayed-time telemetry tape recorder failed during revolution 127.

(b) The reactant supply system measurements of oxygen tank pressure failed at approximately 170 hours g.e.t. on both telemetry (parameter BA02) and the cabin indicator.

(c) After approximately 283 hours g.e.t., the average suit inlet air temperature cabin indicator failed to give the proper indication.

5.1.3.1 PCM tape recorder failure.- The PCM tape recorder failed while in the record mode during revolution 127. The recorder was placed in the record mode at 200:29:30 g.e.t. after a successful playback over the Rose Knot Victor (RKV). At the next station pass over the Coastal Sentry Quebec (CSQ), real-time data indicated a possible failure because there was no tape motion indication. During the subsequent playback over the RKV, it was established that a failure had occurred because only 9 minutes 44 seconds of recorded data were received. Several attempts to regain operation of the recorder were made, but with no success.

Postflight examination of the recorder established the cause of failure. In normal operation, the recorder motor runs continuously and motion is transferred either to the fast playback reel or to the record reel by means of electromagnetic clutches, either of which can be commanded to engage the rotating shaft. During the flight, a ball bearing between the playback clutch and the shaft seized and caused the clutch, in effect, to be continuously engaged. Thus, when in the record mode, the drive mechanism was attempting to drive the tape in opposite directions. The higher mechanical advantage of the record reel apparently permitted the 9 minutes 44 seconds of operation at which time the mechanism stalled. When switched to playback, all of the tape was wound onto the take-up reel because the end-of-tape switch was unable to declutch the playback reel in a normal manner.

Failure analyses of the speed-converter assemblies from both spacecraft 6 and spacecraft 7 revealed that the same playback clutch ball bearing had failed in both tape recorders. Further investigations conducted at the vendor's plant and at the ball-bearing producer's laboratories revealed that the bearing failure was due to foreign particles inside the bearing. These particles were generated by the cutting action of the bearing dust shield on an adjacent aluminum shoulder. A design deficiency allowed this shoulder to be higher than the inner race of the ball bearing and therefore allowed the shield to cut into it. The following corrective action has been initiated:

(a) Cut down the shoulder to eliminate interference with the ball bearing shield.

(b) Add a hardened surface to the shoulder to prevent galling or brinnelling due to the rubbing action of the bearing's inner race on the shoulder.

These modifications are being incorporated into all flight PCM tape recorders.

5.1.3.2 Delayed-time data quality.- The delayed-time data received at the Cape Kennedy (telemetry station II), Texas, Carnarvon, Bermuda, Hawaii, and Canary Island ground stations are summarized in table 5.1.3-I. This table depicts the results of 36 computer-processed data dumps out of the 124 dumps made prior to the failure of the PCM tape recorder. For all ground stations listed, the usable data exceed 99.28 percent. The excessive data losses at Hawaii are attributed to the initiation of a data dump at an inadequate signal-to-noise ratio during revolution 6. The losses at the Canary Island station were caused by a low-angle pass. The Texas station was known to have a local RFI problem; however, processing techniques enabled recovery of 98.98 percent of the data.

5.1.3.3 Real-time data quality.- The real-time data received at Cape Kennedy (telemetry station II), Texas, Hawaii, and Guaymas ground stations are summarized in table 5.1.3-II. For all the ground stations listed, the usable data recovered exceed 97.53 percent. All percentages were derived from computer-processed data edits.

5.1.3.4 Overall system performance.- In this mission there was a total of 268 parameters monitored. Of these, one parameter, the reactant supply system oxygen tank pressure (BA02), failed after approximately 170 hours g.e.t. Further discussion regarding this parameter is presented in paragraph 5.1.7.2. The cabin indicator that displays the average suit inlet air temperature failed after approximately 283 hours g.e.t. This measurement is derived by averaging the suit inlet air temperatures of both the left-hand and right-hand suits in a resistive-element temperature-sensor bridge unit. Each of the individual suit inlet air temperatures, which are telemetry parameters, operated properly throughout the mission. Further information regarding this parameter is given in paragraph 5.1.4.3.

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

Station	Revolution	Total data received		Total losses		Usable data, percent
		Duration, hr:min:sec	Prime subframes	Prime subframes	Percent	
Cape Kennedy (Tel II)	Launch, 1, 2, 11, 12, 15, 30, 31, 32, 44, 45, 74, 75, 76, 88, 103, 104, 105	19:21:26	696 856	694	0.10	99.90
Texas	Launch, 1, 14, 16, 17, 18, 33, 106	08:33:29	308 089	3 138	1.02	98.98
Carnarvon	28, 29	02:14:56	80 958	121	0.15	99.85
Bermuda	59	01:32:49	55 687	0	0.00	100.0
Hawaii	3, 4, 5, 6, 14, 19, 20, 21, 48, 59, 107, 123, 124	14:19:45	515 852	6 269	1.22	98.78
Grand Canary Island	10, 11, 13	03:21:20	120 798	2 490	2.06	97.94
Summation		49:23:45	1 778 240	12 712	0.72	99.28

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TABLE 5.1.3-II.- REAL-TIME DATA RECEIVED FROM SELECTED STATIONS

Station	Revolution	Total data received		Total losses		Usable data percent
		Duration, min:sec	Total master frames	Master frames	Percent	
Cape Kennedy (Tel II)	Launch, 28/29, 75/76, 163/164, 175, 177	51:43	124 106	784	0.63	99.37
Texas	175, 176, 177	27:24	65 743	1320	2.00	98.00
Hawaii	6, 108, 163, 180, 181	42:30	102 926	5756	5.59	94.41
Guaymas	163, 205	17:38	42 327	424	1.00	99.00
Summation		139:15	335 102	8 284	2.47	97.53

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5.1.4 Environmental Control System

The performance of the environmental control system (ECS) was generally good throughout the mission. All parameters were as expected except those reported herein.

5.1.4.1 Crewman comfort. - During the first 45 hours of the mission, both crew members wore the pressure suit with the hoods and gloves off. Thermal comfort was generally good; however, the crew reported being slightly warm when the B pumps were providing coolant. These pumps deliver coolant at approximately one-half the rate of the A pumps, which affects the thermal performance of the suit heat exchanger. Suit inlet temperature varied between 55° F and 59° F when the B pumps were used and between 48° F and 50° F when the A pumps were used with the system adjusted for full cold in either case. A review of data from Gemini VII and previous flights has shown that an indicated suit inlet temperature of 52° F to 54° F is required for maintaining suit comfort, and temperatures above 55° F and below 50° F cause discomfort.

At approximately 45 hours g.e.t., the pilot removed his pressure suit entirely and placed the suit inlet hose near his head and the suit outlet hose in the footwell area. The cabin air temperature at the time of removing the suit was 80° F with a dew point of 57° F, and the pilot reported that his thermal comfort was excellent in this mode. The command pilot remained slightly warm. Both crewmen removed their suits at approximately 191 hours g.e.t. and were very comfortable.

A special test was conducted on the 13th day of the flight to evaluate thermal comfort without the pressure suit and without any forced flow across the body. This was accomplished by turning the pilot's suit flow control valve off and placing the suit return hose in the command pilot's footwell. Comments by the pilot indicated that the lack of ventilation was noticeable and that within 30 minutes, the air got somewhat stuffy. The various configurations tested while both crew members were out of the pressure suits indicated that the ECS maintained good thermal control and removed water and carbon dioxide satisfactorily. The crew apparently stayed very comfortable when the cooling gas was directed across their bodies.

The crew reported at 158 hours 30 minutes g.e.t. that upon awakening, the cabin air and wall temperatures were approximately 66° F as read by the hand-held humidity sensor, 20° colder than normal. Also, the spacecraft was tumbling at a high rate of left yaw and a small amount of left roll. The tumbling was caused by venting of excess condensate from the evaporater which, according to preflight calculations, had been predicted for approximately this time. There are insufficient data to make a determination of the cause for the reduced cabin temperature. Similar events occurred during the Gemini V mission. One possible explanation is a cooling trend due to the combination of (1) the acceleration field induced by the tumbling, and (2) the reduced temperatures reported behind the seats, which, in the presence of this field, would set up convection currents tending to cool the cabin area.

5.1.4.2 Primary oxygen system.- The primary oxygen container was pressurized at 960 psia, with a mass quantity of 103 percent (109.2 lb) at launch. At about 25 minutes g.e.t., the oxygen crossfeed valve was opened to raise the reactant supply system (RSS) oxygen tank pressure (See section 5.1.7). The valve was open for approximately $17\frac{1}{2}$ seconds during which the ECS tank pressure changed from 910 psia to 690 psia while transferring approximately 0.35 pound of oxygen. Intermittent use of the heaters was required to maintain the container pressure above 600 psia until approximately 134 hours g.e.t. The pressure then started rising slowly and started venting at 186 hours 30 minutes g.e.t. Venting continued until the end of the mission.

The mass quantity at 329 hours g.e.t., just before retrofire, was 32.34 percent (34.28 lb).

The cabin leakage rate before flight was measured to be 469.1 scc/min at 5.1 psid which converts to 0.0365 lb/hr in orbit. Using this leakage rate and the quantity usage rate measured during flight, the average metabolic rate of the crew was calculated as 388 Btu/hr.

5.1.4.3 Suit circuit moisture.- The crew reported that free moisture was leaving the suit inlet hoses at approximately 267 hours g.e.t. Immediate analysis indicated three possible causes for this condition:

(a) Inadvertent repositioning of the condensate control valve to the fill position, thereby closing the condensate line from the suit heat exchanger

(b) Localized chilling of the suit heat exchanger or ducting leading to the suit, or both, causing condensation in the ducting

(c) Blockage of the evaporator dump port or condensate lines preventing removal of condensate from the suit heat exchanger

The crew was requested to take the following actions:

(a) Continue use of the B coolant pumps.

(b) Turn on suit compressor number 2 in addition to number 1.

(c) Verify condensate control valve in the normal position.

(d) Verify the evaporator overpressure light not on.

The crew followed the ground requested procedures and verified that the condensate valve was in the proper position, the evaporator overpressure light was not on, and both suit fans were on. About one and one-half hours later, the crew reported that water was continuing to come from the suit hoses. Ground personnel recommended to the crew that they implement a procedure as follows:

(a) Select "A" pumps in both primary and secondary coolant loops.

(b) Orient the spacecraft broadside to the sun.

(c) Place radiator switch to BYPASS.

(d) Roll the spacecraft at a rate of 8° to 10° per second.

(e) Turn on the evaporator heat.

(f) Place radiator switch to FLOW.

(g) Place evaporator heat to OFF.

(h) Select "B" pumps in both coolant loops.

(i) Stop the roll rate.

This procedure which required about 10 minutes, was completed at 268:33 g.e.t., and water was forcibly vented from the water boiler. The venting of water was verified by the Gemini VI-A crew who were station keeping with spacecraft 7 during this time.

The free moisture disappeared by 270 hours g.e.t.; however, postflight crew debriefing revealed that it appeared again at approximately 315 hours g.e.t. The crew took the corrective action of turning on both suit compressors and selecting full warm on the suit and full cold on the cabin coolant control valves. The cabin fan was not turned on. These actions also corrected the situation.

A review of conditions and events at the time of these two occurrences does not provide a positive explanation for the anomaly. A cabin temperature survey was nominal as follows:

Cabin gas	80° F dry-bulb temperature, 76° F dew point
Cabin gas between the crew members	79° F dry-bulb temperature, 67° F dew point
Hatch surface	80° F.

At approximately 260 hours g.e.t., both crewmen were suited and both A coolant pumps were active for rendezvous. During the subsequent 6-hour rendezvous period, the spacecraft was oriented for extended periods with either the adapter facing away from the earth or with the lower part of the cabin facing the earth. A shadow is cast over the lower portion of the cabin in these orientations, reducing the imposed solar heat flux to near zero and allowing a chilling of this area of the cabin. Also, use of the A coolant pumps provided excess cooling for the crew and, as reported during postflight debriefing, in an effort to adjust to comfortable conditions, the coolant flow was reduced through the suit heat exchanger and was allowed to flow through the cabin heat exchanger. The coolant lines to the cabin heat exchanger run along the lower part of the cabin causing further chilling. This chilling is substantiated by reports from the crew that, at approximately 267 hours g.e.t, condensation was noted on the center pedestal water-absorbent material and on the cabin floor near the pedestal. The condensation remained in this area for the balance of the flight. The chilling of the lower part of the cabin could then cause chilling of the suit module, which is located in this area, thus causing condensation in the ducting leading to the pressure suits. No known activities would account for recurrence of chilling to account for the free moisture at 315 hours g.e.t.

The free moisture could also have been the result of flooding of the suit heat exchanger caused by a failure in the condensate removal and dump system. The relief poppet on the evaporator could have frozen closed preventing dumping of condensate overboard. This is unlikely, however, because the evaporator overpressure light never came on. A degradation of the water separator section of the suit heat exchanger could have caused the flooding by failure to transfer condensate out of the heat exchanger as fast as it was being condensed. As the evaporator fills with condensate its pressure increases, thus decreasing the pressure differential across the suit heat exchanger water separator and adding to the effects of degradation. An estimate was made of when the evaporator would have again been full after the forced dump at 268 hours 33 minutes g.e.t., and the estimate corresponds closely to the actual time of recurrence of the free moisture. The suit heat exchanger is being tested for separator degradation.

Concurrent with the observed moisture at 267 hours g.e.t., the onboard suit inlet temperature indicator suddenly changed to the minimum reading (40° F) and remained there for the rest of the mission, although telemetered temperatures remained normal. This failure is being investigated.

5.1.4.4 Coolant temperature-control valve cycling.- During the sixth revolution, it was noted for the first time that the coolant temperature-control valve outlet temperature was cycling between 33.3° F and 35.2° F. The radiator outlet temperature at that time was constant at -12.5° F. Continued observation of this parameter revealed that the cycling occurred only when the radiator outlet temperature was below 0° F and that it increased in excursion with decreasing radiator outlet temperature. The highest excursion observed was 21° F when the temperature ranged from 29° F to 50° F. The period of the cycle was approximately 20 seconds. A test was immediately started by the spacecraft contractor to determine if the cycling was normal and if there were any detrimental effects. The testing showed the cycling was normal when using the lower flow-rate B pumps and that it would not occur when using the higher flow-rate A pumps. The test was continued for 17 000 cycles without effect. The cyclic performance was noted only in the primary coolant loop. This cycling was not observed in the secondary loop because of the difference in temperature sensors between the two coolant loops. The temperature sensor in the primary coolant loop is an in-line sensor and the sensor in the secondary loop is a strap-on sensor which has a much slower thermal reaction time. There is no evidence to indicate that there were any detrimental effects in the ECS as a result of this cycling.

5.1.4.5 Gas entrainment.- The crew reported apparent gas entrainment in the drinking water as was reported during Gemini V. The gas was noticed only in the food bags after reconstitution of the food. It is believed that the gas was not entrained in the drinking water, but was either already in the food bags or was introduced during bag opening for reconstitution. It is also possible that a certain amount of gas is released during the reconstitution process. Prior to the mission, at a detailed review of spacecraft water-servicing procedures, it was concluded that all possible methods of preventing entrained gas were included in the servicing procedures.

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5.1.5 Guidance and Control System

The performance of the guidance and control system was excellent throughout the mission. No malfunctions nor abnormal occurrences were reported by the flight crew and none have been found in the analysis to date. Table 5.1.5-I contains a synopsis of the events pertinent to the system.

5.1.5.1 Inertial guidance system (IGS) performance evaluation.-

5.1.5.1.1 Ascent phase: The IGS pitch, yaw, and roll steering signals are shown in figure 5.1.5-1. Superimposed on the IGS quantities are the steering signals from the primary (launch vehicle) guidance system along with the upper and lower IGS attitude error limits generated for a nominal Gemini VII trajectory. The simulated results of predicted pitch and yaw attitude error behavior during the first 90 seconds of flight are shown separately using measured T -1 hour wind conditions.

The difference in roll steering commands between the primary and secondary guidance systems was slightly less than 0.2° prior to BECO. Roll misalignment between the two systems contributed 0.1° of this deviation and the remaining difference is attributed to the combined effects of roll gyro drift in the three-axis reference system (TARS) and gimbal cross-coupling. The primary guidance system indicated an initial -0.2° offset in attitude error as a result of engine misalignment on the launch vehicle first stage. The difference in the roll steering commands seen during stage II is representative of a TARS linear drift of 10.0 to 12.0 deg/hr.

The pitch steering signals for the two systems differ by 0.70° at BECO. This variation includes a 0.15° deviation resulting from initial misalignment between the two systems. The remaining 0.55° is attributed to pitch programmer deviations or a TARS pitch gyro drift, or a combination of the two. A 1.2° shift in pitch-attitude signal occurred at BECO for both systems as a result of the characteristic steering required to compensate for offset center-of-gravity effects. The stage II IGS pitch steering command increased by 1.0° during the time period from 320 seconds to SECO because of the differences between the actual inertial flight-path angle of 0.5° and the target value of 0°.

The behavior of yaw attitude errors for both systems also indicated a near-perfect powered flight. Each guidance system indicated consistency with the other up to BECO at which time the difference in attitude errors amounted to 0.15°. An initial misalignment of 0.10° accounted for part of this difference; the remaining portion was produced from the combined effect of TARS gyro drift and gimbal cross-coupling. The 1.75°

shift at BECO of both steering signals was indicative of the large center-of-gravity offset compensation required. At about LO + 320 seconds, the IGS yaw steering signal started a slow deviation to about -1.1° at SECO. This deviation, which has occurred on previous flights, resulted from the difference in the out-of-plane velocity components of the two systems. The IGS value at SECO was 12.0 ft/sec. Because the IGS yaw steering command is computed by dividing the out-of-plane velocity by an effective time-to-go to SECO, the steering signal diverges rather than converges in value. Following SECO, both yaw attitude error quantities behave in a similar manner.

Both azimuth updates were received and the flight reconstruction simulations indicated the following values for platform misalignment:

Platform release, deg	-0.470
After first update, deg	0.006
After second update, deg	0.000

As on previous flights, the initial value was well within the specified 3σ value of 0.75°.

If guidance switchover had occurred early in the stage II operation, the SECO conditions would have shown the following deviations from nominal: 5 ft/sec in velocity, 150 feet in altitude, and 0.002° in flight-path angle prior to the incremental velocity adjust routine (IVAR) correction. These deviations would have resulted in an apogee of 180 nautical miles and a perigee of 87 nautical miles. These values compare favorably with the actual Gemini VII trajectory in the presence of the relatively low inertial measuring unit (IMU) navigation errors, and this comparison is further substantiated by the IGS SECO signal which was sent within 30 milliseconds of the primary SECO signal.

The incremental velocity indicator (IVI) display, as actually computed by the onboard IVAR, was reconstructed using IGS navigational and gimbal-angle data. Table 5.1.5-II shows a comparison between the reconstructed IVAR parameters in their final available computation cycle and the values obtained through the data acquisition system (DAS) prelaunch mode. These comparisons tend to validate further the orbit insertion equations. Because the crew left the computer in the ascent mode throughout station keeping, the IVAR remained active until LO + 28.6 minutes. The values reported in the table reflect the orbital navigation variations for a period of 22 minutes combined with the navigational changes due to translational thrusting accomplished during this same period. The final IVI readings verify that the crew-reported readings of 17, 13, and 20 ft/sec occurred at LO + 28 minutes.

If IVAR had been used on this flight before station keeping and after maneuvering for separation, the IVI's would have displayed a 2.0 ft/sec forward and 17 ft/sec out-of-plane velocity correction in component form. If the attitude errors had been nulled, the spacecraft would have been yawed about 84° right, and a resultant correction of 17 ft/sec would have appeared on the fore and aft window. After driving this IVI reading to zero, the in-plane velocity would have changed about 1.7 ft/sec, resulting in an apogee 1 nautical mile higher than for a normal SECO + 20 second insertion without station keeping. This would have corrected the out-of-plane error by about 17.2 ft/sec. Relatively no velocity change at apogee (V_{gp}) would have been required to reach the desired perigee of 87 nautical miles.

The IGS telemetered velocity information was compared with ground tracking data to determine spacecraft IMU and computer errors. The external tracking data used for comparisons were GE Mod III final data and missile trajectory measurement (MISTRAM) data using the 100K ft legs. The GE final data were adequate for quick-look analyses; however, as in previous flights, it became noisy along the vertical axis after LO + 300 seconds as the elevation angle decreased. The regression analysis shows no significant errors in these data. The MISTRAM data were very smooth, and, in general, agreed within 1 ft/sec with GE Mod III final data up to LO + 270 seconds. The velocity residuals along the Y (vertical) axis indicated a discrepancy between the GE final and quick-look MISTRAM data (see fig. 5.1.5-2). The rapid increase in the MISTRAM comparison residuals after LO + 270 seconds suggests a MISTRAM P bias error similar to that noted on the Gemini V mission. The Z (cross-range) axis also shows a discontinuous error trend which started at approximately 27 seconds before SECO. MISTRAM data using the 10K ft legs were also observed, but were too noisy after LO + 300 seconds to aid in resolving the problems in the data from the 100K ft legs. The accelerometer telemetry data acquired during ascent had no significant dropouts, and were excellent for analysis. Although the data of the external tracking systems were difficult to use, estimates of IMU errors were obtained by approximately fitting the first 270 seconds of data, and propagating the errors to SECO (fig. 5.1.5-2).

The error in the Y (vertical) direction was indicative of a platform pitch drift. That is, the error trend increased throughout powered flight in the same manner as downrange velocity which was sensed by the misaligned vertical accelerometer. The estimated drifts are 0.32 deg/hr/g of Y_p gyro input-axis unbalance (YGIAU) and -0.07 deg/hr of Y_p gyro g-insensitive drift. The coupling effects caused by the YGIAU drift, a 5-millisecond timing error, and a scale-factor error of 108 parts/million were the primary error contributors in the X (downrange) direction. Preflight values of X_p gyro input-axis and spin-axis unbalance, Y_p

accelerometer-bias shifts, and a small perturbation in Z gyro input-axis unbalance (ZGIAU) (which was somewhat unstable during testing) fit the GE Mod III final Z (cross-range) residuals very well. (Fig. 5.1.5-3 shows the error coefficient trends.) The residuals in the MISTRAM data could have been fit just as easily, and the error coefficients would have been well within specification.

A preliminary engineering estimate of IMU component errors and the total velocity error induced by each error source during powered flight are given in table 5.1.5-III. In addition, sensor and tracking errors obtained from a preliminary error coefficient recovery program (ECRP) run are presented.

The IMU and tracker error coefficients determined by the ECRP are also presented in table 5.1.5-III. The dominant IMU errors computed, Y_p gyro input axis unbalance and X_p accelerometer scale factor error, substantiate results obtained by the handfit.

The error model used in the regression program was small; hence large uncertainties resulted because of unmodeled errors. Increasing the size of the error model can give small uncertainties, but many of the additional error sources are highly correlated and the true error source magnitude may be reflected into another having similar propagation.

The present best estimate of the guidance position and velocity errors at SECO is given in table 5.1.5-IV. These quantities were obtained from position and velocity comparisons using the present best estimates of the trajectory as a reference. In this table, the IMU error is made up of sensor errors, while navigation error results from various approximations within the airborne computer. An estimate of orbital injection parameters at SECO + 20 seconds determined from the IGS and other sources is given in table 5.1.5-V.

5.1.5.1.2 Orbital phase: Approximately 14 hours of operation were accrued on the IMU during the mission and approximately 6 hours on the spacecraft computer. Operation was excellent throughout. At least four reentry updates were received by the computer and verified to be correct. Platform accelerometer bias was checked on the ground during each "on" period with maximum errors of 0.016, 0.050, and 0.024 pulse per second appearing in the X, Y, and Z axes, respectively. Because all measurements were not taken over constant time intervals with fixed warm-up periods, the errors in the Y axis may have been smaller than indicated. The errors generally were much smaller than these maximums.

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A summary of the major translation activity is shown in table 5.1.5-VI. All but the two perigee-adjust maneuvers were calculated using telemetered accelerometer data. The values shown for these two maneuvers (performed with the IGS "off") were obtained from the trajectory changes seen in ground tracking data. Agreement between the planned and actual changes in velocity for each of the other maneuvers is seen to be close except for the separation maneuver and the D-4/D-7 experiment maneuver which were "timed" rather than performed using the IVI's. Forty-six separate translations, totaling 30.6 seconds, were performed during station keeping with the launch vehicle. These included 22 fore-aft translations requiring 11.2 seconds total, 10 left-right translations totaling 10.7 seconds, and 14 up-down translations for a total of 8.7 seconds.

A summary of platform alignments is presented in table 5.1.5-VII where the significant performances of the platform as controlled by the crew are shown. The primary horizon sensor was used for all alignments and the results presented in the table indicate the accuracy of the alignments. Pitch and roll alignments were determined directly from torquing current data. Yaw alignment can be determined only by observing the effect of orbital travel 90° from alignment termination however there were no data available for the 90° positions.

The L-band radar transponder installed in the nose of the spacecraft was powered up periodically throughout the mission to check the warm-up rate. (See table 5.1.5-I for temperatures.) Two attempts were made on passes over the Kennedy Space Center (KSC) Boresight Facility to interrogate the device from the ground using a Gemini rendezvous radar installed on a variable azimuth and elevation mount. On the first attempt, only intermittent lock-on occurred because of improper orientation of the ground radar. The second test was more successful with solid lock-on occurring at a range of 270 nautical miles and lasting for a period of 110 seconds. Figure 5.1.5-4 shows a time history of the range for this pass indicating radar and transponder lock-on performance. The radar automatic gain control (AGC) data indicate that the received signal at 270 miles was 4 dB above minimum discernible and that, with accurate pointing, lock-on could have occurred at approximately 350 nautical miles.

5.1.5.1.3 Reentry phase: The IGS operated properly throughout the retrofire and reentry phases of flight. The total velocity change as a result of firing the retrorockets was 0.54 percent higher than predicted, as shown in table 5.1.5-VI, causing a footprint shift of approximately 41 nautical miles.

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From retrofire to an altitude of 400K ft, a 0° bank angle trajectory was flown as planned. At 330:19:36.22 g.e.t., the computer called for a 60° right bank angle which indicates proper spacecraft navigation to the 400K ft level as compared with the value computed on the ground when using tracking data acquired after retrofire. No IGS telemetry data are available during blackout from 330:21:38.43 g.e.t. to 330:27:42.84 g.e.t. At 330:28:45.48 g.e.t., the computer properly terminated guidance at a density altitude factor of 4.59927 which indicates proper functioning of the reentry mode at this time in reentry.

Table 5.1.5-VIII contains a comparison of the actual telemetry data with data reconstructed after the flight using the DCS update, gimbal angles, spacecraft body rates, and platform accelerometer outputs. This table indicates close agreement of the sets of data and demonstrates the proper functioning of the reentry mode of the computer.

The IGS computed position at drogue parachute deployment was 0.9 nautical miles from the actual touchdown coordinates obtained from the Grand Turk Island (GTI) radar data and 4.1 nautical miles from the recovery pickup point. The insert in figure 5.1.5-5 shows the relative positions of the spacecraft at touchdown with respect to the planned target. These navigation errors are within the variation expected because of initial condition uncertainty and normal IMU misalignment and component errors. The spacecraft landed 6.4 nautical miles short of the desired landing point. A manual closed-loop reentry was flown by the crew based on the cross-range and down-range errors together with the bank-angle commands. The guidance commands generated by the computer were accurate; however, one needle width of the flight director indicator (FDI) down-range error needles represents 6 nautical miles on the low scale which makes manual control to values less than 6 nautical miles difficult. According to the crew, the bank angle commands based on the computer driven FDI's were followed after 3g and were the values recorded after exit from blackout. At this point, a full-lift (zero bank angle) command was displayed, indicating that the spacecraft had insufficient lift to reach the target. In a four-degree-of-freedom reentry-program reconstruction using White Sands tracking data and nominal aerodynamics, the automatic reentry showed a miss distance of approximately 2.4 nautical miles.

The flight crew reported that they did not exceed a bank angle of 35°. This attitude, corrected by the 4° bank angle bias due to the center-of-gravity lateral-offset effect, would have given the equivalent of a 39° lift vector. Figure 5.1.5-5 shows that this would have caused the spacecraft to overshoot the desired target by more than 40 nautical miles. Because there were no telemetry data during the lifting portion of the flight, no data were available to establish exactly what trajectory was flown during this period. However, based on the crew's report of their attitude during reentry, there appears to have existed a further effect in footprint capability (see fig. 5.1.5-5). This effect could have been caused by either a shift in the predicted center-of-gravity location, by a higher-than-postulated atmospheric density, or by greater aerodynamic drag. Another possibility is that the footprint shift caused by the off-nominal retrofire thrust was larger than the post-retrofire tracking indicated. Further studies are being made to determine the actual aerodynamics of the spacecraft.

5.1.5.2 Control system evaluation.-

5.1.5.2.1 Attitude control and maneuvering electronics (ACME): The control system was utilized extensively throughout the flight in all modes but the reentry mode and the reentry rate command mode. No evidence of anything but proper operation was exhibited.

SECO occurred at LO + 337.0 seconds and transients of -0.24, +0.30, and -0.71 deg/sec observed in the pitch, roll, and yaw rates, respectively, were nulled by the control system when the ACME was turned on 2.25 seconds after SECO. Figure 5.1.5-6 shows the thruster firings and rates during this period. Gimbal angles changed +1.8°, +0.9°, and +1.2° in pitch, roll, and yaw, respectively, because of the SECO transients.

The spacecraft-launch vehicle separation sequence began at LO + 367.62 seconds when aft-firing thrusters 9 and 10 were fired. A false telemetry reset occurred approximately 0.9 second later, about 0.4 second prior to spacecraft separation, and lasted for 2 seconds. When the telemetry returned to normal, the aft thrusters were showing off, indicating that the thrust time was close to the planned 2 seconds. This was verified by the actual change in velocity achieved.

The rate command mode was utilized during the two circularization maneuvers (the only two which can be analyzed with platform data) and attitudes were held within ±1° in pitch and yaw and ±2° in roll.

Reentry data became available at 330:02:03 g.e.t. (3 min 59 sec after planned retrofire) at which time the control mode was "pulse" on reentry control system (RCS) ring A. At 330:20:02 g.e.t. and approximately 400K feet, the attitude control was switched to the direct mode for 57 seconds and then to the rate command mode where it remained. These modes were selected to allow the FDI needles to be flown more accurately. During blackout, the second RCS ring (ring B) was energized and both rings remained on until power down. The maximum rates seen prior to drogue parachute deployment (in the data available) were approximately 7 deg/sec in pitch and yaw which is comparable to previous flights.

5.1.5.2.2 Horizon sensor: The sensor control mode, although used relatively little during this mission, exhibited satisfactory performance. As on previous missions, the horizon sensor did experience loss-of-track during sunset periods as a result of sun interference. Also losses-of-track were numerous during the station keeping following insertion and are attributed to spacecraft attitudes. Sensor outputs were used to align the platform several times with good results. The primary sensor performed well throughout the flight with the crew reporting no difficulties. The secondary sensor was not used.

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

Time from lift-off, sec			Event	Component status					Remarks
Planned	Actual RGS	Actual IGS		ACME	Computer	IMU	Horizon sensor	Transponder	
0.00	0.00	0.00	Lift-off	IGS backup	Ascent	Free	Primary	Off	19:30:03.70 G.m.t.
19.44	19.35	19.55	Start roll program	IGS backup	Ascent	Free	Primary	Off	
20.48	20.39	20.46	Stop roll program	IGS backup	Ascent	Free	Primary	Off	
23.04	22.94	22.94	Start pitch program 1	IGS backup	Ascent	Free	Primary	Off	
88.32	88.04	88.13	Stop pitch program 1 Start pitch program 2	IGS backup	Ascent	Free	Primary	Off	
105.00	sent 105.00 verified 105.30	104.30 to 106.83	No. 1 IGS update	IGS backup	Ascent	Free	Primary	Off	
109.96	109.60	109.72	No. 1 gain change	IGS backup	Ascent	Free	Primary	Off	
119.04	118.66	119.27	Stop pitch program 2 Start pitch program 3	IGS backup	Ascent	Free	Primary	Off	
145.00	sent 145.00 verified 145.30	145.20 to 147.68	No. 2 IGS update	IGS backup	Ascent	Free	Primary	Off	
155.35	155.61	155.00	BECO	IGS backup	Ascent	Free	Primary	Off	
162.56	162.02	162.46	Stop pitch program 3	IGS backup	Ascent	Free	Primary	Off	
169.00	168.60	167.99	First guidance command	IGS backup	Ascent	Free	Primary	Off	
338.61	337.01	336.98	SECO	IGS backup	Ascent	Free	Primary	Off	(see below)

Time	Attitude, deg			Rate, deg/sec		
	Pitch	Roll	Yaw	Pitch	Roll	Yaw
SECO - 2.4 sec	-14.9	+90.6	+0.3	-0.22	-0.07	+0.03
SECO + 2.4 sec	-13.1	+91.5	-0.9	-0.46	+0.23	-0.68

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TABLE 5.1.5-1.- SPACECRAFT GUIDANCE AND CONTROL SUMMARY CHART - Continued

Ground elapsed time, hr:min:sec		Event	Component status					Remarks
Planned	Actual		ACME	Computer	IMU	Horizon scanner	Transponder	
0:06:07.61	0:06:07.62	Aft thrusters fire	Direct	Ascent	Free	Primary	Off	Thruster firing time cannot be determined because of a false reset in the telemetry
0:06:08.61	0:06:08.79	Spacecraft separation	Direct	Ascent	Free	Primary	Off	Spacecraft separation occurred during a data drop-out from 00:06:08.52 to 00:06:09.54 g.e.t.
	0:06:10.52	Turnaround	Direct	Ascent	Free	Primary	Off	Turned to station keep with second stage with a pitch up command. Firing duration was 1.2 seconds
	00:06:47.70	--	Rate command	Ascent	Free	Primary	Off	
	00:06:49.00	Closing maneuver	Rate command	Ascent	Free	Primary	Off	TCA 9 and 10 fired for 2.4 seconds. Attitudes at start of thrust were: Pitch - 159.4°, Roll = 281.5°, Yaw = 20.3°
	00:06:51	Station keeping[a]	Direct, pulse and platform	Ascent	Free	Primary	Off	46 translations totaling 50.6 seconds firing time during station keeping
00:22:17	00:21:17.47	D-4/D-7 maneuver	Rate command	Ascent	Orbital rate	Primary	Off	TCA 16 fired for 21.2 seconds
03:47:59	03:47:56.81	Perigee adjust	Rate command	Off	Off	Primary	Off	Planned ΔV = 59 fps; actual = 58.12 fps Planned Δt = 77 sec; actual = 75.37 sec Translation accomplished using star reference for attitude
	22:22:00	Transponder check	Off	Off	Off	Primary	On	Transponder temperature readings were -7.8°, -5.1° and -0.9° F at times 22:22:00, 22:24:00 and 22:26:00, respectively
	45:30:00	Transponder check	Off	Off	Off	Primary	On	Tracking task over KCC-C failed due to improper orientation of ground radar
	68:43:00	Transponder check					On	Temperature varied between 49.6° F to 54.0° F.
69:43:19	69:43:21.10	Perigee adjust	Rate command	Off	Off	Primary	Off	Planned ΔV = 12.4 fps; actual = 12.6 fps Planned Δt = 16.5 sec; actual = 15.75 sec Translation accomplished using a star as attitude reference

[a]Time in platform mode during station keeping was 51.3 seconds.

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

Ground elapsed time hr:min:sec		Event	Component status					Remarks
Planned	Actual		ACME	Computer	IMU	Horizon sensor	Transponder	
	100:40:00	Transponder check	Off	Off	Off	Primary	On	Temperature constant at 62° F
	116:48:55	Platform alignment	Platform and pulse	Pre-launch	SEF	Primary	Off	Completed 119:11:02 g.e.t. Pitch error = +0.11° at completion Roll error = +0.55° at completion Yaw error = +0.72° at completion
	119:02:35	Bias check						Test results satisfactory
119:11:55	119:11:55.08	Perigee adjust maneuver	Rate command	Catchup	Orbital rate	Primary	Off	Planned ΔV = 61.2 fps; actual = 59.972 fps Planned Δt = 78 sec; actual = 75.600 sec
	119:20:07	Platform alignment	Platform and pulse	Pre-launch	BEF	Primary	Off	Still aligning at 119:46:28 g.e.t. Final alignment data unavailable. Errors at end of data were: Pitch = -0.30°, Roll = +0.27°, Yaw = --
119:55:01	119:55:01.0	Apogee adjust maneuver	Rate command	Catchup	Orbital rate	Primary	Off	Planned ΔV = 12.0 fps; actual = 12.13 fps Planned Δt = 15 sec; actual = 15.0 sec
	140:46:00	Transponder check		Off	Off	Primary	On	2 minutes of solid track over Cape Kennedy (KSC interrogation)
	169:31:48	Transponder check		Off		Primary	On	Transponder temperature increased from 62° F to 83° F over Hawaii, revolution 106
	214:31:00	Transponder check	Off	Off	Off	Primary	On	Transponder temperature increased from 54.1° F to 65.1° F in 19 minutes
	236:39:17	Transponder check and bias check		Off		Primary	On	Transponder temperature test. Biases checked all right. Slight shift in Y
	283:23:00	Thrusters 3 and 4 failure	Pulse and direct	Off	Off	Primary	Off	
	288:15:45	Thruster 3 and 4 test	Pulse and direct	Off	Off	Primary	Off	
	328:44:32	Platform alignment			BEF	Primary	Off	Still aligning at 358:54:11.93 g.e.t. Final alignment data unavailable. Errors at end of data were: Pitch = +0.08°, Roll = -0.19°, Yaw = --
	328:37:30	Bias check						Tests results satisfactory

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

Ground elapsed time hr:min:sec		Event	Component status					Remarks
Planned	Actual		ACME	Computer	IMU	Horizon sensor	Trans-ponder	
329:58:04	329:58:04 (pilot report)	Retrofire	Rate command	Reentry	BEF	N/A	Off	
330:19:23 (T_R + 21:19)	330:19:22.6	400K ft	Pulse	Reentry	BEF	N/A	Off	
330:29:26 (T_R + 31:22)	330:29:30	Drogue para-chute deploy	Rate command	Reentry	BEF	N/A	Off	
330:31:04 (T_R + 33:00)	330:31:02	Main parachute deploy	Rate command	Reentry	BEF	N/A	Off	
330:35:20 (T_R + 37:16)	330:35:01	Touchdown	Rate command	Reentry	BEF	N/A	Off	

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TABLE 5.1.5-II.- IVAR COMPARISONS

	Calculated	Data acquisition system
Velocity to be applied at apogee, V_{gp}, ft/sec	-48.790	-48.848
Velocity to be applied at perigee, V_{ga}, ft/sec . . .	28.743	28.769
Radial velocity, V_p, ft/sec	358.362	358.438
Inertial velocity, V, ft/sec	25 448.562	25 448.285
IVI fore-aft, $\Delta V_{X_{s/c}}$, ft/sec	-17.457	-17.528
IVI right-left, $\Delta V_{Y_{s/c}}$, ft/sec	-13.956	-13.227
IVI up-down, $\Delta V_{Z_{s/c}}$, ft/sec	-19.405	-19.718
Time to apogee, T_{AP}, sec	2 987.784	2 987.438

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

Error source	Specification values	Engineering estimates: Error coefficient	Engineering estimates: Velocity error, ft/sec X	Y	Z	Recovery program estimates and uncertainties: Error coefficient	Recovery program estimates and uncertainties: Velocity error, ft/sec X	Y	Z
Constant drift	±0.3 deg/hr								
X_p-gyro		0.04	0	N	-0.4	0	0	0	0
Y_p-gyro		-0.07	N	-1.9	0	0	0	0	0
Z_p-gyro		0.02	N	0	N	0	0	0	0
g-sensitive drift	0.5 deg/hr/g								
X_p-gyro spin axis unbalance		0.26	0	N	-2.4	0	0	0	0
Y_p-gyro spin axis unbalance		-0.23	N	N	0	0	0	0	0
Z_p-gyro spin axis unbalance		0.07	N	0	-0.6	0	0	0	0
X_p-gyro input axis unbalance		-0.01	0	N	1.2	0	0	0	0
Y_p-gyro input axis unbalance		0.32	0.8	8.8	0	0.38 ± 0.74	1.1	10.5	0
Z_p-gyro input axis unbalance		0.12	N	0	4.1	0	0	0	0
Accelerometer bias	300 ppm								
X_p		38	0.2	-0.9	0	0	0	0	0
Y_p		100	N	0	-1.4	0	0	0	0
Z_p		-15	0	N	0	-73.6 ± 745	0	-0.74	0
Accelerometer scale factor	350 ppm								
X_p		108	2.7	0	0	154.8 ± 383	3.8	0	0
Y_p		N	0	0	0	0	0	0	0
Z_p		N	0	0	0		0		0

N = negligible

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

Error source	Specification value	Engineering estimates				Recovery program estimates and uncertainties			
		Error coefficient	Velocity error, ft/sec			Error coefficient	Velocity error, ft/sec		
			X	Y	Z		X	Y	Z
Timing error, sec		0.005	1.0	0.2	N	0.0115 ± 0.029	2.4	0.43	N
IGS time scale factor	0.050 sec	0	0	0	0	-85 ± 115	-6.4	-1.7	N
Total velocity error			4.7	6.2	0.5		0.9	8.5	0

External tracker errors

System	Range bias, ft	P bias, ft	Q bias, ft	Azimuth, radians	Elevation, radians	Refraction, n units
GE Mod III (final)	N	0	0	N	N	N
MISTRAM 100K	-35.0 ± 52	3.5 ± 1.5	1.8 ± 1.5			36 ± 228

N = negligible

TABLE 5.1.5-IV.- GUIDANCE ERRORS AT SECO

	Position, ft			Velocity, ft/sec		
	X	Y	Z	X	Y	Z
IMU error	740 ± 100	700 ± 100	100 ± 50	4.0 ± 2.0	6.0 ± 3.0	0.5 ± 1.0
Navigation error	480	-10	3	1.5	0.9	0.7
Total guidance error	1320 ± 100	690 ± 100	103 ± 50	5.5 ± 2.0	6.9 ± 3.0	0.6 ± 1.0

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

System	Inertial velocity, ft/sec	Inertial flight-path angle, deg	Inertial velocity components (computer coordinates), ft/sec		
			X	Y	Z
Nominal	25 806	0.002	25 372	4715	12.9
IGS	25 801	0.026	25 387	4597	-183
Preliminary best estimate trajectory	25 793	0.003	25 381	4590	-184
MISTRAM 10K	25 794	0.022	25 382	4587	-186
MISTRAM 100K	25 794	0.044	25 382	4593	-185
GE Mod III/Final	25 793	0.033	25 381	4590	-184

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TABLE 5.1.5-VI.- TRANSLATION MANEUVERS

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Event	Time, g.e.t., hr:min:sec	Components, ft/sec			Total ΔV, ft/sec	Planned ΔV, ft/sec	Deviation, percent
		ΔV_X	ΔV_Y	ΔV_Z			
Tailoff[a]	00:05:38.0	79.98	20.03	1.15	82.45	84.30	2.10
Separation[a]	00:06:07.6	2.97	0.60	-0.16	3.03	2.00	51.50
Closing[a]	00:06:48.9	-1.45	-0.79	-0.49	1.72	2.00	14.0
D-4/D-7[a]	00:21:17.0	-0.26	8.75	0.61	8.78	10.00	12.2
Perigee adjust[b]	03:47:59.0	57.68	-4.29	5.68	58.12	59.00	1.49
Perigee adjust[b]	69:43:19.0	12.48	1.21	0.71	12.56	12.40	1.29
Circularization[a]	119:11:55.0	59.96	0.04	1.38	59.97	61.20	2.01
Circularization[a]	119:55:01.0	-12.12	-0.40	-0.25	12.13	12.00	1.08
Retrofire, actual[c]	329:58:04.0	-298.0	112.0	3.0	318.5	316.8	0.54

[a]Calculated using accelerometer outputs (no bias correction required)

[b]Reconstructed using changes in trajectory.

[c]Crew reported time and IVI readings.

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TABLE 5.1.5-VII.- GEMINI VII PLATFORM ALIGNMENT ACCURACY

Time, g.e.t., hr:min:sec	Mode		Pitch error (sensor minus gimbal angle), deg (a)	Roll error (sensor minus gimbal angle), deg (a)	Remarks
	ACME	Platform			
117:50:06	Pulse, platform	SEF	1.52	0.83	Start alignment
118:25:51			-.09	-.06	Finish alignment
118:48:55	Pulse, platform	SEF	-1.33	-0.27	Start alignment
119:11:02			.11	.55	Finish alignment
119:20:07	Pulse, platform	BEF	-0.80	1.33	Start alignment
119:46:28			-.30	.27	Still aligning, last available data
260:53:47	Platform	BEF	0.08	-0.18	Aligning, first available data
260:56:45			-.25	-.49	Finish alignment
328:44:42	Probably platform (data not available)	BEF	-0.70	-1.11	Aligning, first available data
328:54:11			.08	-.19	Still aligning, last available data before retrograde

[a]Determined for torque current tabular data. Accuracy ±0.63°.

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TABLE 5.1.5-VIII.- COMPARISON OF COMPUTER TELEMETRY REENTRY PARAMETERS WITH POSTFLIGHT RECONSTRUCTION

Parameters	Time = 330:19:38.36 g.e.t. Altitude = 400K ft			Time = 330:28:45.48 g.e.t. Guidance termination		
	Telemetry	MAC[a]	IBM	Telemetry	MAC	IBM
Time in mode, sec	2 606.659	2 606.659	2 606.659	3 155.952	3 155.952	
Radius vector, ft	21 301 316	21 301 460	21 002 982	21 002 982	21 003 027	
Velocity, ft/sec	24 407.805	24 407.134	24 407.896	1 655.521	1 650.2662	
Flight-path angle, deg	-1.392	-1.386	-1.392	-23.375	-23.279	
Down-range error, n. mi. . . .	NA	NA	NA	5.3	-	
Cross-range error, n. mi. . . .	0.634	0.929	0.630	-1.327	-1.336	
Bank angle command, deg	-60	-60	-60	0.0	0.0	0.0
Latitude, deg	28.848	28.848	28.849	25.298	25.298	
Longitude, deg	256.876	256.795	256.888	289.800	289.777	
Density altitude factor	NA	NA	NA	4.59927	4.59851	
Half-lift range prediction, n. mi.	NA	NA	NA	6.6	6.4	
Range to target, n. mi. . . .	1 776.4	1 780.6	1 775.7	11.5	12.8	
Spacecraft heading, deg	88.1	88.0	88.1	102.5	102.5	
Heading to target, deg	89.1	89.1	89.1	109.1	108.5	

[a]Program initialized with White Sands tracking vector.

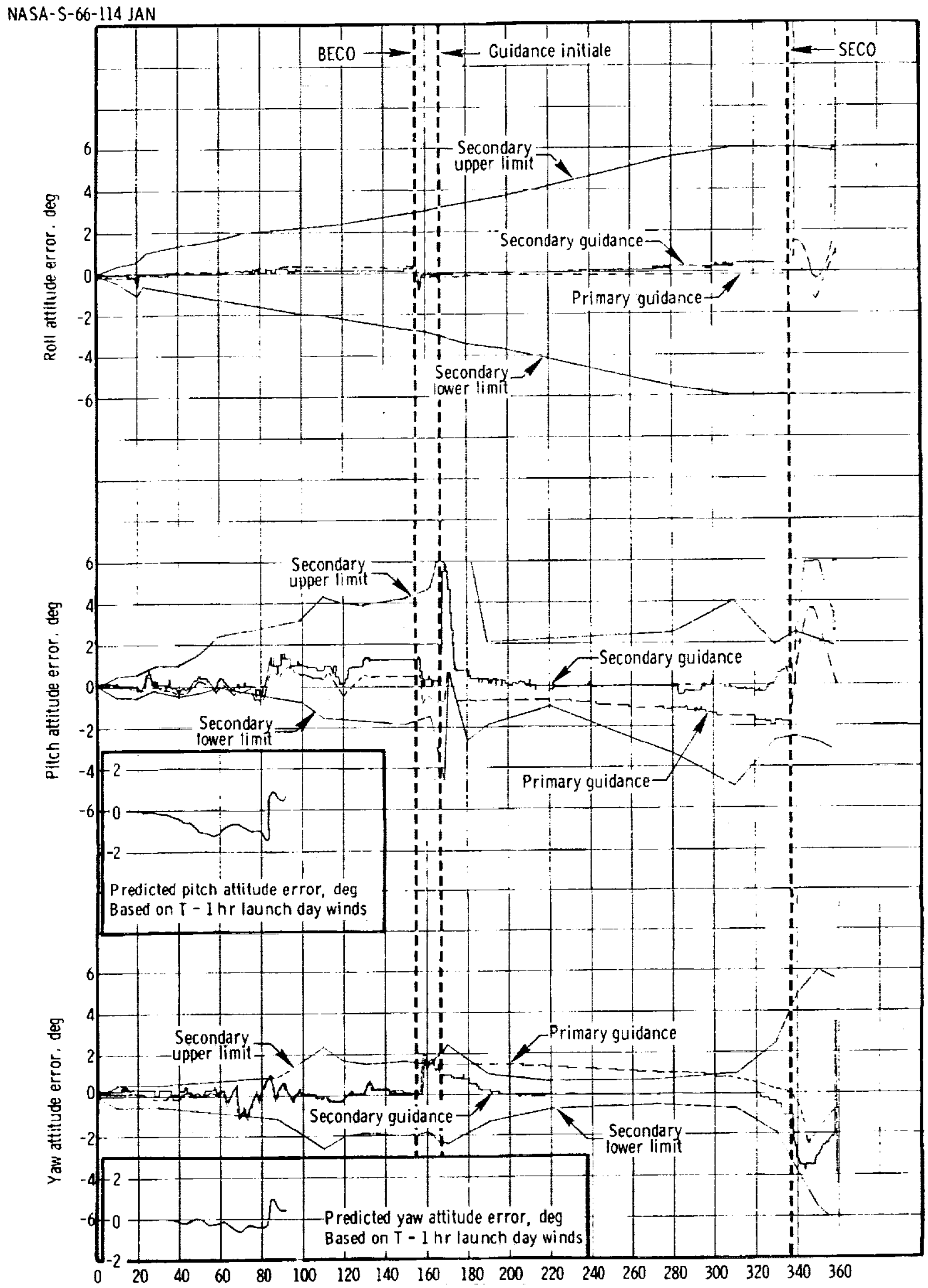

Figure 5.1.5-1. - Comparisons of launch vehicle and spacecraft steering errors.

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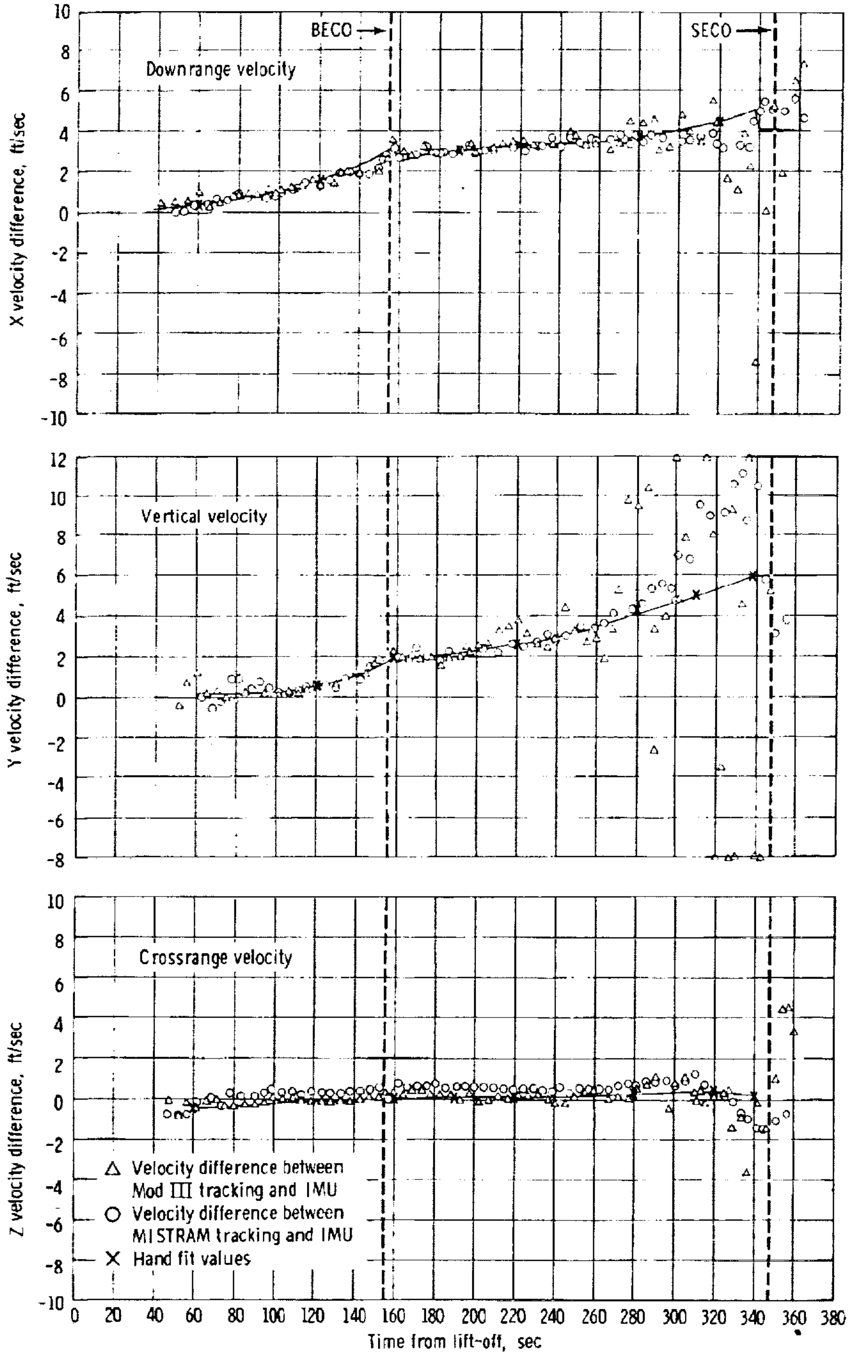

Figure 5. 1. 5-2. - Comparisons of spacecraft IGS and radar tracking velocities.

NASA-S-66-124 JAN

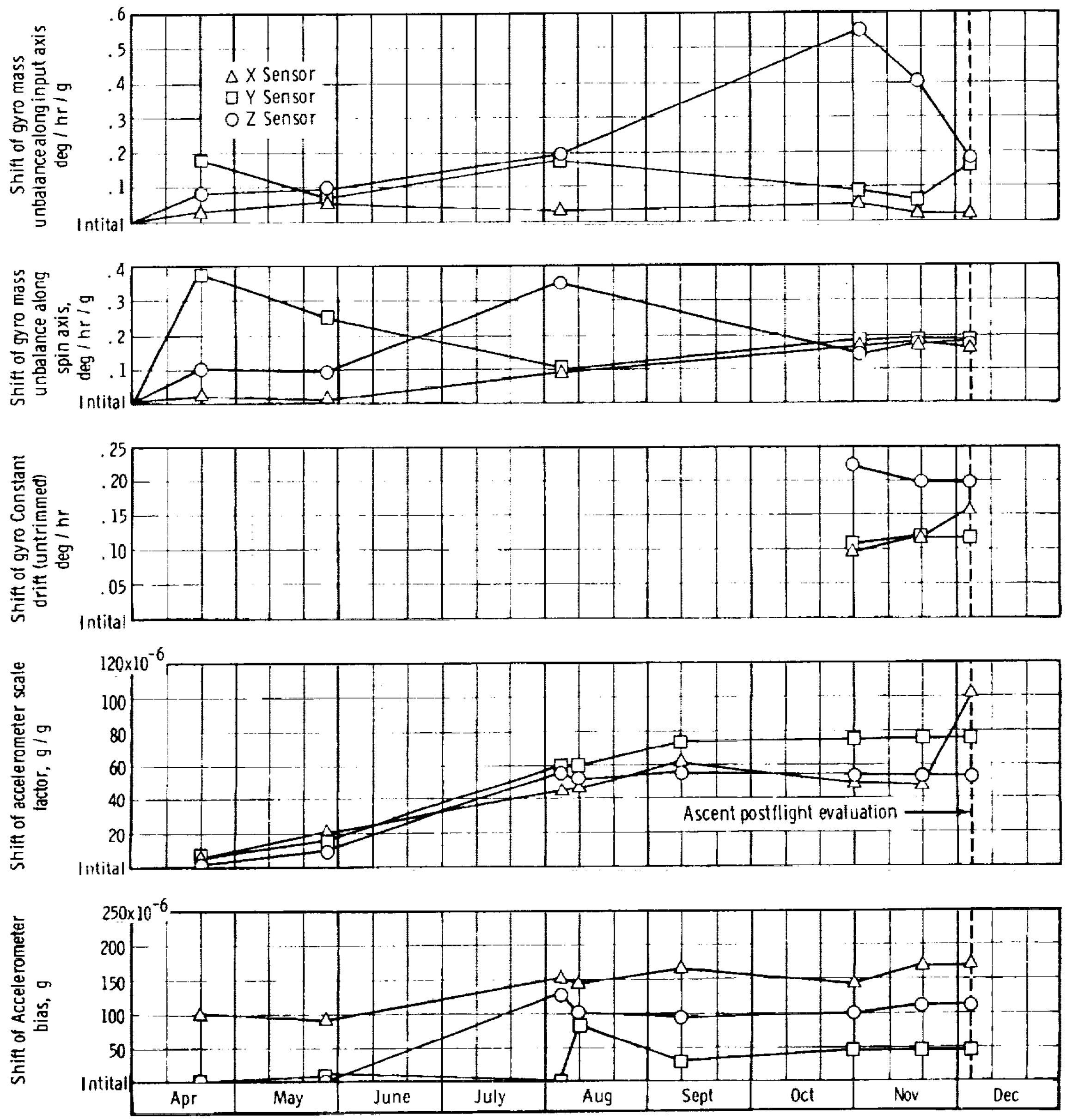

Figure 5.1.5-3.- IMU error coefficient history.

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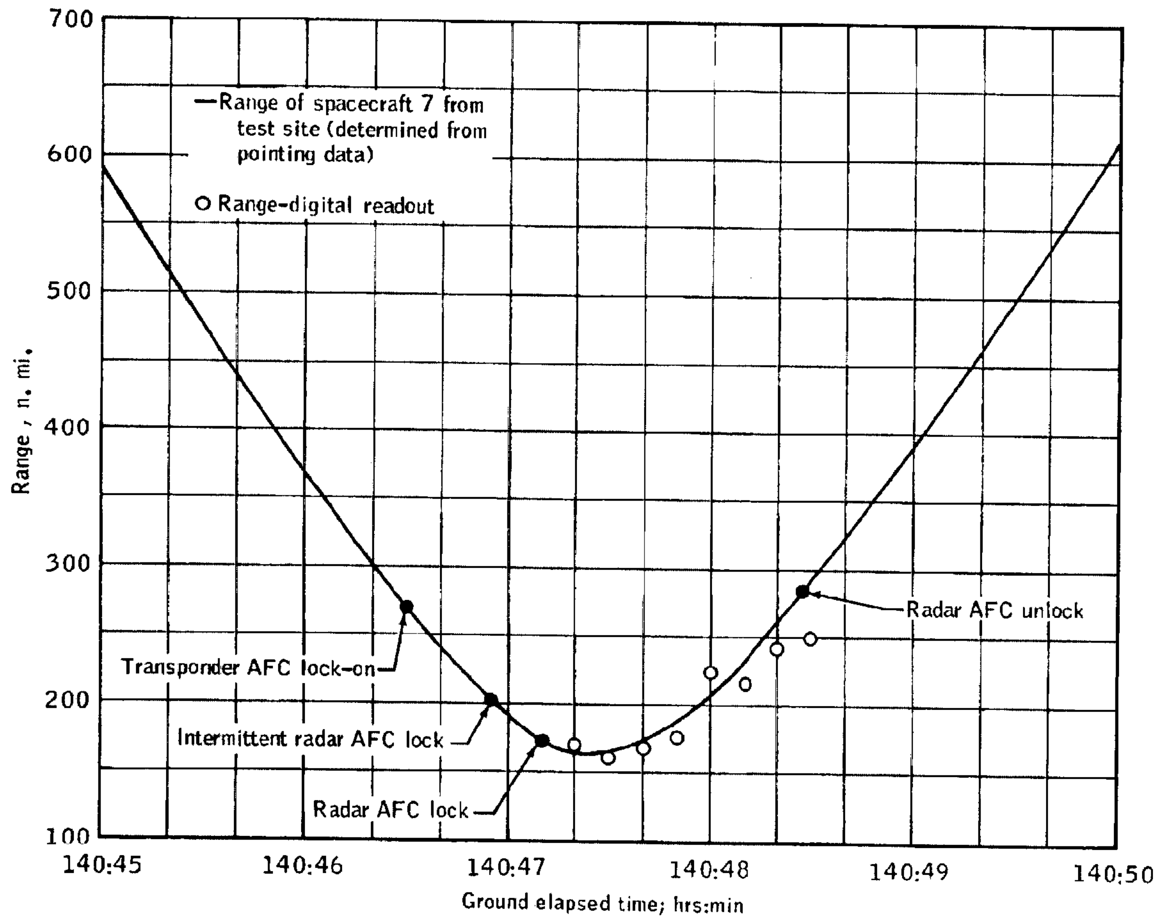

Figure 5.1.5-4. - Transponder tracking test results.

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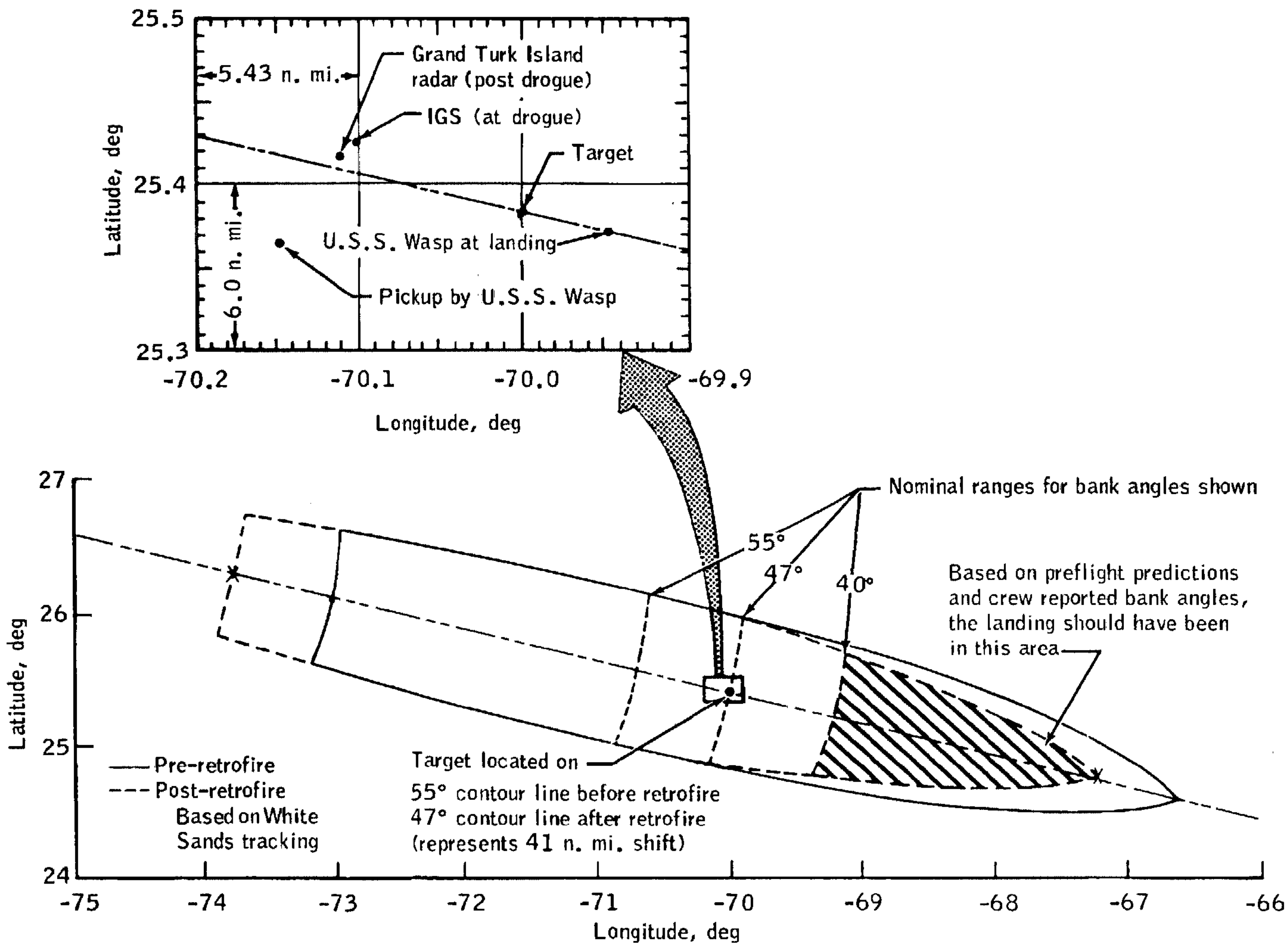

Figure 5.1.5-5. - Touchdown comparisons.

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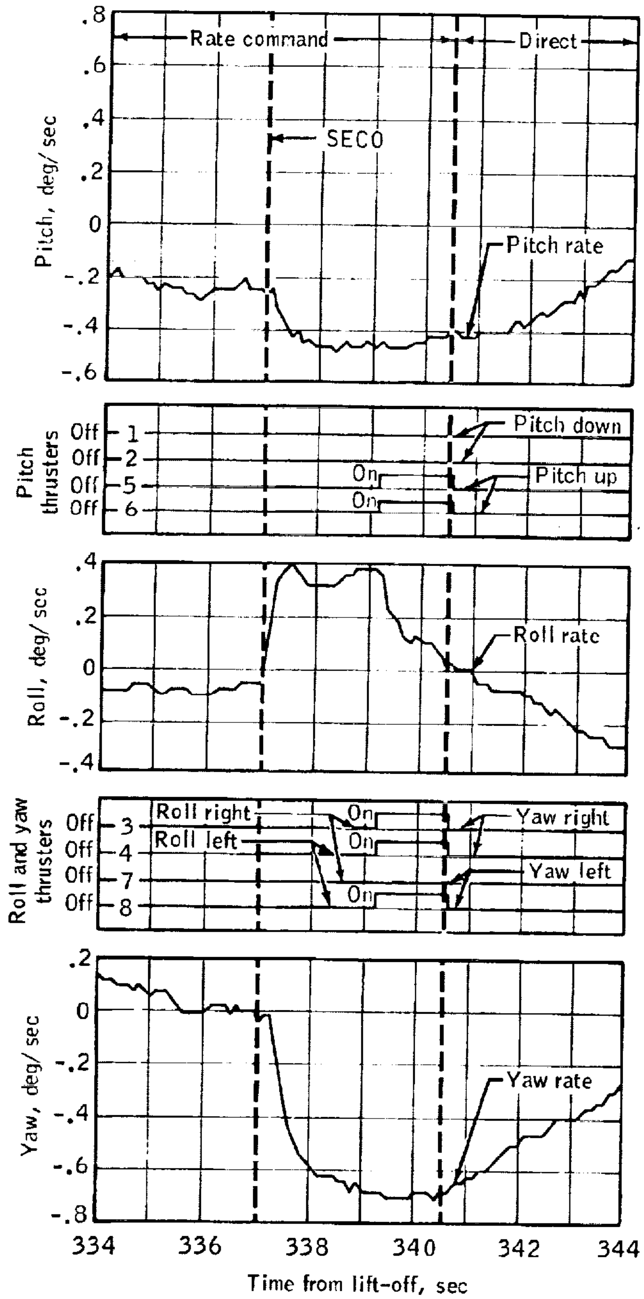

Figure 5.1.5-6. - SECO transients.

5.1.6 Time Reference System

Analysis of the available data indicates that the power to the electronic time reference module of the spacecraft electronic time system experienced two accidental shutoffs by the crew. The first occurred during revolution 29 while the pilot was removing his pressure suit and lasted approximately 577.60 seconds. The second shutoff occurred during revolution 49 when the circuit breaker was switched off by mistake and lasted approximately 2.86 seconds. Accuracy of the electronic time reference was calculated to be 0.2 part per million for the entire mission period after correcting for the shutoff errors (580.46 sec) and the normally delayed lift-off start (12 milliseconds). The design specifications require an accuracy of ±10 parts per million at a temperature of 25°±10° C.

The event timer, ground-elapsed-time digital clock, and the 8-day G.m.t. panel clock operated satisfactorily. The flight crew reported that they did not use the panel-mounted battery-operated electronic clock. The recovery forces failed to compare the time on this clock and the 8-day clock with Greenwich mean time; therefore, the accuracy of these clocks during the mission is unknown. The time correlation buffer operated satisfactorily according to preliminary examination of the cnboard voice tape transcriptions.

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5.1.7 Electrical System

The electrical system performed in a generally satisfactory manner during the entire mission. After insertion into orbit, an indication of out-of-specification differential pressure within the section 2 fuel cell was exhibited on the cabin warning light and by telemetry. This, coupled with cyclic load sharing by the individual stacks in section 2, and several degradations in performance caused the fuel cell system to receive considerable attention by the crew and ground personnel during the last half of the mission. This subject is covered in detail in section 5.1.7.2.

5.1.7.1 Power system.- Nominal electrical power was supplied during the entire mission.

During the period of time between 206:56 and 211:29 g.e.t. the section 2 control circuit breaker tripped. It was reset, and 32 minutes later it tripped again. This is a 5-ampere breaker through which power is supplied to the hydrogen (H_2) and oxygen (O_2) purge valves, H_2 inlet valves, the water valve, and the main cryogenic shutoff valves for section 2. Following the second occurrence, the flight crew did not leave the breaker on except for short periods when it was required. When the circuit breaker was turned on with no known load, the current was observed to be approximately 0.8 ampere but it did not trip again. The condition of the squib batteries during postflight discharge was excellent, indicating that no constant current drain had been demanded from them. The circuit breaker probably experienced varying fault-load conditions and responded as it should have. Investigation of the parts of the circuits which were available after the flight revealed no discrepant conditions. The circuit breaker is presently being examined in the Malfunction Investigation Laboratory at the Kennedy Space Center.

After landing, the flight crew observed oscillations of the main bus ammeter needles. This same response was observed on other spacecraft and was attributed to motion of the spacecraft on the water. In an effort to determine if this is the case, a postlanding electrical test was performed while the spacecraft was still on the water. In the Gemini spacecraft, the main bus ammeter no. 1 indicates current supplied from reentry batteries 1 and 2 and main bus ammeter no. 2 indicates current supplied from reentry batteries 3 and 4. In the spacecraft 7 postlanding test, batteries 3 and 4 were turned off. When batteries 3 and 4 were removed from the bus, ammeter no. 2 response went to zero and ceased to oscillate. The response of ammeter no. 1 increased as expected and its oscillations continued to follow spacecraft motion. Whether or not the amplitude of the oscillation of ammeter no. 1 remained the same or increased remains unanswered. Ammeter response to spacecraft motion and ammeter response to electrical stimulus could not be separated because of the loss of the telemetry tape recorder. Postflight inspection revealed the usual blown fusistors caused by a partial short circuit resulting from the normal slag formation in fired pyrotechnics.

Twenty-nine percent of the rated capacity of the main batteries and 39.6 percent of the rated capacity of the squib batteries were used during the mission.

5.1.7.2 Fuel cell.-

5.1.7.2.1 Fuel cell and main battery load sharing: During the ascent phase, the fuel cells assumed approximately 78 percent of the overall main-bus load. During the orbit phase, prior to the power-up for retrograde, the fuel cells provided 100 percent of the main-bus power. In addition, to conserve squib-battery power, the main-to-squib bus tie switches were closed and the fuel cells supplied the squib and control busses from 237 hours 59 minutes to 327 hours 13 minutes g.e.t. During the preretrofire phase, four of the six fuel cell stacks supplied approximately 29.4 amperes and the main batteries supplied 15.8 amperes for a total of 45.2 amperes at 24.2 volts. The minimum load recorded during the entire mission was 14.2 amperes at 25.8 volts. This load was supplied by only three of the six fuel cell stacks when the section 2 fuel cell was off the line during a crew sleep period between 269:36 and 280:24 g.e.t. The maximum load of 45.2 amperes at 24.8 volts was supplied by all six fuel cell stacks at 119:42 g.e.t. when the guidance system was powered up for the circularization maneuvers.

5.1.7.2.2 Performance variations: The performance of fuel cell section 1 during section activation and the performance on the first, eleventh (including a power up for rendezvous), and last days of spacecraft 7 flight are shown in figure 5.1.7-1. During these periods, the voltage decay averaged 0.003 and 0.005 volt per hour at 10 and 24 amperes, respectively. These decay rates are within the range experienced in laboratory life tests. A review of each of the other daily performance curves shows a continuous and consistent decay trend throughout the mission. However, minor degradations for periods are evident on these daily performance curves, particularly on the 9th, 10th, and 11th days. Most of the excessive variation in section 1 performance was caused by intermittent degradations of stack 1C. As expected, the poorest load sharing of stacks occurred at the low section loads. The load sharing of the stacks varied from approximately 25 to 40 percent of section current.

The performance decay rate of section 2 (see fig. 5.1.7-2) throughout the first 127 hours of flight, although greater than section 1, was also within the range experienced in laboratory life tests. At 127 hours, the first of several rapid performance declines was experienced. The declines started at 127, 149, 201, and 220 hours g.e.t. and lasted for approximately 15, 24, 9, and 13 hours, respectively. All of these declines were followed by recoveries to the section 2 normal performance decay. In addition, a minor decline and recovery started at 217 hours g.e.t. and lasted for 3 hours.

The larger performance decay of section 2 compared to section 1 was caused mainly by the reduction in performance which occurred between the second activation and the first day of flight. Based upon this, and ignoring the frequent declines and recoveries, the average performance decay for the first 11 days of the mission was approximately 0.003 volt per hour which was the same as the average performance decay of section 1 at a 10-ampere load. Furthermore, the consistent return to this average during this period indicated that there was no abnormal membrane degradation. At 259 hours g.e.t., the last rapid performance decline in section 2 started. This decline culminated in a decision to remove stacks 2A and 2C from the bus. Figure 5.1.7-3 shows a time history of the current supplied by each of the two fuel-cell sections. This figure also shows the individual load sharing of the three stacks of each of these sections.

During normal operation, stack 2C had the highest performance of all 6 stacks, carrying up to 24 percent of the system load and up to 48 percent of the section. All of the rapid declines in performance of section 2 included severe drops in stack 2C performance. When section 2 was placed on the bus after the second decline, the performance of stacks 2A and 2B was low. Stacks 2A and 2B required much of the second recovery period between 186 and 190 hours g.e.t. to return to the normal performance trend line.

Prior to its initial decline, section 2 maintained approximately 48 percent of the system load. Following the initial recovery, the section 2 load share increased to about 51 percent. This trend towards increased section 2 load sharing was observed on each subsequent recovery and just prior to the last performance decline it was assuming 55 percent of the system load.

Major performance recoveries of section 2 were realized at the times noted between 142 and $242\frac{1}{2}$ hours g.e.t. after one of the following actions was taken by the flight crew:

(a) At 142 hours g.e.t., stack 2C was placed on open circuit for 10 minutes and recovery took place after 7 minutes.

(b) At 173 hours g.e.t., section 2 was placed on open circuit for 13.6 hours, purged at 186 hours g.e.t., and the cross-over opened for 1.4 hours.

(c) At 219 hours g.e.t., the low pressure reactant cross-over valve was opened for 2.1 hours.

(d) At 242 hours g.e.t., stack 2C was placed on open circuit for 30 minutes.

During the mission, the section 2 oxygen-to-water differential pressure warning light was on most of the time. It was reasoned that the differential pressure warning light meant low oxygen-to-water pressure across the water separators in section 2. With this out-of-tolerance differential pressure, the extraction rate of water from the section would be reduced severely. Therefore, when performance of stack 2C in section 2 started dropping, it was suspected that water was accumulating in section 2. Stack 2C showed degradation first, because it was carrying 45 to 50 percent of the section's load. The effect of excessive water is to reduce the effective active membrane area in each cell. Therefore, section 2 was given extra purges to move water out of the purge ports, and was open circuited to stop the production of water. Open-circuit operation also results in higher oxygen pressure which causes a higher differential pressure during purging. A postflight analysis of the available data supports the theory of water accumulation, and validates the subsequent actions taken during the mission to remove water from the section.

The variations in product-water storage are compared with the performance of the fuel-cell sections in figure 5.1.7-4. The product-water storage variation is presented as the difference between (1) the product water that should have been theoretically stored based on ampere-hours of electrical power minus the crew water consumption, and (2) the calculated storage based on the pressure changes of the nitrogen gas in the water accumulation tanks. Temperature corrections were made using the temperature changes of the orbital attitude and maneuver system (OAMS) helium pressurant located in the equipment adapter section. The figure shows that during the period from 100 hours to 265 hours g.e.t. there was a maximum storage fluctuation of 8 pounds around the gradual storage reduction. The gradual storage reduction, totaling 12 pounds at the end of the flight, is attributed to losses of water during purges of oxygen and hydrogen (see section 5.1.7.2.3), possible loss of nitrogen in the water reference system, and possible water leakage. A significant observation is that when periods of maximum product-water storage occurred, the section current characteristics at constant voltage show good fuel-cell performance. When periods of minimum or decreasing product-water storage occurred, section 2 had very low or degrading performance. The responses to the corrective actions were significant increases in stored water followed by rapid returns to normal performance in stack 2C and in section 2. Section 1 also experienced periods of performance degradation that were correlated with fluctuations in water storage.

No explanation can be given at this time for the cause of this variation in water storage. Several theories are apparent but none can be supported due to lack of data.

5.1.7.2.3 Purging: Photographs of spacecraft 7, taken during station keeping with spacecraft 6, revealed an ice formation around the hydrogen vent port on the equipment adapter section. The size of this ice formation was approximately 2 inches in diameter and 5 inches long (fig. 5.1.7-5). This was unexpected because heating of this outlet had been provided. Although all evidence points to the outlet never having been completely blocked, the ice formation may have obstructed the flow of hydrogen sufficiently to impair the effectiveness of purging.

Attempts to determine quantitative effects of purging on the electrical performance of the stacks and sections have met with little success. The performance improvement from purging was smaller than expected and was obscured by performance changes and normal data scatter.

The illumination of the oxygen-to-hydrogen differential pressure warning light, a normal occurrence experienced during ground hydrogen purging of the fuel cells, was not experienced during hydrogen purges of the sections. Illumination of this light was also not experienced on the flight of Gemini V during hydrogen purges. Partial or total restriction at the vent port resulting from freezing of the moisture carried with the hydrogen could cause limitation of flow and preclude illumination of the oxygen-to-hydrogen differential pressure warning light during purges in flight. The flight crew reported that with proper lighting conditions and spacecraft orientation they could see ice crystals during the hydrogen purges of both sections and that this visual verification occurred throughout the mission. This report verifies purge flow at those times when sighting conditions were right and also verifies that the vent port was not, at these points in the mission, completely restricted.

A recovery of the performance of section 1 occurred at the same time as an inadvertent triple-length hydrogen purge of section 1 at 136 hours 10 minutes g.e.t. Both sections 1 and 2 were showing degraded performance at that time.

In some other periods of degraded fuel-cell operation, purges were concurrent with marked reversal in the performance trends but there were enough examples which showed the opposite effect to preclude definite correlation between recovery and purging.

5.1.7.2.4 Pressure differential indications: Prior to launch, both sections 1 and 2 experienced short periods of oxygen-to-water differential pressure excursions slightly beyond the activation limits of the sensors. The section 1 indication occurred when operating from reactant supply system (RSS) regulators with the crossover valve open, and lasted for approximately 6 minutes. The section 2 indication occurred when operating from aerospace ground equipment (AGE) regulators shortly after transition from RSS to AGE and lasted only for a moment.

During the launch phase, oxygen-to-water differential pressures beyond the sensor differential pressure activation limits were indicated intermittently for both sections. Preflight calculations and simulated water-system test results led to anticipation of these differential pressure indications during this period.

During orbital flight, oxygen-to-water differential pressure indications were not anticipated but were experienced. Oxygen-to-hydrogen differential pressure indications because of a hydrogen purge were anticipated but were not seen. (See paragraph 5.1.7.2.3.)

The section 2 oxygen-to-water differential pressure warning light remained on after launch for the major portion of the mission. There were approximately 16 hours total of short periods when this light was not illuminated, 11 hours of which were prior to 80 hours g.e.t. Prior to the first section 2 performance problem at 127 hours g.e.t., the differential pressure warning light had been on continuously for about 50 hours.

The section 1 oxygen-to-water differential pressure indicator was on momentarily at 31 hours g.e.t. More indications of longer durations began at 242 hours g.e.t. when the warning light came on and stayed on for approximately 40 minutes and shortly thereafter came on again for an additional 40 minutes. Beginning at 283 hours g.e.t., the section 1 oxygen-to-water differential pressure indicator started behaving in the same manner as the section 2 indicator had behaved early in the mission. It was indicating an out-of-tolerance differential pressure continuously from 309:57 to 329:57 g.e.t. when the equipment adapter section and fuel cells were jettisoned.

Correlation of differential pressure indications with variations in other parameters is not positive, and the exact cause or causes have not been established at this time.

5.1.7.3 Reactant supply system.-

5.1.7.3.1 Hydrogen supply: At lift-off, the reactant supply system (RSS) hydrogen pressure was approximately 188 psia and the mass quantity was 106 percent (23.58 lb). The pressure then cycled between 160 and 240 psia because of intermittent use of the internal heater until about 240 hours g.e.t. From 240 hours g.e.t. until the end of the mission, the pressure was almost constant at 240 psia. The hydrogen tank did not vent throughout the mission. At 329 hours g.e.t., just before retrofire, the mass quantity was 38.43 percent (8.55 lb). Total usage for the mission was 15.03 pounds. Based on a real-time estimate of average power consumption which was not very accurate, a specific hydrogen consumption of 0.0027 pound per amp-hour is indicated. This estimate of specific hydrogen consumption is 0.7 percent over theoretical.

5.1.7.3.2 Oxygen supply: The RSS oxygen container was pressurized to 230 psia with a mass quantity of 101 percent (181.8 lb) at launch. The internal heater was in the off position and the pressure decreased gradually, because of normal extraction, to approximately 140 psia at 22 minutes g.e.t. The crew was instructed to open the crossfeed valve to transfer oxygen from the primary oxygen container to the RSS oxygen container in order to increase the pressure to 250 psia. The crossfeed valve was opened for 17.5 seconds at 25 minutes g.e.t. Approximately 0.35 pound of oxygen was transferred, increasing the tank pressure to 417 psia. The crossfeed system had been installed between the environmental control system (ECS) and RSS oxygen containers to preclude the recurrence of low fuel cell oxygen supply pressure that occurred during the Gemini V mission. The internal heater was used intermittently to maintain proper container pressures until 78 hours g.e.t. when the heater was placed in the automatic position for the remainder of the flight. The automatic control apparently worked satisfactorily for the remainder of the flight; however, the pressure transducer failed at approximately 171 hours g.e.t. evidenced by a constant indication of 910 psia on both telemetry and onboard indicators. Satisfactory automatic heater operation was indicated after 171 hours g.e.t. by observing the expected load variations on the main bus ammeter.

At 329 hours g.e.t., just before retrofire, the mass quantity was 33.86 percent (60.95 lb). Total usage for the mission was 121.2 pounds. Based on the real-time estimate of average power consumption which is not very accurate, a specific oxygen consumption of 0.021 pound per amp-hour is indicated. This estimate of specific oxygen consumption is 1.9 percent under theoretical.

5.1.7.4 Sequential system.- The performance of the sequential system during the mission was nominal. The major electrical sequential spacecraft events and times of occurrence, except as noted below, may be found in table 4.2-I. Equipment section separation, auto retrofire initiation (no. 1); manual retrofire, retrorocket no. 2 fire, retrorocket no. 3 fire, and retrorocket no. 4 fire indications are not available because the spacecraft onboard PCM tape recorder was inoperative during this period and the spacecraft was not in the receiving range of any instrumentation aircraft or network ground station.

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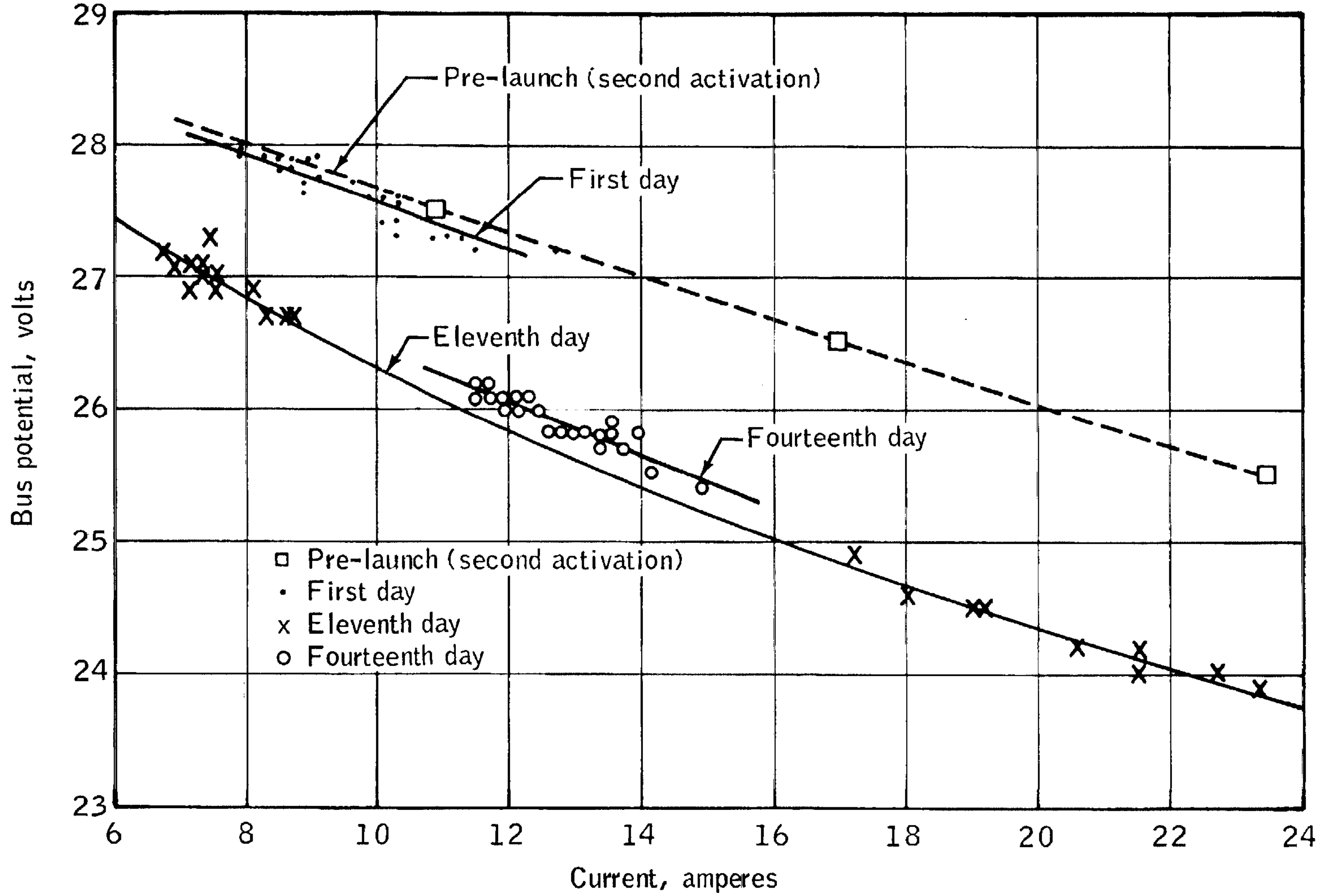

Figure 5.1.7-1. - Fuel cell section 1 performance.

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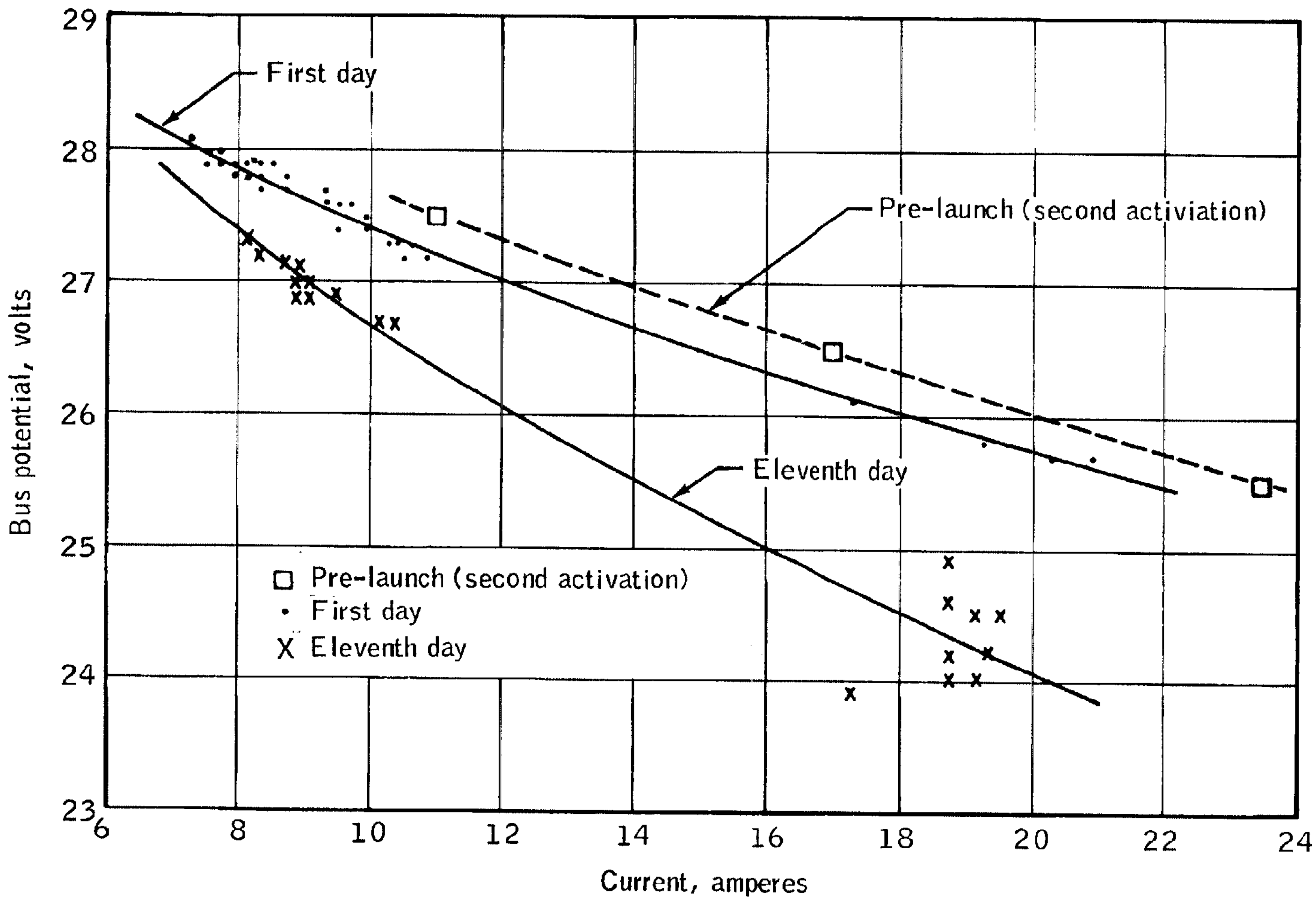

Figure 5.1.7-2. - Fuel cell section 2 performance.

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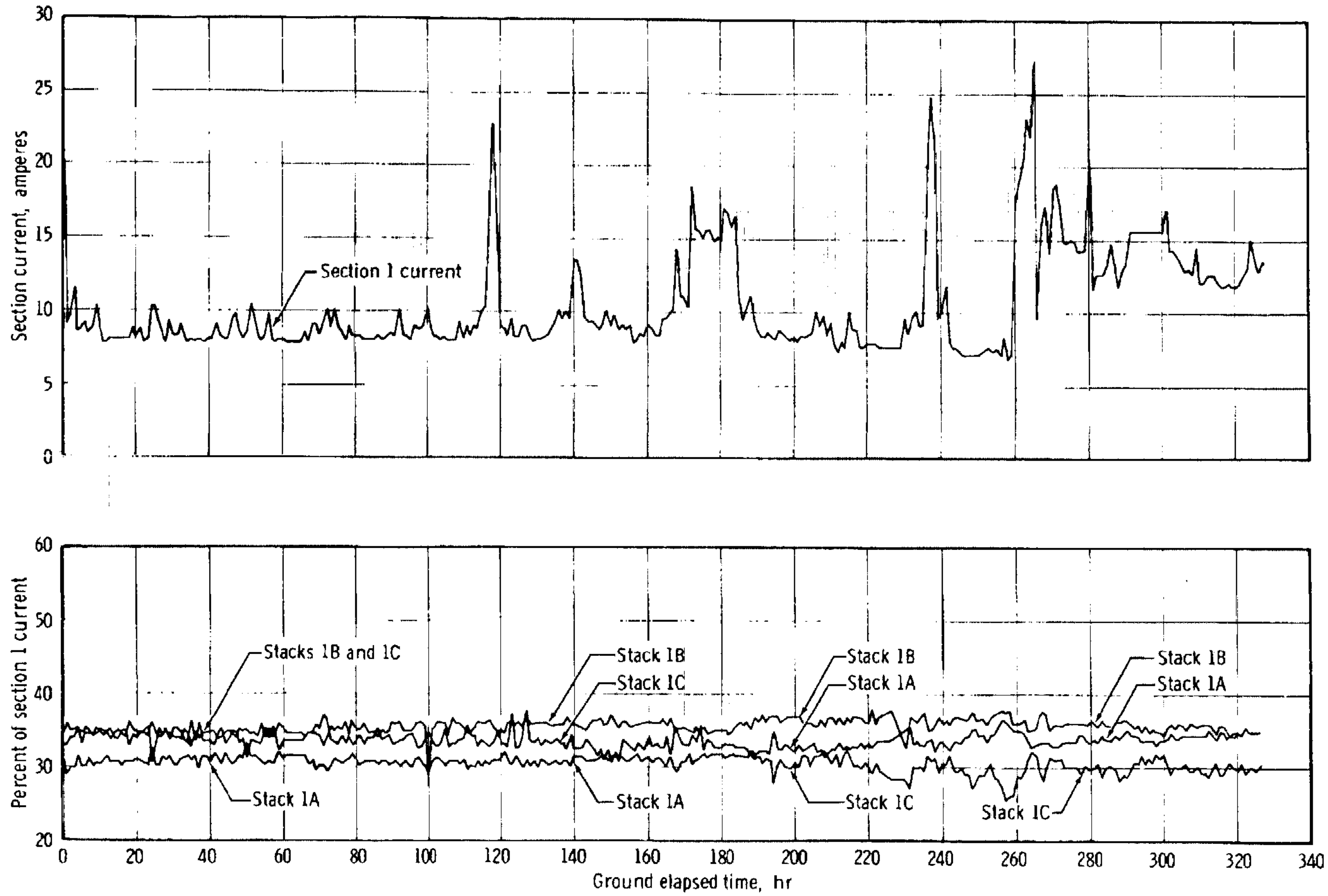

(a) Section 1.

Figure 5. 1. 7-3. - Fuel cell load-sharing characteristics.

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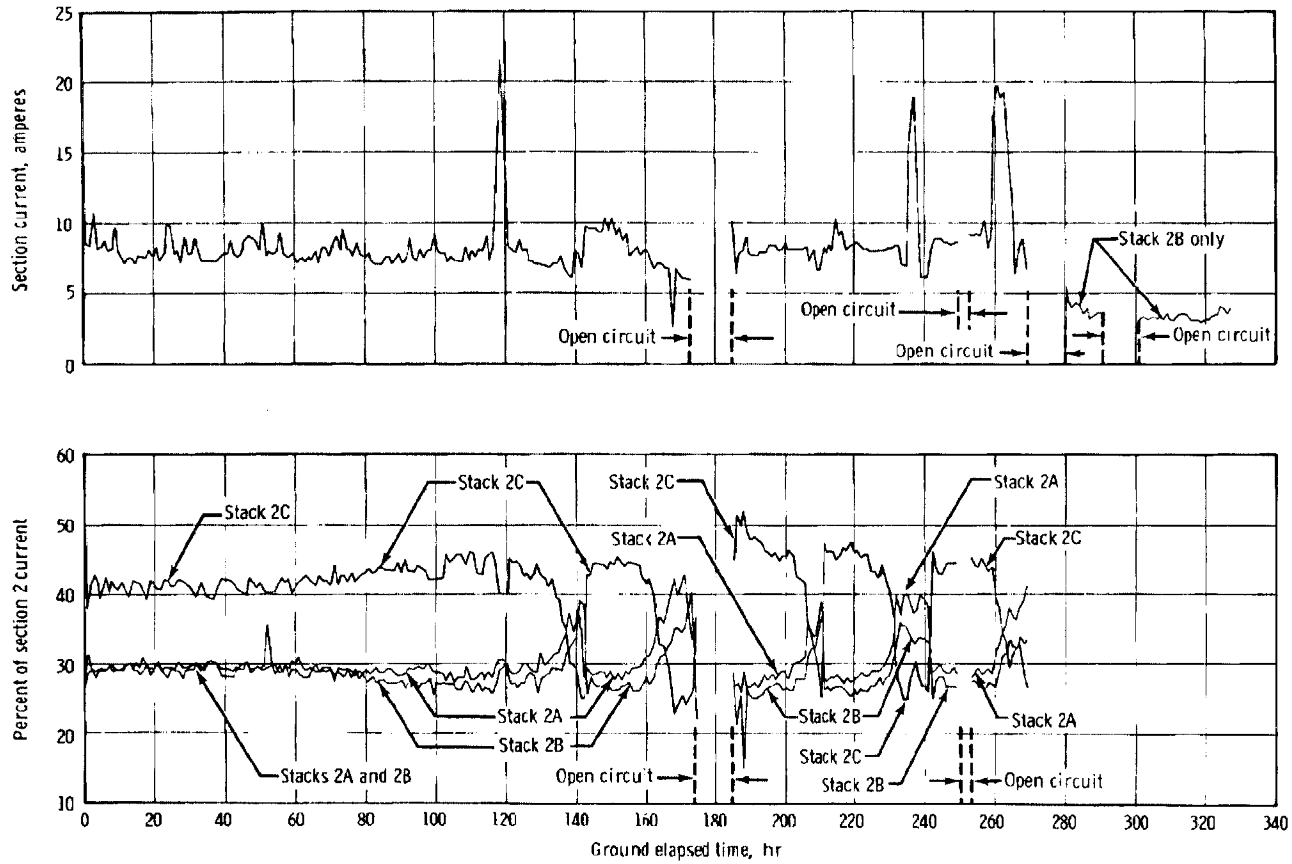

(b) Section 2.

Figure 5.1.7-3. - Concluded.

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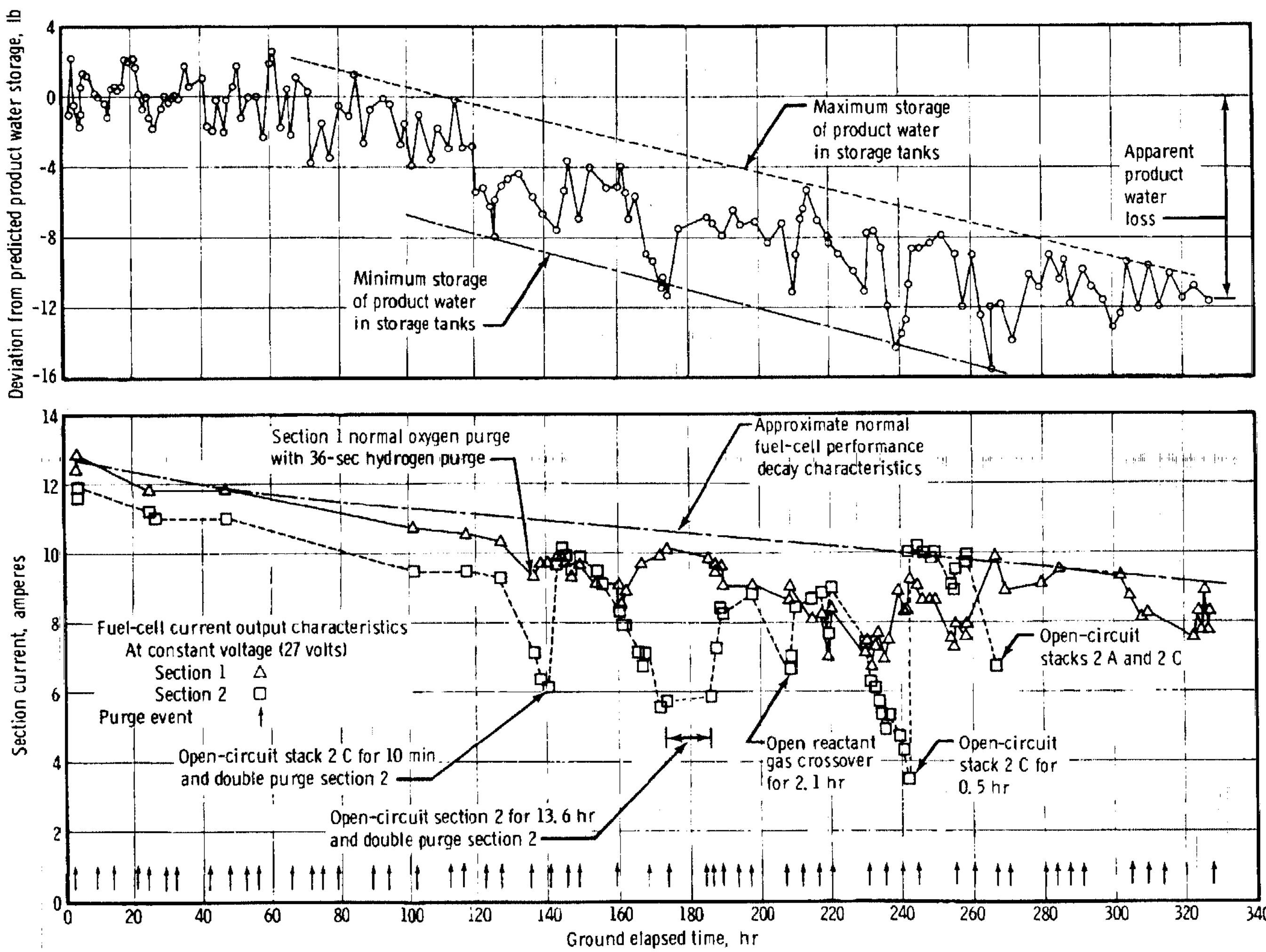

Figure 5.1.7-4. - Comparison of fuel cell performance with fuel cell product water storage.

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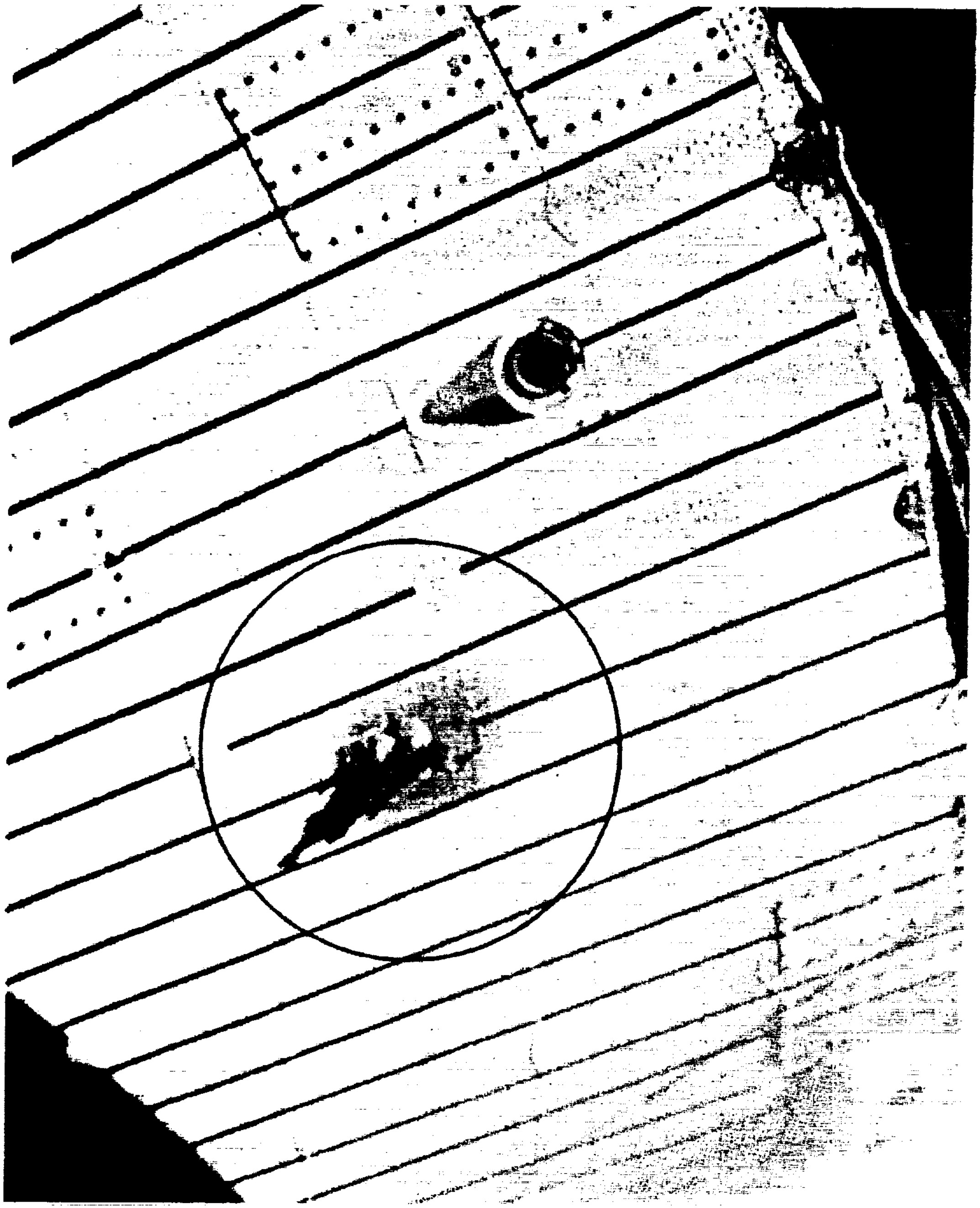

Figure 5.1.7-5. - Ice formation at hydrogen vent.

5.1.8 Spacecraft Propulsion Systems

5.1.8.1 Orbital attitude and maneuver system.-

5.1.8.1.1 Preflight: Fuel and oxidizer servicing of the orbital attitude and maneuver system (OAMS) was performed 10 days and 8 days prior to launch, respectively. The helium source pressurant tank servicing was completed 3 days before launch. Table 5.1.8-I compares the planned and actual quantities of pressurant and propellant. These loadings constitute an available overall system oxidizer-to-fuel mixture ratio of 1.35 by weight. A revised fuel-loading procedure was used which permitted a 3.9-pound increase over the planned fuel quantity. The procedure required the filling of the two tanks to capacity and subsequently withdrawing 8 pounds of fuel to provide the proper ullage. The addition of the reserve fuel tank provided a further increase of 12.9 pounds of usable fuel.

Activation of the OAMS occurred approximately 22 minutes before lift-off. All parameters were within the expected limits. A static firing of all eight attitude thrust chamber assemblies (TCA's) was performed to expel any entrapped gas in the propellant manifolds and to provide a final end-to-end verification of satisfactory system operation. All attitude TCA's were fired three times for an accumulated check-out firing time of about 1.5 seconds each.

5.1.8.1.2 Flight: The crew reported no propulsion problems associated with any of the maneuvers. Specific data relating to the performance of the engines during the basic maneuvers are presented in table 5.1.8-II.

An unusual amount of yaw-right activity (TCA 3 and 4) occurred during the maneuvers that used the aft-firing TCA's. The cause and amount of the apparent thrust-vector misalignment are not available, but the control capability was adequate to maintain desired attitudes during thrusting. A study of alignment, thrust vector, and center-of-gravity tolerances revealed that a 3σ variation would have provided a practically continuous firing indication from telemetered data which samples and holds firings over 0.1-second periods. The consequences of this apparent misalignment would be higher-than-normal propellant consumption and firing time for these TCA's.

The crew reported a TCA malfunction at 283:28 g.e.t. when they were unable to reduce a yaw-left drift rate which had built up during the sleep period. Yaw-right commands produced very low response but no noticeable roll coupling, indicating a nearly equal loss in performance of TCA 3 and 4. Alternate control modes, secondary bias power, and secondary valve drivers were tried with no success. While firing these TCA's in the pulse mode, the crew observed some reflected light which was indicative of some level of combustion. From the corrective control required, they estimated that the control authority in this mode had dropped to approximately 25 percent of normal. Attempts at yaw-right control in direct mode resulted in the apparent venting of one of the propellants with no observation of reflected light from combustion. The injector head temperature on TCA 3 dropped below the 0° F instrumentation low limit during the direct mode firing checks in the revolution following the failure and again after a final direct mode check at 327:20 g.e.t. The injector head temperature prior to these checks was 45° F indicating satisfactory heater operation. The crew reported that the OAMS heaters located in the equipment adapter section were energized throughout the mission. From this information, the degradation in TCA performance appears to be the result of an obstruction in the propellant feed system. The available data are insufficient to establish the exact cause of the failure. Evaluation of spacecraft angular-rate data and other pertinent system data is in progress in an attempt to better describe the nature of the malfunction.

The data show the accumulated firing time on all maneuver TCA's to be no less than 420 seconds. The 420 seconds does not include the firing time during station keeping with spacecraft 6 and the firing time of TCA 12 when used for yaw-right attitude control because of the failure of the PCM delayed-time tape recorder at approximately 201 hours g.e.t. Calculations using flow rates determined during acceptance testing show the maximum amount of propellants used for maneuvering was at least 145 pounds. If all the remaining 175 pounds of propellants were used for attitude control, this would represent a maximum accumulated firing time of 1975 seconds. A statistical study of data from several revolutions which contain aft-thrust TCA maneuvers and other revolutions which contain only attitude control reveals that the usage of TCA 3 and 4 did not exceed 405 seconds. However, the specification life of 578 seconds would not have been exceeded if this number were in error by even as much as 40 percent. Because the maximum injector head temperature of TCA 3 was 370° F, 86° F less than similar temperatures measured during qualification testing, the flight duty cycle could not have been as severe as that used for qualification testing. There have been no failures of design in the ground test programs even during overstress testing. Three TCA's have been fired over repetitive mission duty cycles accumulating more than 2000 seconds on each TCA which exceeds the specification value by more than a factor of three.

The usable propellant remaining over the duration of the mission along with the preflight planned usage rate is presented in figure 5.1.8-1. Included in the figure are the ground-computed values as determined by the general gaging equation and the flight values read by the crew on the onboard propellant quantity indicator (PQI). The PQI values have subsequently been corrected for mixture-ratio variations from the fixed mixture ratio of 0.93 used as a meter gaging constant. A comparison of the two sources of propellant quality shows a maximum variation of 15 pounds which compares well with the estimated preflight PQI accuracy of ±5 percent (±17 lb) and gaging equation accuracy of ±3 percent. Mixture-ratio variations are shown in figure 5.1.8-2. The 0.93 mixture ratio determined for the entire mission agrees exactly with the preflight planned value. The total quantity of usable OAMS propellant was 340 pounds based on the 0.93 mixture ratio. By the end of the mission the crew had expended practically the entire usable quantity of propellant.

The addition of a reserve fuel tank to the OAMS provided the most accurate check on gaging system errors currently available. At approximately 290:24 g.e.t., calculated from ground servicing data corrected by telemetry data, 12.3 to 14.3 pounds of usable monomethyl hydrazine (MMH) was in the reserve tank at activation of the "F" package when fuel was depleted in the main tank. At this time the gaging equation used for ground-computed propellant quantities and the corrected PQI readings both indicated approximately 20 pounds of usable MMH remaining.

From a comparison of these results, it is concluded that the gaging accuracy was between 3.24 and 4.37 percent of the total usable propellant. The preflight estimate of propellant uncertainty using the PQI and the gaging equation was ±3 percent of the total usable propellant.

5.1.8.2 Reentry control system.-

5.1.8.2.1 Preflight: The fuel loadings of 15.83 and 15.80 pounds for the A-ring and B-ring, respectively, were completed 10 days prior to launch. Eight days prior to launch, 20.23 and 20.11 pounds of oxidizer were serviced in the A-ring and B-ring, respectively. The respective A-ring and B-ring nitrogen source pressurant tanks were pressurized to 3037 psia at 75° F and 3046 psia at 77° F, 8 days prior to launch. Planned loadings are compared with actual loadings in table 5.1.8-I.

5.1.8.2.2 Flight: In accordance with the flight plan, the reentry control system (RCS) heaters were turned on during the second day of flight and were left on for the remainder of the mission. Throughout the orbital phase until RCS activation, at approximately 329:15 g.e.t., the A-ring source temperatures varied between 67° F and 79° F, the B-ring source temperature varied between 65° F and 88° F, and the A-ring oxidizer feed temperature varied between 62° F and 93° F. From system activation until landing, the maximum and minimum temperatures recorded were 58° F and 22° F for the A-ring source temperature, 70° F and 29° F for the B-ring source temperature, and 87° F and 66° F for the A-ring oxidizer feed temperature. Because of the failure of the PCM tape recorder, the temperatures noted were limited to real-time telemetry for the last 130 hours of the mission.

After system activation, regulated pressures of the A-ring and B-ring stabilized at 298 psia and 299 psia, respectively. Throughout reentry, the pressures recorded varied between 297 and 313 psia in the A-ring and 298 and 314 psia in the B-ring.

Source pressure leakage over the 22-day interval from servicing to activation was negligible. The respective A-ring and B-ring source pressures just prior to system activation were 2960 psia at 67° F and 2970 psia at 73° F which compare closely to the service pressures of 2990 psia and 3000 psia corrected to flight temperatures at activation.

No data are available prior to retrofire during the time of A-ring and B-ring checkout; however, the crew reported no difficulties with checkout. Available spacecraft rate data during reentry show no apparent problems with thruster operation.

Single-ring reentry (A-ring) was used until control authority became inadequate during communications blackout at which time the crew reported that B-ring control was added. Coming out of blackout at 125K feet at 330:28 g.e.t., it was noted that A-ring fuel was expended. The crew reported that B-ring propellant was expended near the time of the drogue parachute deployment (330:29:30 g.e.t.). Postflight deservicing verified that no propellant remained in the system. The consumption of the entire RCS propellant load is attributed to the use of the tight control deadband of the orbit rate command mode which was used during the intervals of greatest demand on the RCS.

5.1.8.3 Retrograde rocket system.- In approximately 120 hours of flight, the temperature of retrorocket no. 4 decreased to 42° F from the lift-off value of 70° F. The temperatures stayed within 6° F of 42° F for the remainder of the mission with a value of 40° F at retrofire. Because of the loss of the PCM tape recorder, actual times of ignition for the four retrorockets were not obtained. Performance of the system was nominal as shown in table 5.1.8-III. The crew reported a less accurate alignment of retrorocket no. 4 evidenced by a requirement for more yaw control for that one than for the other three. Telemetry data are not available for confirmation of this situation. However, any disturbance torques were well within the control capability of the RCS.

TABLE 5.1.8-I.- OAMS AND RCS SERVICING DATA

System	Pressure at reference temperature of 70° F, psia		Propellant, lb		Propellant quantity indicator, percent
	Preactivation	Postactivation	Oxidizer	Fuel	
OAMS					
Planned	2680	2650	245.9	180.9	93
Actual	2748	2683	247.5	180.9	95
RCS					
A ring					
Planned	3015	2785	20.2	15.8	
Actual	3008	(a)	20.2	15.8	
RCS					
B ring					
Planned	3015	2785	20.2	15.8	
Actual	3005	(a)	20.1	15.8	

[a]No telemetry data available due to loss of PCM tape recorder

TABLE 5.1.8-II.- OAMS MANEUVER TRANSLATION PERFORMANCE SUMMARY

Maneuver	Thrust duration, sec		Velocity increment, ft/sec		Acceleration, ft/sec^2	
	Planned	Actual	Planned	Actual	From thrust calculations	Actual
Separation (TCA 9 & 10)	3	(a)	2.0	3.03	0.75	(a)
Closing (TCA 9 & 10)	2.4	2.4	2.0	1.72	0.75	0.72
D-4 & D-7 experiment (TCA 16)	26	21.2	10.0	8.78	0.38	0.41
Perigee adjust (1) (TCA 9 & 10)	77	75.2	59.0	58.1	0.76	0.77
Perigee adjust (2) (TCA 9 & 10)	16.5	16.2	12.4	12.6	0.76	0.78
Circularization (1) (TCA 9 & 10)	78	75.6	61.2	60.0	0.77	0.79
Circularization (2) (TCA 9 & 10)	15	15.1	12.1	12.1	0.77	0.80

[a]Telemetry loss

TABLE 5.1.8-III.- RETROGRADE ROCKET SYSTEM PERFORMANCE

Parameter	Nominal	Actual	Deviation, percent
ΔV, ft/sec			
Aft	296	298.1	0.7
Down	113	111.8	-1.1
Right	000	4.8	-
Total ΔV, ft/sec	[a]316.8	[b]318.5	0.5
Vehicle pre-retrofire weight, lb . . .	5645	5658	0.2

[a]Motor performance is based on specification values.

[b]The actual value is the magnitude of the incremental velocity indicator vector telemetered to Hawaii just after retrofire. A value of 318.9 (0.6 percent deviation above the nominal and 0.1 percent above the actual) should have been realized, based upon retrorocket acceptance test data, flight temperature, installation cant angle, and spacecraft estimated weight at the time of retrofire.

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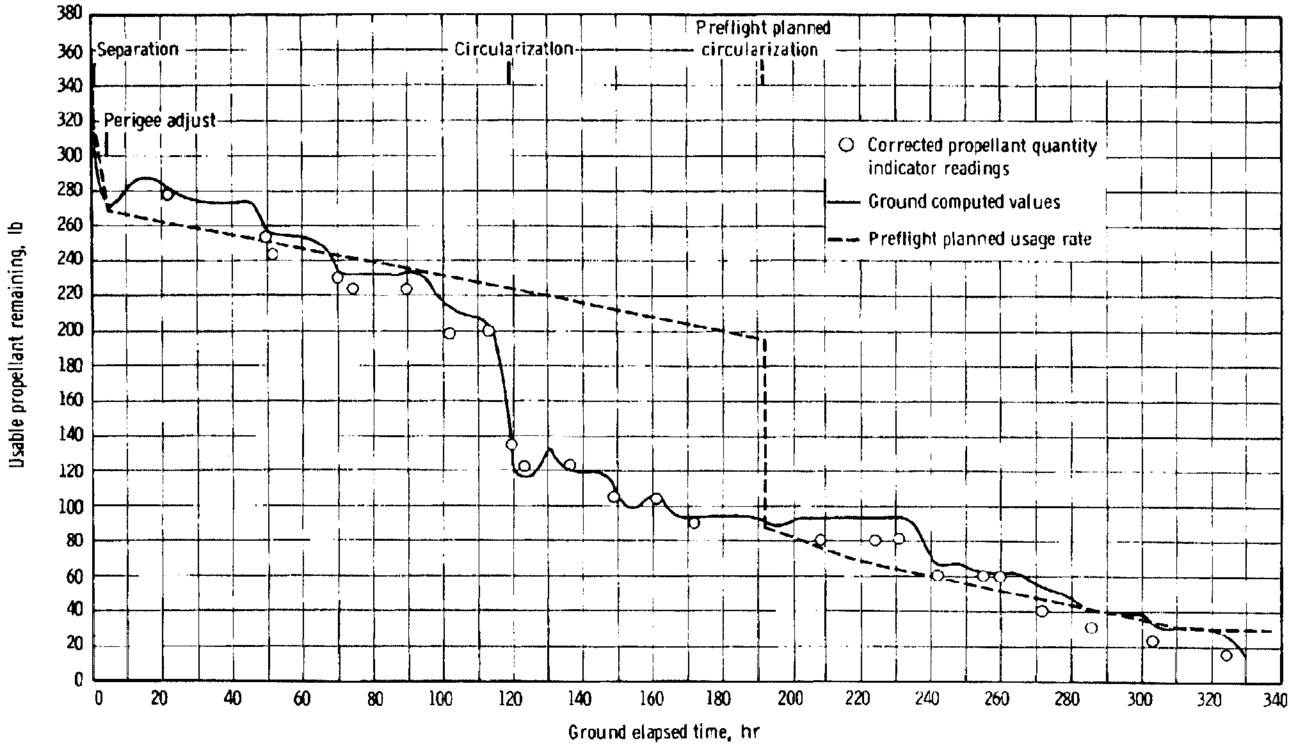

Figure 5.1.8-1 - OAMS propellant consumption.

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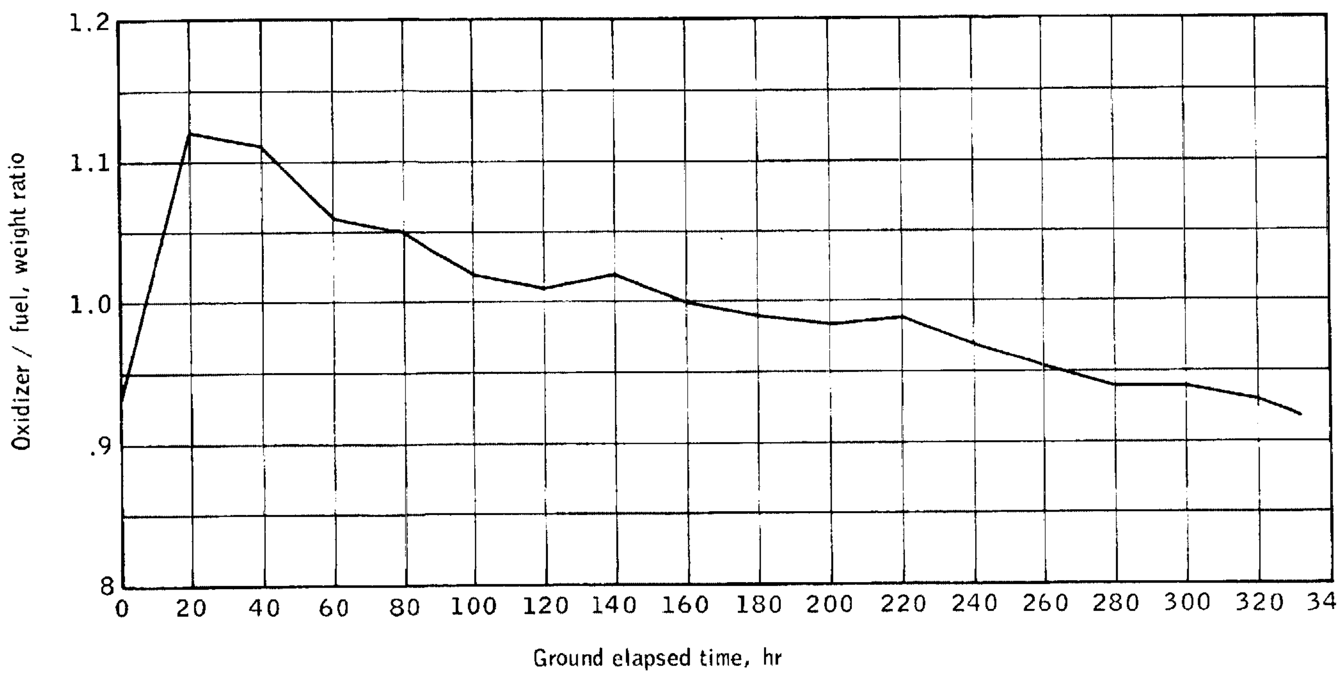

Figure 5.1.8-2. - Calculated accumulative expended oxidizer to fuel ratio.

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5.1.9 Pyrotechnic System

Based on a successful mission and all available related data, it can be stated that the pyrotechnic system performed all required functions in a satisfactory manner.

Early in the station keeping with spacecraft 6, the crew of spacecraft 6 reported that a cord-like material was attached to the aft edge of the spacecraft 7 equipment adapter section. This material has since been identified as part of the spacecraft – launch vehicle shaped-charge separation assembly. Figure 5.1.9-1 is a photograph of spacecraft 7 taken from spacecraft 6 during station keeping which also shows a cross-section of the assembly as an inset. The cord-like material shown entangled with the magnetometer boom is composed of the V-shaped silicone rubber holder for the flexible linear shaped charge (FLSC) and pieces of the formed plastic blast absorber. These pieces are the larger white material shown adhering to the FLSC holders. The photograph clearly shows the U-shaped fiberglass blast shield from which this material has been stripped.

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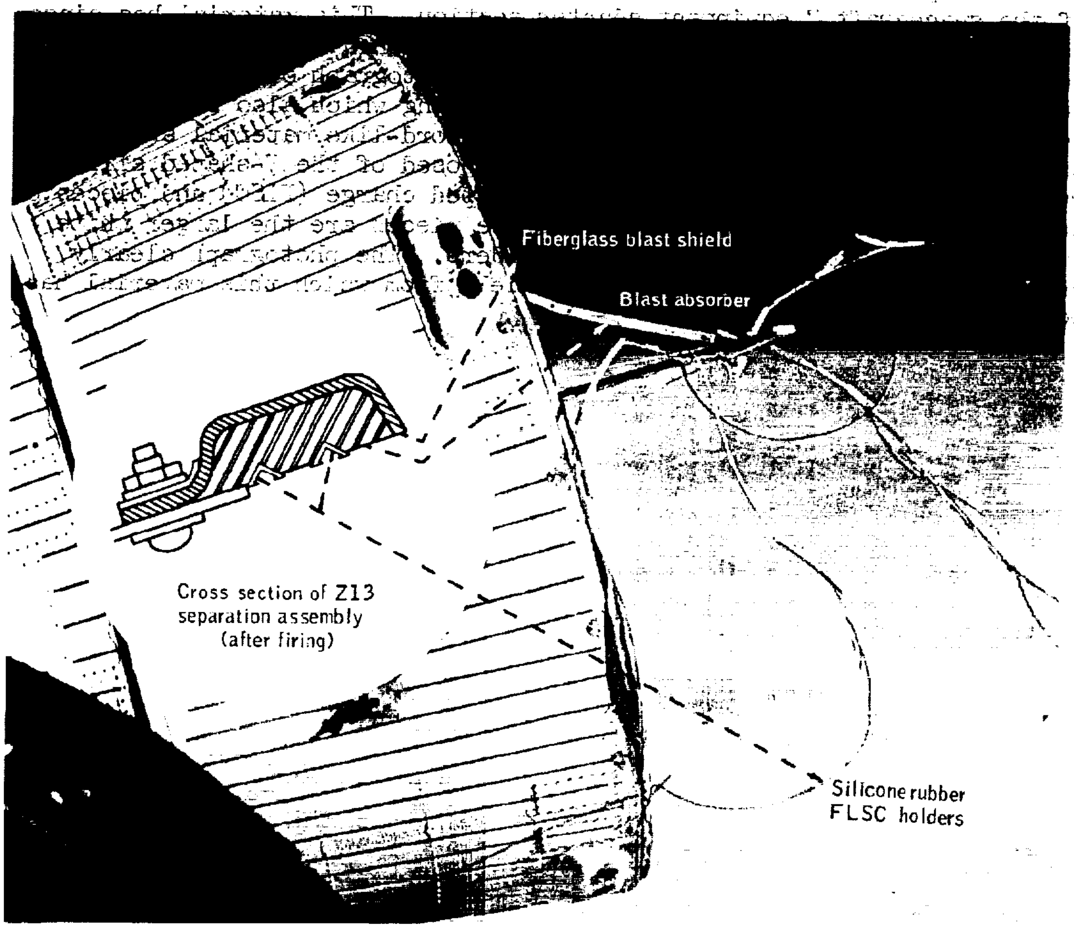

Figure 5.1.9-1. - Inflight condition of fired Z13 shaped charge assembly.

5.1.10 Crew Station Furnishings and Equipment

5.1.10.1 Crew station design and layout.- The basic design of the crew station was satisfactory for the Gemini VII mission. Some problems were identified and these are discussed in the following paragraphs.

5.1.10.1.1 Long-duration habitability: The habitability of the crew station was reasonably satisfactory for the 14-day mission. Some discomfort was experienced by both crewmen because of the cramped quarters, but frequent use of the exerciser and removal of the space suits helped to alleviate this problem. The command pilot had some difficulty sleeping soundly because he was unable to straighten his body to full length. One factor which helped the crew remain alert throughout the mission and provided them with undisturbed sleep was their schedule of simultaneous sleep periods on a normal day-night schedule. During sleep periods at the start of the mission, the crew tried using the polaroid window filters to block out the sunlight but found that the filters did not block the heat from the sun nor all of the light. By placing aluminum foil from the food packages between the windows and the polaroid filters, the crew was able to make the interior of the cabin completely dark and block out the direct heat from the sun. This addition to the window filters enabled the crew to independently set their schedule of day and night without regard to orbital lighting conditions.

Removal of the pressure suits in orbit was a significant factor affecting the long-duration habitability. The pilot removed his pressure suit early in the flight. With the suit removed he found that his mobility and comfort increased substantially and his perspiration rate decreased. Later in the mission the command pilot also removed his pressure suit and experienced the same marked improvements in physical comfort and mobility with no detrimental effect noticed because of suit removal. Although they were able to endure long-term wear of the pressure suits, the crew stated that removal of the suits made their tasks substantially easier, particularly in the latter part of the mission.

5.1.10.1.2 Equipment stowage: All loose equipment was stowed in the normal stowage containers for launch. Because of the large volume of food required for this mission, an auxiliary food stowage pouch was incorporated in the right footwell. Five packages of food were stowed in this pouch for launch. The rest of the food was stowed in the two aft stowage boxes. The crew experienced some initial difficulty in removing food from the aft boxes because they were so tightly packed. The first package in each box was particularly difficult to remove. Wet waste was stowed in the right aft stowage box, and dry waste was stowed behind the seats. After the ninth day, the area behind the seats became full, and the crew then used the regular dry-waste stowage bags for the remainder of the mission. These bags were stowed on top of the seats.

after they were full. As a result of careful planning and extensive practice in the mission simulators and because of the detailed and thorough stowage mockup, the flight crew was able to effectively manage the waste and take care of the housekeeping throughout the mission.

One significant problem with the basic stowage provisions occurred early in the mission. The lower shelf of the center stowage box deflected downward about $\frac{3}{4}$ inch the first time the center stowage door was opened in flight. The crew had considerable difficulty in trying to close the door and finally resorted to the use of the swizzle stick as a lever to pry the bottom bracket up sufficiently to engage the latch on the door. Postflight investigation has shown the door to again close readily. Similar difficulties were encountered during the spacecraft 6 flight and during the spacecraft 8 altitude chamber tests. This indicates that the pressure differential experienced in orbit was the source of the problem. The corrective action is described in section 5.1.1.

5.1.10.1.3 Cabin lighting: As on previous missions, the crew reported that the lighting of the center instrument panel was poor for dark-side operations. In order to illuminate the center panel adequately, it was necessary to brighten the center cabin light to the point that it interfered with visibility outside the spacecraft. If the center light was turned low enough to be compatible with outside visibility, the center panel was difficult to read. This lighting deficiency was more critical on this mission because of the need for frequent reference to the ground-elapsed-time digital clock on the center panel. This clock was incorporated for the first time in this spacecraft, and it was used as the master time reference for flight events. The crew used their penlights to read this display when the cabin lighting was adjusted for dark-side visibility. Even the use of the penlights was undesirable under these circumstances. Action has been initiated to provide satisfactory lighting of this display on future Gemini spacecraft.

Except for the poor lighting on the digital clock, the rest of the cabin lighting was acceptable for the mission. There were minor areas where the lighting was less than desirable, such as the center console and the water management panel; however, deficiencies in these areas had no significant effect on the mission.

5.1.10.2 Controls and displays.-

5.1.10.2.1 Controls: The basic attitude and maneuver controls were very satisfactory. All other controls performed satisfactorily except that the swizzle stick was used to keep the fuel-cell hydrogen manual heater switch down. The switch is very small and had to be held for extended periods of time.

The crew expressed concern that the fuel cell power and control switches do not require a more positive motion for actuation. The switches are guarded, but they are located such that they are susceptible to accidental actuation. These switches are not used extensively, and inadvertent actuation was a hazard during suit doffing and donning.

5.1.10.2.2 Displays: The fuel cell differential pressure warning lights came on shortly after lift-off, and the one for section 2 remained on for most of the mission. This situation has been evaluated and is discussed in section 5.1.7.

The launch vehicle fuel and oxidizer pressure gages were adequate. However, the use of decals on the outside of the gages was found to be marginal because of the resulting parallax. The main bus ammeters were found to be very useful for monitoring the spacecraft electrical system. The ammeters which show individual stack currents were difficult to read because of the manner in which the instrument faces are canted relative to each other. The voice tape recorder was inadvertently left running for several periods of time when there was no activity or conversation. There is no light or other indication to show that the recorder is operating.

5.1.10.3 Spacesuits.-

5.1.10.3.1 Suit configuration: The pressure suit provided for the crew was of a special lightweight, low-bulk design. Bioinstrumentation, communications, and blood-pressure fittings were the same as those used for the previous Gemini suits. The pressure-source entry for the M-1 experiment leg cuffs was through the suit at the right thigh under the thigh pocket.

The command pilot doffed and donned his suit twice during the flight, and the pilot, three times. The average time to complete the suiting operation and to make complete bioinstrumentation and communications hook-up was 16 to 17 minutes for either crew member.

Two-piece orbital flight suits were provided to assure thermal comfort for the pilots when out of the lightweight pressure suits. The orbital flight suits were worn infrequently by the crewmen and were found to be relatively uncomfortable because of the tight fit.

5.1.10.3.2 Systems anomalies: The interphone operation was acceptable with the pressure helmet off, but was found to be noisy when the pressure helmet was on and closed.

During the early phase of reentry, the command pilot removed the fabric pressure helmet and placed it in the stowed position at the back of the head. This action was taken in an effort to get better visibility.

Before the mission, a minor problem in upward visibility had been noted with the command pilot's suit. A restraint strap was designed to reposition the visor relative to his face to improve the upward visibility; however, an evaluation indicated that he could obtain adequate visibility from the closed visor by merely repositioning his head within the helmet. For this reason, the helmet was not modified to incorporate the visor restraint strap. The pilot had no difficulty with visibility from the helmet visor and kept his helmet on and zipped up until after landing.

5.1.10.4 Flight crew operational equipment.-

5.1.10.4.1 16-mm variable speed sequence camera: The 16-mm variable speed sequence camera functioned normally throughout the mission. The quality of the pictures was degraded somewhat by the deposit on the windows.

5.1.10.4.2 Optical sight: The optical sight was used satisfactorily although there was an anomaly in its operation. The command pilot found it necessary to tap the sight to obtain proper operation for the bright setting on several occasions. Postflight investigation established that there was an intermittent connection in one of the filaments of the dual-filament lamp for the reticle. A voltage regulator provided with the sight was for use only if additional dimming was required, but the regulator was not used.

5.1.10.4.3 Flight data books: Flight data books and displays were excellent and found to be very satisfactory for the mission.

5.1.10.4.4 Dew point hygrometer sensor: The dew point sensor was used for the first time on this flight. It appears to have operated satisfactorily throughout the mission.

5.1.10.5 Flight crew personal equipment.-

5.1.10.5.1 Food: A total of 86 man meals ($14\frac{1}{3}$ days for 2 men) of food was provided for the Gemini VII mission. An average meal included one rehydratable food item, one rehydratable drink, and two bite-size food packets. Meals were eaten three times a day on a schedule similar to that of a normal day. Approximately 41 of the 43 individual meals provided per man were consumed by each crew member. This corresponds to an approximate intake of 2200 calories per man per day. Both crewmen experienced difficulty getting the larger chunks of rehydratable foods through the feeder spouts. One food bag burst at the heat-seal seam during use. This failure was caused by the restricted flow of the rehydrated food chunks which required the application of greater hand pressure. Action has been initiated to provide larger feeder spouts for bags containing rehydratable foods for future missions. In at least two instances, the disinfectant tablet attached to the food bag crumbled prior to use. The tablets used in the food for this mission had been made softer than in previous missions to insure that the tablets would dissolve in the minimum amounts of moisture remaining in the used food bags. The majority of the beef bite items had broken apart within the plastic pack prior to use. The crew did not eat these items after the crumbling was noticed. Crumbling was caused by the evacuation of the overwrap after the individual food items had been packaged. The crew objected to the lack of similarity of the flight menu to a normal breakfast, lunch, and dinner sequence. They indicated, in particular, a preference for more typical breakfast menus. No major objection was indicated to the foods in the menu, but only to the order in which they were packed.

5.1.10.5.2 Water metering device: Spacecraft 7 was provided with a water dispenser capable of measuring the total water intake of the flight crew. This device, utilized for food rehydration as well as drinking, operated satisfactorily throughout the flight. The crew found the requirement to log each drink of water bothersome. This detailed logging of water intake was required for operational medical purposes.

5.1.10.5.3 Launch day urine collection device (UCD): Neither crewman used the UCD prior to removal.

5.1.10.5.4 Urine disposal system: Due to the requirement established by M-5 and the M-7 experiments for the postflight analysis of urine voided throughout the mission, a new urine system was provided. This system, designated the chemical urine volume measuring system, injected a known quantity of tritium tracer into the urine container bag and allowed the extraction of a 75-cc sample of the tracer and urine mixture such that total volume voided could be ascertained in postflight analysis.

Both pilots experienced frequent leakage from the receiver during usage and upon removal. Postflight debriefings established that the crew consistently positioned the receiver control valve 22° past the urinate position during usage. This offset valve angle in turn resulted in a reduction of flow area of approximately 50 percent (i.e., flow area equivalent to a $\frac{3}{8}$-inch diameter passage now becomes $\frac{1}{4}$-inch diameter passage). This reduction in area and the resulting flow restriction is considered to have been the principal cause of the leakage.

The latex receivers tended to become sticky due to urine deposits after two to three urinations. Replacement receivers were utilized throughout the flight; however, their usefulness was consistently impaired after the first day of use. This condition also contributed to the urine leakage.

A flowmeter was provided for installation in series with the urine receiver. This flowmeter generated an output signal which was recorded on the voice tape recorder. The flowmeter data will be reduced and compared with the data derived from the postflight urine sample analysis. The flight crew used the flowmeter on approximately 80 percent of the urinations. Approximately 80 samples were taken by the flight crew during the Gemini VII mission.

5.1.10.5.5 Defecation device: The defecation devices were utilized 15 times during the Gemini VII mission. No problems occurred relative to usage or stowage of these items.

5.1.10.5.6 Personal hygiene items: The wet pads provided with each food pack and each defecation device were utilized by the flight crew for cleansing of the face and hands. Each crewman frequently rewet these pads by dispensing one-half ounce of water into them with the water metering dispenser. The personal hygiene towels were used extensively as liquid absorbers. The oral hygiene items were used at least once each day by both crewmen (see 7.2.2.6 for a detailed discussion of oral hygiene). There were no problems noted relative to any of these items.

5.1.10.5.7 Survival equipment: The individual survival kits were not utilized during the postlanding phase; however, the life vests were inflated by the crew prior to helicopter pickup and operated satisfactorily.

5.1.10.5.8 Miscellaneous: Several items were carried on the spacecraft as either new equipment or as special equipment for the long-duration flight. Urine sample bags capable of containing 75 cc of the urine-tracer mixture were provided. One of these bags exhibited a small leak in the area of the heat-seal seam during flight; however, the moisture was absorbed by use of the personal hygiene towel. This failure is attributed to a weak heat seal. Penlights were provided for each crewman and were utilized frequently for lighting the instrument panel, water management panel areas, and areas under the seats. The penlights were found to be more useful than the spacecraft utility lights.

5.1.10.6 Bioinstrumentation equipment.- The bioinstrumentation consisted of the basic operational monitoring package, two experiment sensors and associated equipment, two biomedical magnetic tape recorders, and one blood-pressure reprogramming adapter.

The basic instrumentation consisted of axillary and sternal electrocardiogram, impedance pneumograph (respiration), oral temperature, and blood pressure sensors. These parameters were monitored on each crewman. The electrocardiograms and respiration measurements were monitored continuously and telemetered on a real-time basis. In addition, these parameters were recorded on both magnetic tape biomedical recorders. One recorder ran continuously during the first 4 days of the mission to record the electroencephalographic data (experiment M-8) from the command pilot. The other recorder ran periodically during the remaining 10 days of the mission to obtain checks of the phonocardiographic data from the pilot. Oral temperature and blood pressure measurements were made during crew status reports and were telemetered on a real-time basis. Except for the specific cases mentioned below, the quality of the real-time biomedical data was excellent throughout the 14-day mission.

All sensor attachment points were examined when the crew removed their suits aboard the carrier. During the course of the flight, several electrodes on both crew members were reapplied utilizing the equipment available in the onboard electrode kit. During postflight unsuiting, the sensors were found to be firmly attached and ample electrolytic paste was still present. The skin showed an exceptionally small amount of irritation at the electrode sites even when compared to irritation caused by the electrodes on shorter duration flights. Comments made by the crew during recovery operations aboard the carrier and during the debriefing sessions indicated that there was no discomfort associated with the electrode points of attachment, and the only sensation noticed was a slight itching which occurred occasionally during the flight. The difficulties experienced by the command pilot with the sensors used for the M-8 experiment are discussed in section 8.10.

During the course of the mission, the impedance pneumograph signal from the command pilot was intermittent. After the flight, checks made of the flight equipment in the laboratory disclosed no discrepancies.

The pilot's axillary electrocardiogram was inverted because the input leads were reversed when they were attached to the pilot prior to launch. The procedure used to clean the electrocardiogram sensors prior to application removed the identifying markings and the axillary and sternal sensors were inadvertently interchanged. The error was noted after the pilot was suited, but corrective action was not taken because the pilot would have had to remove his suit and crew ingress would have been delayed. Normal electrocardiographic information was obtained by reversing the inputs to the oscillographs at the ground stations.

No problems were incurred when the crew took blood-pressure measurements during this flight. The problem area, encountered on previous flights, was eliminated by a design change in the quick-disconnect fitting on the blood-pressure measuring system pneumatic line at the entry to the pressure suit.

The blood-pressure reprogramming adapter did not present any operational problems, but no post-retrofire blood-pressure data were obtained because the magnetic tape supply for the pilot's biomedical tape recorder was exhausted. Only the pilot attempted to make this blood-pressure measurement.

5.1.11 Landing System

The landing system satisfactorily performed all functions and provided a safe landing for the crew. All system events occurred within design tolerances after being initiated by the crew. Figure 5.1.11-1 illustrates the occurrence of each major event with respect to ground elapsed time and pressure altitude.

The crew commented on the magnitude of oscillations experienced while descending on the drogue parachute, estimating it to be ±20°. However, recorded data indicate that the spacecraft oscillations did not exceed ±10°, and were normally lower. The most likely explanation for this apparent discrepancy is that the drogue parachute oscillations exceeded those of the spacecraft by the amount indicated. A difference between parachute and spacecraft oscillations was confirmed by the observation of the periodic slackening of the bridle cables.

Two previous Gemini crews described the loads and ensuing oscillations experienced during the repositioning maneuver as being excessive. The Gemini VII crew, however, had undergone this maneuver during repositioning simulation tests conducted at the spacecraft contractor's facility, subsequent to the GT-3 mission. They described the maneuver as being identical to that experienced in those tests and stated that the procedures established at that time were adequate to accomplish the sequence safely.

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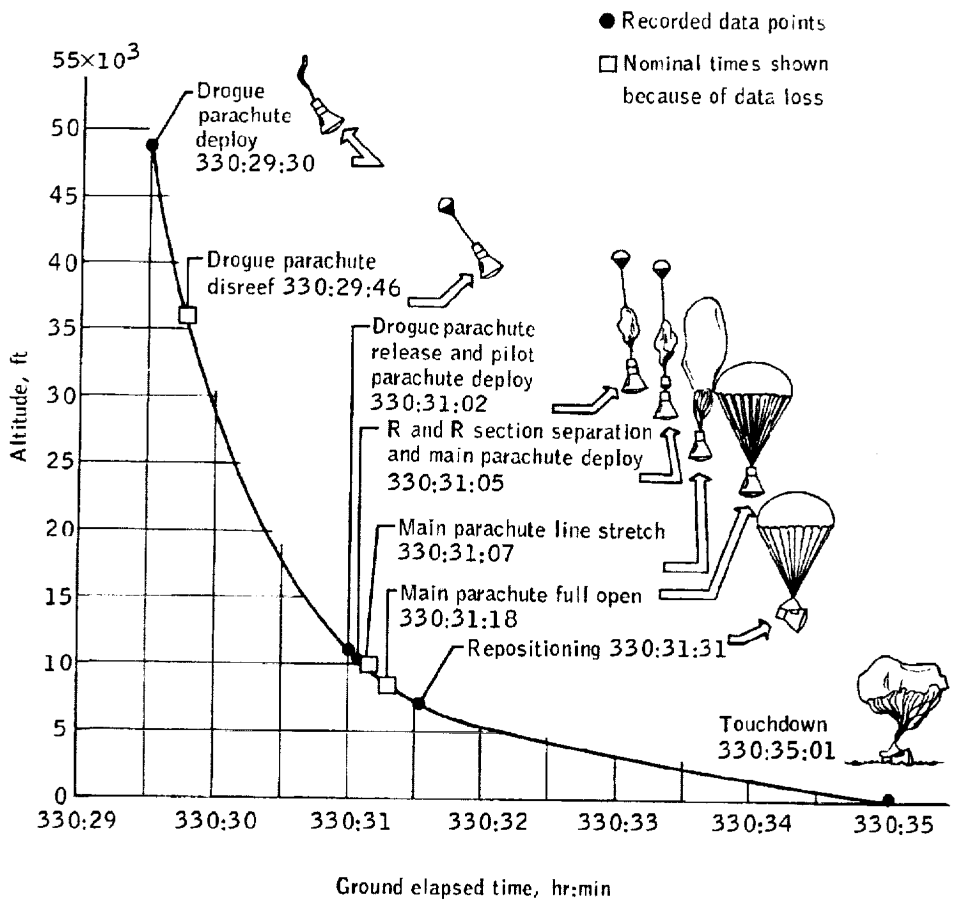

Figure 5.1.11-1. - Landing system performance.

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5.1.12 Postlanding

All postlanding and recovery aids functioned properly. The UHF descent and recovery antennas extended properly when the spacecraft was repositioned. The sea dye marker was automatically dispensed upon touchdown, and the recovery hoist loop along with the recovery flashing light were deployed when the main parachute was jettisoned by the crew. The HF antenna extended and retracted properly when commanded by the crew. All of these functions were verified from communication transcripts, photographs taken during recovery operation, discussions with the flight crew and recovery personnel, and recorded data. Figure 6.3-7 in section 6.3, RECOVERY shows the bearing information obtained during the short period of HF-DF operation after landing.

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5.2 GEMINI LAUNCH VEHICLE PERFORMANCE

The performance of the Gemini launch vehicle (GLV) was satisfactory in all respects and spacecraft 7 was placed in the nearest-to-nominal orbit yet achieved in the Gemini program.

5.2.1 Airframe

Maximum launch vehicle structural loading occurred in the pre-BECO region of flight and reached approximately 78 percent of design ultimate load. This loading compares with the lowest of 76 percent and the highest of 81 percent that occurred on the GLV-1 and GLV-4 vehicles, respectively.

5.2.1.1 Longitudinal oscillation (POGO).- Small amplitude, intermittent longitudinal oscillations in the period from LO + 110 seconds to staging are exhibited by the flight data. Maximum response at the interface between the spacecraft and the launch vehicle occurred at LO + 133 seconds and lasted for 3 seconds. An amplitude of ±0.13g at a frequency of 11.8 cps was indicated in the filtered data.

5.2.1.2 Structural loads.- Ground winds were approximately 9 mph during the Gemini VII countdown and resulting structural loads were not significant.

Estimated loads for the Gemini VII flight are shown in the following table. These data indicate that the most critical structural loading occurred at launch vehicle station 320 during the pre-BECO region of flight.

GLV station, in.	Maximum qα		Pre-BECO	
	Load, lb	Design ultimate, percent	Load, lb	Design ultimate, percent
276	30 000	30.0	48 700	48.7
320	157 100	45.5	269 400	78.1
935	459 300	63.3	442 200	61.0
1188	498 400	74.0	457 100	67.9

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5.2.1.3 Post-SECO pulse.- Telemetry data do not show any indication of the post-SECO pulse experienced by some of the earlier Gemini and Titan II vehicles.

5.2.2 Propulsion

Performance of the propulsion system was satisfactory. Preflight predicted engine performance is compared with postflight reconstructed engine performance in tables 5.2-I and 5.2-II for stages I and II. Good agreement between predicted and actual performance is indicated by the data.

5.2.2.1 Stage I engine performance.- The start transients of both subassemblies were well within the range of GLV and Titan II experience. The oxidizer pressurant pressure switch (OPPS) did not make until 87FS1 + 2.022 seconds at a pressure of 410 psia. The actuation pressure was within the switch specification of 360 to 445 psia on rising pressure. Although there is no specification on OPPS actuation time, the 87FS1 + 2.022 seconds was within 178 milliseconds of initiating an automatic engine shutdown. In order to reduce the possibility of an inadvertent shutdown because of a late OPPS actuation, the diameter of the oxidizer pressurant back pressure orifice was reduced from 0.50 inch to 0.46 inch on GLV-6 and will be similarly reduced on subsequent vehicles. Engine performance during steady-state operation was normal. Shutdown was initiated by oxidizer exhaustion with approximately 20 pounds of usable fuel remaining.

5.2.2.2 Stage II engine performance.- As indicated in table 5.2-II, stage II engine performance was close to that predicted. The start transient and subsequent steady-state operation appeared normal except for a pressure pulse in chamber pressure (P_c) at 91FS1 + 1.25 seconds. This pulse was similar to those that have been noted in a few previous Titan II flights. Shutdown was initiated by radio guidance system (RGS) command. The shutdown transient was similar to those experienced on other GLV's equipped with the redundant engine shutdown system. Shutdown total impulse was 36 190 pounds-second as compared to a predicted value of 37 000 ± 7 000 pounds-second. No post-SECO pulse was noticed in the data.

5.2.2.3 Propellant loading and autogenous system performance.- The following tables provide data on propellant weights and flight propellant temperatures. The actual propellant temperatures and weights measured agree well with the respective preflight values.

PROPELLANT LOADING RESULTS

Propellant	Stage I		Stage II	
	Requested weight, lb	Actual weight, lb	Requested weight, lb	Actual weight, lb
Fuel	90 181	90 164	21 895	21 957
Oxidizer	172 747	172 531	38 445	38 609

AVERAGE PROPELLANT TEMPERATURES

Propellant	Stage I		Stage II	
	Preflight predicted temperature, °F	Actual temperature, °F	Preflight predicted temperature, °F	Actual temperature, °F
Fuel	45.7	42.6	40.3	40.5
Oxidizer	44.5	41.1	46.0	44.4

A comparison of propellant tank pressure during flight with preflight predictions shows good agreement, indicating adequate autogenous system performance.

5.2.2.4 Performance margin.- Real-time calculations, performed during the countdown, predicted that the vehicle minus 3σ payload capability would exceed the spacecraft weight by 73 pounds at lift-off. Postflight reconstructed vehicle performance indicated the actual payload capability to be 8869 pounds. This capability was 784 pounds more than the spacecraft weight and 61 pounds greater than 8808 pounds vehicle nominal capability predicted prior to flight.

5.2.3 Flight Control System

The performance of the flight control system was satisfactory. The primary flight control system was in command throughout the flight and no switchover to the secondary system was required. The three-axis reference system (TARS) and the inertial guidance system (IGS) compared favorably during both stage I and stage II flight. Switchover could have been successfully accomplished at any time during the flight.

5.2.3.1 Stage I flight.- Ignition and lift-off transients were normal. The peak actuator travel and rate gyro disturbances recorded during the ignition and holddown period are shown in table 5.2-III. The combination of thrust misalignment and engine misalignment at full thrust initiated a small roll transient at lift-off. The control system responded satisfactorily to correct the roll transient, limiting the roll rate to a maximum of 0.9 deg/sec counterclockwise at 0.23 second after lift-off. No significant transients were noted in the pitch and yaw channels.

The TARS roll and pitch programs were properly executed. The rates and initiation times were nominal. All TARS-initiated discretes were executed as programmed. The planned and actual roll and pitch programs are listed in table 5.2-IV.

Analysis of the primary flight control attitude error signals during stage I flight shows proper response to wind disturbances and to the guidance programs. The maximum rates and attitude errors are shown in table 5.2-V.

5.2.3.2 Staging.- Staging was satisfactory. The pitch, yaw, and roll rates at staging were slightly lower than those observed on previous flights.

The maximum attitude errors and vehicle rates recorded during staging were as follows:

Axis	Attitude error, deg	Time from lift-off, sec
Pitch	-1.37	157.9
Yaw	+1.78	158.0
Roll	-1.10	156.7

Axis	Primary rates, deg/sec	Time from lift-off, sec
Pitch	+2.39 -2.43	155.77 156.32
Yaw	+1.77 -0.69	156.88 159.26
Roll	+1.18 -2.00	157.14 155.98

5.2.3.3 Stage II flight.- The radio guidance enable command was initiated by the TARS timer at LO + 161.99 seconds. The first pitch guidance command was received at LO + 168.32 seconds and consisted of a small 2-percent pitch-down command at LO + 168.67 seconds, followed by a full 2.0 deg/sec command for 2 seconds. Throughout the remainder of the flight, small pitch and yaw commands at a maximum pitch rate of 0.25 deg/sec and maximum yaw commands of 0.06 deg/sec were transmitted to the vehicle to achieve the desired cutoff conditions.

From LO + 250 seconds to LO + 320 seconds, propellant slosh modes caused vehicle oscillations in pitch varying between 1.5 and 1.7 cps. The maximum peak-to-peak pitching rate due to the sloshing was 1.2 deg/sec between LO + 250 seconds to LO + 320 seconds. There were indications of very low magnitude sloshing oscillations in the yaw channel with coupling into the roll channel during this period.

The control system indicated attitude biases in both pitch and yaw during stage II flight; however, they were well within predicted limits. The yaw bias of 1.25° compares closely with the Gemini V yaw bias of 1.2° and is approximately the same as biases experienced on other Gemini flights. Roll attitude error was approximately 0° throughout stage II flight. The attitude errors in pitch, yaw, and roll are shown in figure 5.1.5-1. The biases are caused by engine thrust vector misalignment, center-of-gravity movement from the vehicle longitudinal axis, and the position of the roll thrust vector off the longitudinal axis.

5.2.3.4 Post-SECO flight.- The vehicle pitch, yaw, and roll rates during the period from SECO through spacecraft separation were less than those observed on previous flights. The maximum rates measured during this period are shown in table 5.2-VI.

Successful spacecraft separation was accomplished at 31.89 seconds after second stage engine cutoff (SECO), 91FS2.

5.2.4 Hydraulic System

The operation of the hydraulic system was normal throughout the mission. The response of all engine-driven hydraulic pumps during engine start was normal. Starting transients and steady-state pressures are shown in the following table.

System event	Stage I primary system, psia	Stage I secondary system, psia	Stage II system, psia
Starting transient (max)	3420	3390	3840
Starting transient (min)	2590	2930	2680
Steady state	3120	3020	2880
BECO	2960	2880	NA
SECO	NA	NA	2770

5.2.5 Guidance System

Performance of the GLV stage I and stage II guidance systems was satisfactory throughout the powered flight and resulted in placing the spacecraft into an acceptable orbit.

5.2.5.1 Programmed guidance.- The programmed guidance was within acceptable limits as shown in table 5.2-IV. As discussed in section 4, a nominal trajectory was flown. The errors at BECO were 132 ft/sec high in velocity, 2016.0 feet high in altitude, and 0.13° low in flight-path angle.

5.2.5.2 Radio guidance.- The guidance system acquired the pulse beacon of the launch vehicle, tracked in the monopulse automatic mode, and was locked on continuously from lift-off to 34.2 seconds after spacecraft – launch vehicle separation. At that time, there was a

13.6 second period of intermittent lock until final loss of signal at 77.6 seconds after SECO. Track was maintained to an elevation angle of 1.4° above the horizon. The average received signal strength at the central station during stage II operation was satisfactory. Rate-lock was continuous from LO + 42.8 seconds to LO + 404.9 seconds (SECO + 67.9 sec) except for the normal momentary interruption at staging. Rate-lock was maintained to an elevation angle of 2.0° above the horizon.

Normal steering commands were issued, as planned, by the airborne decoder at LO + 168.34 seconds. At that time, an initial 10 percent pitchdown steering command (0.2 deg/sec) was given for 0.5 second, followed by a 100-percent pitchdown steering command (2.0 deg/sec) for 2.0 seconds. The 100-percent command was given as planned, indicating a nominal first stage trajectory. The steering gradually returned (4.0 sec later) to relatively small and slowly varying pitch commands having a maximum magnitude of 0.25 deg/sec. This produced generally negative pitch rates until LO + 277.0 seconds. At that time, because of the noisy tracking data, the rates became quite oscillatory. This particular phenomenon is characteristic of atmospheric conditions for late fall and winter at the launch site. As a result, the commands varied between 0.1 to 0.2 deg/sec (pitchdown) until 2.5 seconds before SECO. Yaw steering started at LO + 168.4 seconds. The yaw commands were of very small magnitude, with the commands over the radio guided portion of flight amounting to maximum positive and negative yaw rates of approximately 0.06 deg/sec.

SECO occurred at LO + 337.01 seconds at an elevation angle of 6.89° above the local horizontal referenced to the launch site. The conditions at SECO + 20 seconds were well within 3σ limits. The flight-path angle was 0.05°, the velocity was 25 793 ft/sec, the altitude was 529 700 feet, and the yaw velocity was 7.0 ft/sec to the left. Comparison of the actual values with the planned values (see table 5.2-VII) shows that the flight-path angle was 0.05° high, the velocity was 11.0 ft/sec low, the altitude was 481 feet high, and the yaw velocity was 7.0 ft/sec low. Because the shutdown thrust transient was nominal, the insertion errors were attributable to shutdown timing at SECO and to the noise in the guidance data. At the end of tail-off, vehicle rates were 0.30 deg/sec pitchdown, 0.19 deg/sec yaw right, and 0.27 deg/sec roll clockwise.

The computing system, in conjunction with the RGS ground and airborne systems, completed all prelaunch and launch operations in a normal and satisfactory manner. The spacecraft inertial guidance system ascent updates from the ground-based computer were sent by way of the spacecraft digital command systems and verified by the buffer as follows:

Update sent, LO + sec	Update verified, LO + sec	Value, ft/sec
105.00	105.30	-116.67
145.00	145.30	- 73.59

5.2.6 Electrical System

The electrical system performed nominally throughout the flight. The auxiliary power system (APS) and instrumentation power system (IPS) voltage and current data reflected function and event occurrences as anticipated. The power system and instrumentation system power sources remained within required limits. The operation of the stage II flashing beacon lights was normal.

5.2.7 Instrumentation System

5.2.7.1 Ground.- All 136 measurements programmed for use during the countdown and launch performed as anticipated. The umbilical release sequence was reversed, but no adverse effect resulted. Completion of umbilical releases was accomplished in 0.823 second.

5.2.7.2 Airborne.- The airborne system had 191 measurements programmed for use during the flight. Two anomalies were experienced by the instrumentation system or its associated ground equipment during the flight. The first occurred at LO + 79.5 seconds when a temporary loss (37 milliseconds) of the PCM data train was experienced. The second occurred at BECO + 23 seconds when a signal attenuation was evidenced on the ground recorder. Both anomalies are under investigation. Data loss during staging was as expected (250 millisecond period) and final loss of the telemetry signal occurred at LO + 420 seconds.

5.2.8 Malfunction Detection System

Performance of the malfunction detection system (MDS) during preflight checkout and flight was satisfactory. All MDS hardware functioned properly. Table 5.2-VIII presents the MDS parameters.

5.2.8.1 Engine MDS.- The actuation times of the malfunction-detection thrust-chamber pressure switches have been evaluated. Limits and actuation times and pressures for the stage I engine subassembly 1 and 2 switches (MDTCPS), as well as the stage II engine subassembly 3 malfunction-detection fuel-injector pressure switch (MDFJPS) are as follows:

Switch	Limits, psia	Actuation time from lift-off, sec	Pressure, psia
Subassembly 1 MDTCPS	Make : 540/600	-2.565	595
	Break : 585/515	+155.566	570
Subassembly 2 MDTCPS	Make : 540/600	-2.425	550
	Break : 585/515	+155.574	540
Subassembly 3 MDFJPS	Make : 540/600	+156.299	(a)
	Break : 585/515	+388.167	(a)

[a]The stage II MDFJPS pressure cannot be determined, because there was no analog telemetry channel of injector pressure.

5.2.8.2 Airframe MDS.- The MDS rate-switch package performed as required throughout the flight. No vehicle overrates occurred from lift-off through spacecraft separation.

5.2.9 Range Safety and Ordnance

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

5.2.9.1 Flight termination system.- Both GLV command receivers were receiving a minimum signal strength carrier after LO + 288 seconds. At this time, the command carrier was being transmitted from Grand Turk Island, a station not previously used on manned Gemini missions. The 83.6° launch azimuth necessitated the use of this station. The low signal strength was also noted by the spacecraft command receivers indicating that this occurrence was a transmitter phenomenon.

The low signal strength in no way interfered with receipt of the auxiliary second-stage cutoff (ASCO) signal.

The following command facilities were used:

Time, sec	Facility
LO to LO + 66	Eastern Test Range (ETR) 600-W transmitter and single-helix antenna
LO + 66 to LO + 118	ETR 10-kW transmitter and quad-helix antenna
LO + 118 to LO + 258	Grand Bahama Island 10-kW transmitter and steerable antenna
LO + 258 to LO + 640	Grand Turk Island 10-kW transmitter and steerable antenna

5.2.9.2 Range safety tracking system.- Missile trajectory measurement system T (MISTRAM) was used as the primary source of data for impact prediction (IP) and provided accurate information through insertion. Brief calibration-circuit losses of lock were experienced at 34, 69, and 72 seconds after lift-off but did not interfere with the operation of the system.

5.2.10 Prelaunch Operations

The split count was initiated through the range sequencer for the scheduled engine ignition at 19:30 G.m.t. on December 4, 1965. See section 4.1 for a detailed discussion of lift-off timing. Propellant pre-chill was begun at 21:45 G.m.t. on December 3 and propellant loading was complete at 06:34 G.m.t. on December 4. Total elapsed time for propellant loading was 3 hours 24 minutes. Automatic charging of the oxidizer standpipe was successfully accomplished for this launch. No erector vibrations were experienced by the Gemini VII crew as were noted by the Gemini V crew.

No hold-fires were experienced during the countdown and launch was successfully accomplished. Pad damage was minimal and Gemini VI-A was erected by 16:00 G.m.t. on December 5, 1965.

TABLE 5.2-I.- PRELIMINARY STAGE I ENGINE PERFORMANCE

Parameter	Preflight predicted	Postflight reconstructed	Difference, percent
Thrust (engine)[a], lb	433 687	436 306	+0.60
Thrust (engine, flight average), lb	458 970	462 433	+.75
Specific impulse[a], lb-sec/lb	259.59	261.74	+.83
Specific impulse (flight average), lb-sec/lb	276.80	279.26	+.89
Engine mixture ratio[a]	1.9465	1.9396	-.35
Engine mixture ratio (flight average) . . .	1.9318	1.9230	-.46
Burn time (87FS1 to 87FS2), sec	158.72	159.17	-.28

[a]Standard inlet conditions

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TABLE 5.2-II.- PRELIMINARY STAGE II ENGINE PERFORMANCE

Parameter	Preflight predicted	Postflight reconstructed	Difference, percent
Thrust (engine)[a], [b], lb	102 200	102 731	+0.52
Thrust (engine flight average)[b], lb	102 680	102 584	-.09
Specific impulse[a], [b], lb-sec/lb	315.30	312.65	-.84
Specific impulse (flight average)[b], lb-sec/lb	315.92	313.11	-.89
Engine mixture ratio[a]	1.8039	1.8001	-.21
Engine mixture ratio (flight average) . . .	1.7666	1.7732	+.37
Burn time (91FS1 to 91FS2), sec	183.26	181.40	-1.02

[a]Standard inlet conditions

[b]Includes roll control nozzle thrust

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

a. Travel			
Actuator designation	Maximum during ignition		Maximum during hold-down null check, in.
	Travel, in.	Time from lift-off, sec	
Pitch 1_1	-0.094	-2.75	+0.02
Yaw/roll 2_1	-0.090	-2.75	-0.04
Yaw/roll 3_1	+0.200	-2.80	-0.02
Pitch 4_1	-0.071	-2.80	-0.01

b. Rates				
Axis	Stage I gyro maximum rate, deg/sec		Stage II gyro maximum rate, deg/sec	
	Primary	Secondary	Primary	Secondary
Pitch	-0.20	-0.30	+0.39	+0.47
Yaw	+0.39	+0.19	-0.19	+0.19
Roll	+0.38	+0.40	--	--

TABLE 5.2-IV.- PLANNED AND ACTUAL LAUNCH VEHICLE EVENT TIMES AND RATES

Event	Planned time from lift-off, sec	Actual time from lift-off, sec	Difference, sec	Planned rate, deg/sec	Actual rate, deg/sec	Difference, deg/sec
Roll program start	19.44	19.35	-0.09	1.250	1.260	0.010
Roll program end	20.48	20.39	-.09	1.250	1.260	.010
Pitch program 1 start	23.04	22.94	-.10	-.709	-.691	-.018
Pitch program 1 end	88.32	88.04	-.28	-.709	-.691	-.018
Pitch program 2 start	88.32	88.04	-.28	-.516	-.500	-.016
Pitch program 2 end	119.04	118.66	-.38	-.516	-.500	-.016
Pitch program 3 start	119.04	118.66	-.38	-.235	-.250	.015
Pitch program 3 end	162.56	162.02	-.54	-.235	-.250	.015

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

Axis	Attitude error, deg	Time from lift-off, sec
Pitch	+1.10 -0.68	92 80
Yaw	+0.94 -0.96	83 69 and 73
Roll	+0.47 -0.47	91 20
Axis	**Rates, deg/sec**	**Time from lift-off, sec**
Pitch	+0.18 -1.01	0.5 65.5
Yaw	+0.68 -0.79	80.7 67.6
Roll	+1.58 -1.01	20.0 155.5

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

Pitch axis	Rate, deg/sec
Maximum positive rate at 91FS2 + 2.5 sec	+0.99
Maximum negative rate at 91FS2 + 16.1 sec	-0.40
Rate at 91FS2 + 20 sec	-0.30
Rate at 91FS2 + 31.9 sec (spacecraft separation) . . .	-0.20
Yaw axis	
Maximum positive rate at 91FS2 + 12.7 sec	+0.20
Maximum negative rate at 91FS2 + 0.6 sec	-0.38
Rate at 91FS2 + 20 sec	+0.19
Rate at 91FS2 + 31.9 sec (spacecraft separation) . . .	+0.19
Roll axis	
Maximum positive rate at 91FS2 + 0.3 sec	+0.38
Maximum negative rate at 91FS2 + 6.5 sec	-0.31
Rate at 91FS2 + 20 sec	+0.27
Rate at 91FS2 + 31.9 sec (spacecraft separation) . . .	-0.21

TABLE 5.2-VII.- COMPARISON OF PLANNED AND ACTUAL TRAJECTORY PARAMETERS

Condition	Planned	Actual
SECO + 20 seconds		
Time from lift-off, sec	358.61	357.01
Altitude, ft	529 219	529 700
Space-fixed velocity, ft/sec	25 804	25 793
Space-fixed flight-path angle, deg	0	0.05
Yaw velocity, ft/sec	0	-7.0

TABLE 5.2-VIII.- GEMINI VII 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 (1500 psia equiv.)	3360 psi	-2.34	2560 psi	-2.69
Stage I secondary hydraulics	None	3400 psi	-2.84	2840 psi	155
Stage I tandem actuators					
No. 1 Subassembly 2 pitch	±4.0 deg	0.90 deg	79.5	0.55 deg	92
No. 2 Subassembly 2 yaw/roll	±4.0 deg	.70 deg	82	.70 deg	69
No. 3 Subassembly 1 yaw/roll	±4.0 deg	.65 deg	72.5	.7 deg	83
No. 4 Subassembly 1 pitch	±4.0 deg	.60 deg	92	.8 deg	80.5
Stage I pitch rate	+2.5 deg/sec -3.0 deg/sec	.18 deg/sec	0.5	1.01 deg/sec	66
Stage I yaw rate	±2.5 deg/sec	.68 deg/sec	81	.79 deg/sec	68
Stage I roll rate	±20 deg/sec	1.58 deg/sec	20.02	1.01 deg/sec	155
Stage II pitch rate	±10 deg/sec	.39 deg/sec	274	2.02 deg/sec	171.3
Stage II yaw rate	±10 deg/sec	1.46 deg/sec	156.96	.58 deg/sec	159.5
Stage II roll rate	±20 deg/sec	.98 deg/sec	157.04	1.4 deg/sec	156.3

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

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

5.3 SPACECRAFT - LAUNCH VEHICLE INTERFACE PERFORMANCE

The various functions of the spacecraft - launch vehicle interface, as defined in reference 11, performed within specification limits. The performance of the electrical and mechanical interfacing systems was derived from the overall performance of the launch vehicle and the spacecraft as determined from instrumentation and crew observations.

The electrical circuitry performed as anticipated in all respects. The malfunction detection system (MDS) and the spacecraft inertial guidance system (IGS) steering signals to the launch vehicle remained passive throughout powered flight.

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6.0 MISSION SUPPORT PERFORMANCE

6.1 FLIGHT CONTROL

The Gemini VII mission was controlled from the Mission Control Center in Houston (MCC-H) using a three-shift operation. This section of the report is based on real-time observations and may disagree with some of the detailed evaluations in other report sections which were made from analyses of postflight data.

6.1.1 Premission Operations

6.1.1.1 Premission activities.- The premission activities, consisting of pad support, simulations, and network checkout, were conducted during the period from November 12 to December 4, 1965. The launch-site operations supported by MCC-H were the Electrical Interface Integrated Validation, the Joint Guidance and Control Test, the Joint Combined Systems Test, the Final Systems Test, the Simulated Flight Test, and the Precount, Midcount, and Final Countdown. Simulations conducted by the flight controllers were 1 day of launch aborts, 1 day of reentry simulations, 1 day of simulated network simulations, and 2 days of actual network simulations. All network simulations were conducted with the assumptions that Gemini VII was in orbit, that Gemini VI-A was on the launch pad, and that the countdown had progressed to T-120 minutes. The simulations were carried through rendezvous in order to exercise the mission phases which were considered to be the most critical with respect to flight control. During this period, 3 days of simulations were conducted for Gemini VI-A only. Three days were used to check the digital-command-system (DCS) data flow and the telemetry-data flow between the MCC-H and the remote sites, and to check the remote-site telemetry station patching. Few problems were encountered during the premission activities.

6.1.1.2 Documentation.- The documentation for the mission was generally good and required very little change before or during the mission.

6.1.1.3 MCC/network flight control operations.- The network was placed on mission status on November 22, 1965, the day the remote-site flight controllers were deployed. After November 22, the normal network checkout took place. The network was demonstrated to be in good condition, and no problems were evident which would hinder support of the mission.

6.1.1.4 Prelaunch.- On December 2, a problem was discovered in the real-time computer complex (RTCC) time-to-retrofire logic. For retrofire at perigee from high-energy elliptical orbits (87 n. mi. to 203 n. mi) the time-to-retrofire computations would not converge. It was decided to continue with this limitation and, if the situation occurred during the mission, the auxiliary computing room (ACR) data would be used instead of the RTCC.

During the countdown and again during revolution 30, when updating the spacecraft computer, errors occurred in the 2K bits/sec and 40.8K bits/sec telemetry data readouts of the onboard computer memory. This problem was thought to be an error in the programs for the remote-site data processors (RSDP) at Texas and Bermuda or the buffer formatter at Cape Kennedy. Because of the complexity of locating the error and reprogramming the equipment concerned, no attempt was made before the launch or during the remainder of the mission to correct the problem.

During the countdown a problem was encountered with the closed-circuit television channel no. 33, which is used to display the pitch parameters during the countdown and launch to the mission operations control room (MOCR) guidance officer in MCC-H. The problem was isolated by maintenance and operations (M and O) technicians to cabling which could not be taken down for maintenance during the countdown. However, the channel began operating properly and continued to do so throughout the launch phase. If the channel had not been working, the pitch parameters could have been monitored in the staff support room (SSR) during the remainder of the countdown and during the launch.

Except for the minor problems mentioned in the previous paragraph, the countdown was nominal, and at no time was there any loss of mission support.

6.1.2 Mission Operations Summary

6.1.2.1 Powered flight.- The launch phase was nominal from a systems and trajectory standpoint. The following table shows a summary of the launch vehicle stage II cutoff conditions from the various data sources.

Data source	Inertial velocity, ft/sec	Flight-path angle, deg	Altitude, n. mi.
GE/Burroughs	25 786	+0.04	86.9
IP 3600-raw	25 793	+0.04	87.0
IP 3600-smooth	25 796	-0.04	87.0
Bermuda radar	25 795	+0.05	87.0

The GE/Burroughs solution was selected to transfer to orbit phase, and predicted an orbit of 86.8 by 177.7 nautical miles. The post-insertion Bermuda low-speed solution gave 86.9 by 176.9 nautical miles.

At 25 seconds prior to SECO, the guidance officer lost the Burroughs steering parameters on his strip-chart recorders. These parameters had been sent to MCC-H via Goddard Space Flight Center (GSFC) on the FM-FM aeromedical data lines. The problem was traced to the fact that GSFC switched these lines back to the aeromedical parameters too soon. This problem cannot occur on Gemini VIII because these parameters will be routed to MCC-H by direct line from Cape Kennedy.

6.1.2.2 Orbital.- After SECO, the planned station keeping with the second stage of the GLV was performed successfully. However, the crew reported that the second stage was tumbling much more than expected. The nominal 10 ft/sec maneuver to separate from the second stage was scheduled for 25 minutes g.e.t., but was reported by the crew to be 7.5 ft/sec at 22 minutes 17 seconds g.e.t. Subsequent tracking gave an orbit of 88.1 by 174.5 nautical miles.

The perigee-adjust maneuver scheduled at third apogee was calculated as 59 ft/sec and postmaneuver tracking indicated that it was executed nominally.

Because of progress on launch complex 19 in preparation for the Gemini VI-A launch, it was decided to do an orbit adjustment on the third day of the flight (Dec. 7), which would allow later adjustments for either an eighth or ninth day launch of the Gemini VI-A mission. A posigrade thrust of 12.4 ft/sec was asked for, and subsequent tracking verified a nominal maneuver.

On the fifth day of the flight (Dec. 9), adjustments were executed to circularize the Gemini VII orbit and optimize the phasing with Gemini VI-A, if launched on the eighth day. The first maneuver, at apogee in revolution 75, was 61.2 ft/sec posigrade. At the next perigee a 12.1 ft/sec retrograde maneuver was executed. Subsequent tracking verified a very near to circular orbit of 161.6 by 162.7 nautical miles.

A procedure was established in which certain tracking sites in the continental United States, the Eastern Test Range, and Australia were released on an every-other-day pattern. This procedure worked out very well, and it is believed that adequate spacecraft tracking was obtained from the sites that were called up.

The aerodynamic K-factor was changed during the mission when it became apparent that the orbital decay was less than expected. The final K-factor value used in the RTCC was 0.5.

At an elapsed time of 4 hours, the master digital command system (MDCS) lost 21 hours in the time-to-retrofire (T_R) clock. This happened again on the next shift, and the problem was finally isolated on the third shift.

During revolution 29, it was reported that the spacecraft T_R was different from the ground T_R by 9 minutes. It was determined that the pilot had inadvertently opened the time reference system circuit breaker when removing his suit.

The retrofire officer changed to the middle-of-mission aerodynamics in the RTCC at 7:30:00 G.m.t. on the third day of the flight (Dec. 7).

On the sixth day of the flight (Dec. 10), while the retrofire officer was attempting to load the T_R for a revolution 104 area 1 (planned landing area) in the spacecraft, both communications processors failed. The "A" communications processor was brought back up and the T_R was successfully loaded prior to Cape Kennedy loss of signal (LOS). There was no loss of mission traffic or data as a result of the communications processor failures.

The retrofire officer changed to the end-of-mission aerodynamics in the RTCC at 19:20:00 G.m.t. on the 10th mission day (Dec. 14).

One facet of the mission that was found to be sometimes confusing was the necessary use of multiplication factors resulting from the mismatch of various shunts and gages and their respective onboard displays. The telemetry parameters all indicated correctly; however, any communications with the crew concerning (a) any one of the six fuel-cell stack currents, (b) the environmental control system (ECS) primary-oxygen tank pressure, (c) the fuel-cell hydrogen tank pressure, or (d) the fuel-cell oxygen tank pressure required conversion from ground readings to onboard readings when transmitting to the spacecraft, or from onboard readings to ground readings when receiving spacecraft transmissions.

In order for the ground to accurately gage orbital attitude and maneuver system (OAMS) propellant remaining, it is necessary that all delayed-time telemetry data be reviewed to determine the duration of the thrust maneuver since the previous computation. In the past, these data were reviewed by playing the delayed-time telemetry data back through the remote-site telemetry ground station and recording the thruster activity on an analog recorder. The recording was then analyzed by the remote-site systems engineer, and all thrust times were determined. For this mission, however, a program was written for processing the delayed-time telemetry data by the RSDP which computed the duration of all maneuver thruster "on" times and provided a tabulation of the total. This program was used with some success. However, all data were reduced manually as a check, and the answers obtained manually did not agree completely with the RSDP answers. It is believed that the errors in the program are related to the method used, in which thrust indications during periods of telemetry loss-of-sync were disregarded. Correction to this program will be made prior to the Gemini VIII mission.

A drop in fuel-cell oxygen tank pressure was noted at the Canary Island station during revolution 1. The pressure was 200 psi and holding steady at Bermuda LOS, but had fallen to 180 psi at the Canary Island acquisition of signal (AOS) (150 psi onboard reading). The pressure continued to fall throughout the Canary Island pass, and ground indications were 154 psi at LOS. The tank heater was reported as being on but of no apparent help since the pressure was still falling. It was assumed that either stratification in the tank similar to that observed on GT-2 was occurring, or that a heater failure as on Gemini V had occurred. Over the Kano station, the crew reported the tank pressure as 100 psi (120 psi actual) and a decision was made to open the crossfeed valve between the environmental control system (ECS) and the reactant supply system (RSS). The valve was opened and an immediate rise in pressure in the fuel-cell oxygen tank was experienced. The crew closed the crossfeed valve when the onboard pressure reached 250 psi. This rapid drop in tank pressure did not occur again, and the crossfeed valve was not opened during the rest of the mission. The possibility of a heater failure was ruled out since the heater was later observed to be functioning properly.

Over the Canary Islands, following the launch phase, it was noted that the fuel-cell section 2 differential pressure warning light (oxygen to water) was on. The fuel cells were later purged with the fuel-cell crossover valve open and the light remained on. This result ruled out a possible regulator problem. Also, the possibility of a cracked water separator was ruled out since this would have caused a rapid rise in stored-water pressure which was not noted.

The fuel-cell performance was essentially normal, with stack current stable, until 126 hours g.e.t. At that time, stack 2C was noticed to be rapidly degrading in performance. The stack was open-circuited approximately 10 hours later for 20 minutes, and its performance immediately improved to the previous value of 20 percent of the total load. It was suspected at the time that the stack was flooded with water, and that open-circuiting of the stack had resulted in partial removal of the water.

Stack 2C continued with a degradation cycle of once per day until it was shut off at 286:57:34 g.e.t. when it would not return to a value near normal. Each day, various corrective measures, such as open-circuiting the stack, opening the crossover valve, and open-circuiting the complete section, would result in the performance of stack 2C returning to initial load sharing. Each time the performance of stack 2C returned to normal, water removal from the cell was believed to be the reason.

Later in the flight, at approximately 280 hours g.e.t., fuel-cell stack 2A began following the same degradation cycle as stack 2C. This was believed to support the suspicion that a water problem involved the entire section. Also, the fuel-cell control circuit breaker no. 2 which powers the solenoids of the section 2 water valve was reported to have opened twice during the time between 211 and 212 hours g.e.t.

Fuel-cell stacks 2A and 2C were taken off the line by using the stack switches at 286:57:34 g.e.t. It was believed that isolated freezing had probably restricted the water valve. Stack 2B continued to perform with slight degradation for the remainder of the mission.

The PCM tape recorder failed at approximately 200 hours g.e.t. The first indication of failure occurred over CSQ on revolution 126 where it was noted that the PCM tape-motion telemetry signal indicator was not illuminated following AOS, with the recorder in the record mode. The previous dump performed at the RKV less than 1 hour earlier had been completed normally. A replay of the RKV real-time data indicated no anomalies during or after the dump, and the tape-motion indicator was on at LOS to that station. The initial analysis was that the recorder had failed in the record mode. Failure of the recorder was confirmed by the RKV during revolution 127. At AOS, the tape-motion light was off, but it came on when the tape dump was commanded. Because the previous dump had been performed one revolution earlier, about 4 minutes of dump should have been received. Instead, only 35 seconds of modulation were received and, at the end of that time, the tape motion indication went out. All attempts to get the recorder back into the record mode failed. Replay of the last dump indicated that the recorder stopped recording at 200:29:30 g.e.t.

After power-down of the spacecraft at the conclusion of the rendezvous, the crew reported that water ran out of their suit hoses at the time that the suits were disconnected. At first, this water was thought to be condensate resulting from chill-down of the spacecraft during the powered-up period. A cabin temperature survey revealed a high relative humidity in the cabin of approximately 90 percent. At Hawaii in revolution 167 (267:25 g.e.t.), the crew reported that water was continuing to come from the suit hoses and also that their onboard suit temperature gage was off-scale low. This much water indicated that the suit heat exchanger was flooded and was not removing water from the suit circuit. Normally, the condensate from the suit heat exchanger is transferred to the water boiler and eliminated overboard through a relief valve. It had been predicted that the water boiler would be full by this time and would start venting. The indications were that either the water boiler was full and the valve was not allowing the water to dump or moisture had condensed in the suit hoses because of the low cabin temperature. Over RKV, the following procedure was relayed to the crew and this was performed over CSQ at the times shown in the table.

Time from lift-off, hr:min, g.e.t.	Procedure
268:33	Select A pumps in primary and secondary loops, start to orient spacecraft broadside to the sun, select an 8 to 10 deg/sec roll rate, and radiator to BYPASS.
268:37	Turn evaporator heater ON.
268:41	Select radiator to FLOW.
268:42	Select B pumps, turn evaporator heater off, and stop roll rate.

The Gemini VI-A crew reported that large amounts of water did vent from the water boiler. Approximately 2 hours later, the Gemini VII crew reported that the cabin was warm and dry, indicating that the suit heat exchanger had been cleared and was again removing condensation in a normal fashion.

The only major problem concerning the simultaneous system monitoring of two spacecraft occurred during spacecraft 6 reentry. Just prior to the spacecraft 6 reentry, the Gemini VII crew reported that the yaw right thrusters were not operating properly. The network was configured to support Gemini VI-A and no detailed evaluation could be started until after the spacecraft 6 reentry. After blackout, during the spacecraft 6 reentry, it was noted that RCS fuel consumption was higher than predicted and that the anomalies such as high reentry control system (RCS) fuel usage and Y axis accelerometer output were not as expected. However, the study of these results had to be postponed and the network had to be reconfigured in order to analyze the spacecraft 7 thruster problems. But the time lost in the reconfiguration process did not cause any loss of data.

Coming out of darkness in revolution 177, the crew noted when they attempted to reduce the spacecraft rates that their yaw-right thrusters (TCA 3 and 4) had failed. After spacecraft 6 reentry, the crew of spacecraft 7 reported the following data:

(a) Attitudes could be controlled fairly well by using pitch and roll thrusters.

(b) Solenoids could be heard clicking when commanding yaw right. The crew reported later that they could no longer hear the solenoids.

(c) Unignited globules of liquid were seen when they attempted to yaw right. They could not determine the color of the liquid although it appeared white.

(d) The secondary drivers and secondary bias power were tried in rate-command, pulse, and direct modes with no improvement.

(e) A weak glow on the dark side of the spacecraft could be seen when they called for thrusters, but they were realizing very little thrust.

A review of the thrust chamber assembly (TCA 3) injector-head temperature history showed that the first indication of a perturbation occurred over the Canary Islands in revolution 175 where the temperature decreased from an average of approximately 55° to 43° F. No significant change was seen until after Carnarvon AOS in revolution 177, where it was 46° F. At Hawaii in revolution 177, the temperature was 11° F and dropped to 5° F as the spacecraft passed over the United States. Subsequently, the indication went off-scale on the low side (less than 0° F). It was believed that the low temperatures resulted from flowing of liquid through the TCA without good combustion.

The TCA 3 and 4 circuit breakers were turned off for several revolutions in an attempt to bring the temperature back up. The temperature rose slowly, but steadily, from somewhere below 0° F at 285:01 g.e.t. to 34° F at 290:30 g.e.t. At 22° F, TCA 3 and 4 were tested using the rate command mode, with negative results; however, the previous temperature rise indicated that the TCA heaters were working. TCA 3 and 4 circuit breakers were then turned off, and the right-hand forward-firing maneuver (TCA 12) was used to provide yaw-right capability.

Another test was performed during revolution 204 at 327:09 g.e.t. The TCA 3 injector-head temperature was 48° F prior to the test, and fell to 9° F at 328:00 g.e.t. after the attempted firing. TCA 3 and 4 were fired individually for 3 seconds in the direct mode. The crew was apparently misunderstood when, at that time, it was believed they reported that thruster 3 was unchanged, but that thruster 4 was improved. (During debriefing, the crew stated that neither thruster showed any change, and that yaw-right authority was still about one-fourth of normal when in the pulse mode.) After the second test, the crew said that they would use the maneuver thruster 12 for gross yaw-right attitude changes with TCA 3 and 4 as a vernier control. They later reported that this method worked well for preretrofire platform alignment.

6.1.2.3 Reentry.- The tracking prior to retrofire indicated a very stable orbit, and the calculated retrofire time did not change during the last two revolutions. A T_R based on a Greenwich mean time of retrofire computed (GMTRC) of 13:28:07 was loaded into the spacecraft computer from the Texas station on revolution 205 and a valid update for a revolution 207, area 1 planned landing area was also loaded into the computer and verified. Retrofire occurred on time, and the incremental velocity indicator (IVI) readouts received over Canton Island indicated that retrofire had been nominal. A solution for backup guidance parameters was obtained from the IVI readings and Hawaii tracking data. California and White Sands tracking data were rejected, therefore backup guidance parameters based on the Hawaii solution were transmitted to the crew. The crew flew a manual closed-loop reentry, and landed at a distance of approximately 7.8 nautical miles from the target point. (Editor's note: Best tracking data available at the time of publication of this report shows a target miss of 6.4 nautical miles short and 0.5 of a nautical mile to the left.)

The reentry control system (RCS) propellant usage during reentry was higher than expected. In fact, all of the RCS propellant was expended. Part of the reentry was flown with the RCS in the rate command mode. This is a very tight mode of operation and requires more propellant usage than either the reentry rate command mode or the direct mode. (Editors note: Fuel usage during reentry in the direct mode could be very high depending upon the method of control.) The reentry trajectory was very close to nominal and the command pilot had to reverse bank many times in order to keep the crossrange error zeroed. While this high usage of RCS propellant was not a serious problem on this flight, the usage rate will require a review of mission rules.

6.2 NETWORK PERFORMANCE

The network was placed on mission status for Gemini VII on November 22, 1965, and was ready to support the mission at lift-off on December 4, 1965.

6.2.1 Mission Control Center, Houston, and Remote Facilities

The network configuration and the general support required at each station are indicated in table 6.2-I. Figure 4.3-1 shows the worldwide network stations. In addition, approximately 15 aircraft provided supplementary photographic, weather, telemetry, and voice relay support in the launch and reentry areas. North American Air Defense Command (NORAD) Space Acquisition Detection and Tracking System (SPADATS) radars provided tracking of the Gemini launch vehicle and the spacecraft.

6.2.2 Network Facilities

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

6.2.2.1 Remote sites.-

6.2.2.1.1 Telemetry: The performance of the network telemetry system was very good. No major equipment malfunctions or operational errors significantly affected the overall telemetry data coverage during the mission. The Texas (TEX) station experienced several minor problems resulting in some data loss. Five minutes prior to acquisition, during the third revolution, the 150-channel event recorder failed, but was repaired and back in service for the next pass. During the first 4 mission days, a telemetry tape recorder was malfunctioning because of defective tapes and head misalignment. During the second day, industrial interference was present on two frequencies and was subsequently cleared. The telemetry requirements for this mission fully tested the capabilities of remote-site equipment to support a dual mission.

6.2.2.1.2 Radar: The tracking performance of the network radar was excellent. The Mission Control Center, Houston (MCC-H) computers showed a range bias in the Hawaii data and large residuals in the Canary Island data. These problems were not seriously detrimental to the mission but are presently being investigated by the Goddard Space Flight Center.

6.2.2.1.3 Acquisition aids and timing: The performance of the acquisition aid and timing systems was excellent throughout the mission.

The Guaymas and Canary Island stations each encountered problems with a planetary gear on the antenna pedestals; however, no data were lost. The California and Hawaii stations encountered problems resulting from moisture in the preamplifier and hybrid circuits of their acquisition aids, but did not lose data. These problems are also being investigated by the Goddard Space Flight Center.

6.2.2.1.4 Command: The only problem of significance in the command system was the transmittal of several non-valid commands at the Texas, Bermuda, and Air Force Eastern Test Range sites. Invalid transmissions at Bermuda occurred in the downrange up-link (DRUL) and were attributed to line noise. The problems at Texas and the Eastern Test Range are under investigation.

6.2.2.2 Computing.-

6.2.2.2.1 Real time computing center (RTCC): In general, most of the RTCC problems experienced during the Gemini VII mission were hardware problems. These problems had no significant effect on mission support.

With one exception, the orbit determination program was able to determine very quickly the proper orbit and provide satisfactory results. During revolutions 130 to 134, poor solutions were obtained because data from only one part of the orbit was available. As a result, because data from the Eastern Test Range and the United States were the only data available for orbit determination, three passes over the United States were required for a valid determination of the orbit.

A computer program error caused an inhibiting of the recovery world-map processor display. The error has been identified and corrected.

The telemetry system had four minor program problems during the mission. Three problems occurred with the off-line report processor, and one with the summary tab display processor. These problems were corrected with no adverse effect on the mission.

During the Gemini VII mission, the RTCC was able to accomplish 15 reconfigurations within the anticipated time span of 10 to 15 minutes each. Coordination and interface with the network during reconfiguration were good. These reconfigurations were necessary to receive and display information from a particular spacecraft at a particular time and, in some cases, from both spacecraft simultaneously.

6.2.2.2.2 Remote site data processors (RSDP): On December 10, Hawaii reported a G.m.t. input discrepancy which caused an intermittent error in the ground elapsed time. By having the Coastal Sentry Quebec run program checks on December 11, it was concluded that an error existed in the telemetry on-line monitoring compression and transmission system program which increased the ground elapsed time by a constant 4 hours. All sites were requested to change the teletypewriter header accordingly whenever the error occurred prior to transmitting summaries. This problem is presently under investigation by the Goddard Space Flight Center.

During revolution 131, all Canary Island summaries were rejected for errors in the ground elapsed time of the teletypewriter headers. Engineering unit printouts indicated that G.m.t. had been updated by 10 hours. The problem was traced to the telemetry output buffer. Although this problem occurred only on this revolution, a similar problem occurred on the Coastal Sentry Quebec on December 15. This problem is also under investigation by the Goddard Space Flight Center.

6.2.2.3 Communications.-

6.2.2.3.1 Ground communications: Ground communications during the mission were generally good. Some adverse propagation conditions occurred, causing minor problems but no loss of data.

On December 6, a severe storm in the Port Augusta, Australia, area knocked down several line poles between Perth and Adelaide, Australia. Immediately, communications were partially restored by the use of HF radio. Although the Carnarvon biomedical data were poor, the data were usable. Normal line service was restored late in the day.

On December 14, a severe electrical storm in the Hawaii area caused a commerical power failure at the Oahu Syncom ground station. A parametric amplifier failure at the same time caused loss of communications to the Coastal Sentry Quebec via Syncom. Service was partially restored by another route until the Clark Air Force Base Syncom station could be brought up 2 hours later. The Oahu station was in operation again on December 15. No data were lost.

6.2.2.3.2 Air-to-ground: Spacecraft communications during the mission were good. On December 16, however, the Spacecraft Communicator was unable to reach the spacecraft through Kano on revolution 176 due to a ground-to-air transmitter failure at Kano.

6.2.2.3.3 Frequency interference: The only systems on board the spacecraft on which interference was reported were telemetry and the HF voice link.

A total of 12 interference reports on 15.016 mc/s was accumulated. Of these, only one was fully investigated. The cause has not been determined, but the interference disappeared after the Gemini VI-A first launch attempt on December 12. None of the 11 other interference reports on the 15.016-mc/s frequency were acted upon because either the source was not identified, or the interference originated in areas that could not be cleared.

The Texas station (TEX) consistently received ignition noise on 230.4 mc to 298 mc caused by a local industrial firm. An agreement was reached with the firm and the interference was eliminated during those passes on with TEX was active.

TABLE 6.2-I.- GEMINI VII NETWORK CONFIGURATION

Stations \ Systems	C-band radar	SPANDAR	R and R telemetry	Real-time telemetry display	Delayed time telemetry	High speed telemetry	GLDS	Remote site data processor summary	GLV telemetry	Digital command system	Downrange uplink	Data routing and error detection	RF command	Voice	Teletype	Horizon sensor radar data	Flight controller, manned	Acquisition aid	Telemetry RCV antenna	Flight controller, air-to-ground	Air-to-ground remoting
MCC-H				X	X			X		(X)				X	X	X	X			X	X
MCC-C			X		X	X	X		X	X		X		X	X	X		X	X		
~~MIA~~ MILA	X																				
CNV			X						X		X		X								
PAT	X																				
WLP		X												X	X			X			
GBI	X		X		X	X			X		X		X					X	X		X
GTI	X		X		X	X					X		X					X			X
BDA	X		X		X	X					X		X	X	X	X		X	X		X
ANT	X		X		X	X					X		X					X	X		
RKV[a]			X	X	X			X		X			X	X	X		X	X		X	
CYI	X		X	X	X			X		X			X	X	X		X	X		X	
ASC	X		X															X	X		X
KNO			X											X	X			X			X
PRE	X																				
TAN			X											X	X			X			X
CRO	X		X	X	X			X		X			X	X	X		X	X		X	
CSQ[a]			X	X	X			X		X			X	X	X		X	X		X	
RTK[a]	X		X															X			X
CTN			X											X	X			X			X
HAW	X		X	X	X			X		X			X	X	X		X	X		X	
CAL	X		X											X	X			X			X
GYM			X	X	X			X						X	X		X	X		X	
WHS	X													X	X			X			
TEX			X	X	X	X		[X]			X		X	X	X	X	X	X		[X]	
EGL	X													X	X			X			
WOM	X													X	X						
A/C			X																		X

[a]Ship positions: CSQ - 125°E 20°N; RKV - 39°W 19°S; RTK - 175°W 25°N

(X) - Master DCS

[X] - Backup to MCC-H remoting

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6.3 RECOVERY OPERATIONS

6.3.1 Recovery Force Deployment

The four catagories of planned landing areas designated for the Gemini VII mission were:

(a) Primary landing area (supported by an aircraft carrier and located in the West Atlantic zone)

(b) Secondary landing areas (East Atlantic, West Pacific, Mid-Pacific, and areas within the West Atlantic zone not supported by the aircraft carrier)

(c) Launch site landing area

(d) Launch abort landing areas

Data concerning the deployment of ships and aircraft in planned landing areas are provided in table 6.3-I. Figure 6.3-1 shows the deployment of ships and aircraft in the launch abort landing areas. The four worldwide landing zones are illustrated in figure 6.3-2, and the ship support provided for each of the numbered landing areas is listed in table 6.3-I.

The recovery forces were assigned positions in these areas so that any point in a particular area could be reached within a specified access time. The ship and aircraft access times, which varied for the different areas, were based upon the probability of the spacecraft landing within a given area and the amount of recovery support in that area.

Ten ships (including 1 mine sweeper), 31 fixed-wing aircraft, 10 helicopters, and various special vehicles were positioned for support of the four categories of planned landing areas. Twenty-six of the aircraft, with pararescue teams aboard, were deployed around the world on strip alert. These aircraft were at the locations shown in figure 6.3-2 to provide contingency recovery support and support in the zones described in the preceding paragraphs.

The normal contingent of Department of Defense (DOD) ships and aircraft were used for recovery support. Special equipment, such as retrieval cranes, airborne UHF electronic receivers (homing systems), spacecraft flotation collars, and swimmer interphones, were furnished to the DOD by NASA. All aircraft providing contingency and secondary landing-area support carried pararescue teams ready to drop to the spacecraft, install a spacecraft flotation collar, and render assistance to the flight crew. Twin-turbine helicopters (Type SH-3A), launched from the aircraft carrier, provided location support and were used to transport swimmer teams, flotation collars, and photographers to the landing point. Fixed-wing aircraft from the carrier were utilized to relay communications and to transport the on-scene commander to the landing point.

6.3.2 Location and Retrieval

The MCC-Recovery Control Center informed all recovery forces of flight progress throughout the mission. As the orbital ground tracks shifted during the mission, possible landing points were passed to all forces, and the positions of the recovery ships and aircraft were altered accordingly.

On December 18, 1965, at 329:23 g.e.t., a nominal retrofire time of 329:58:08 g.e.t. was predicted and deployed forces were notified accordingly. Details of the primary landing area are shown in figure 6.3-3. The aircraft carrier U.S.S. Wasp, on station at latitude 25°22.1' N., longitude 69°56.8' W., established radar contact at 329:47:00 g.e.t. and vectored the airborne on-scene commander to the landing point calculated by the U.S.S. Wasp to be 25°22.8' N., 70°07' W. Visual contact was made by the on-scene commander at 330:33:00 g.e.t. when the spacecraft was at an altitude of approximately 4500 feet. The first visual sighting report was immediately transmitted to the primary recovery ship U.S.S. Wasp, and a helicopter-borne swimmer team was dispatched to the landing point. Swimmers were deployed at 330:43 g.e.t. and the spacecraft flotation collar was attached to the spacecraft and inflated by 330:47 g.e.t.

Radio and interphone communication with the flight crew indicated that they were in good physical condition and desired to be brought aboard the recovery ship by helicopter. The left hatch was opened at 330:52 g.e.t., both pilots were in the liferaft by 330:54 g.e.t. and were hoisted aboard the recovery helicopter by 330:57 g.e.t. The flight crew was on the carrier deck at 331:07 g.e.t. The carrier had the spacecraft onboard at 331:38 g.e.t. and secured in the spacecraft transportation dolly at 331:39 g.e.t. See figures 6.3-4 to 6.3-6 for photographs taken during recovery.

The U.S.S. Wasp reported the position of the spacecraft at pickup was 25°21.9' N., 70°08.8' W., approximately 2 miles from where it had landed.

The rendezvous and recovery (R and R) section and main parachute floated for a short time after landing and were sighted by "Air Boss One" in a fixed-wing aircraft. However, the R and R section and parachute sank before swimmers were able to arrive at the scene.

Aft stowage box seals were in good condition. On the morning of December 19, 1965, the day after recovery, the flight crew departed the carrier, U.S.S. Wasp, and flew to Cape Kennedy. Following completion of spacecraft postretrieval procedures (section 6.3.4), the spacecraft was off-loaded at Mayport Naval Station, Florida, at 1345 G.m.t., December 20, 1965.

6.3.3 Recovery Aids

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

Aircraft	Time of contact, hr:min, g.e.t.	Range, n. mi.	Receiver	Mode
Search 1 (SH-3A)	330:34	12	SPP ARC-27 ARA-25	Pulse and CW CW CW
Search 2 (SH-3A)	330:34	2	SPP	Pulse and CW
Search 3 (SH-3A)	330:33	10	SPP	Pulse and CW
Kindley Rescue 1 (HC-97)	330:33	180	SPP	Pulse and CW
Patrick Rescue 1 (HC-130)	330:33	100	ARD-17	CW
Patrick Rescue 2 (HC-130)	330:33	100	ARD-17	CW
Patrick Rescue 3 (HC-130)	330:33	100	ARD-17	CW
Relay 2 (EA-1E)	330:35	25	ARC-27 ARA-25	CW CW

6.3.3.2 HF transmitter.- Seven stations of the DOD high frequency-direction finding (HF-DF) network received signals from the spacecraft. Six stations had bearing information to the spacecraft as shown in the following table:

Station	Signal strength	Bearing evaluation	Signal quality	Time of contact, hr:min, g.e.t.
1	5	None	Good	330:38
2	3	Good	Good	330:37
3	5	Good	Excellent	330:38
4	5	Good	Poor	330:40
5	3	Poor	Good	330:38
6	5	Good	Excellent	330:38
7	4	Good	Good	330:38

No recovery force units reported HF reception. The HF antenna was retracted by the flight crew prior to spacecraft retrieval.

6.3.3.3 UHF transmitter.- Signals from the spacecraft UHF voice transmitter were received by aircraft as follows:

Aircraft	Time of contact, hr:min, g.e.t.	Range, n. mi.	Receiver
Swim 1 (SH-3A)	330:27	57	ARC-27
Swim 2 (SH-3A)	330:28	--	ARC-27
Photo 1 (SH-3A)	330:28	--	ARC-27
Relay 1 (EA-1F)	330:35	9	ARC-25
Relay 2 (EA-1F)	330:34	27	ARC-25
Air Boss 1 (S-2E)	330:30	2	ARC-52
Air Boss 2 (S-2E)	330:33	33	ARC-52

6.3.3.4 UHF survival radio.- This radio was not used.

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

6.3.3.6 Fluorescent sea marker.- The sea dye marker diffusion appeared normal and was observed by all aircraft in the landing area at ranges from 2 to 7 nautical miles. The recovery ship reported a range of 6 nautical miles.

6.3.4 Postretrieval Procedures

Spacecraft postretrieval procedures were performed as specified in references 12 and 13. All onboard film and other specified loose equipment were expedited to Cape Kennedy and Houston by special flights from the carrier.

Photographs were taken of all observations. Visual inspection of the spacecraft disclosed no excessive heating effects and all screws and bolts appeared to be present. Other observations included the following:

(a) A gouge was noted in the right lower quadrant of the heat shield that was similar in size, shape, and position to that found after recovery of spacecraft 6, indicating that it resulted from retrieval operations.

(b) Both spacecraft windows were fogged and droplets of water were between the panes. The right-hand window was covered by a clear yellow granular film as was the aft portion of the right-hand hatch and the top portion of the reentry control system (RCS) module.

(c) The left-hand hatch was unlocked, and the right-hand hatch which had not been opened since ingress before launch required 325 in-lb of torque to release the lock. Both hatch seals were in good condition.

(d) The interior of the spacecraft appeared to be very clean but cluttered.

(e) The left-hand hatch cams were both in the "neutral" position, whereas the right-hand hatch cams were in the "locked" position.

(f) Ejection seat "D" rings had been stowed; however, the left-seat drogue mortar had not been safetied.

(g) All main batteries and the no. 3 squib battery were in the "on" position. Powering down occurred at 16:48 G.m.t., December 18, 1965.

(h) The UHF voice and recovery antennas were deployed, as were the recovery light and the hoist loop. All appeared to be in good condition. The HF antenna had been extended, but was retracted by the flight crew after the swimmers had been deployed into the water.

(i) The fresh-air door had separated. Readings from the RCS vapor leak detector were negative.

(j) A shim ring from one of the yaw-right thrust chamber assemblies was pulled out from its normal position.

6.3.5 Reentry Control System Deactivation

After the spacecraft was unloaded from the carrier U.S.S. Wasp at Mayport, Florida, it was transported by dolly to a previously selected, well-isolated area where deactivation was begun at 2:00 a.m. e.s.t. on December 21, 1965. (Note: Both spacecraft 6 and 7 arrived in Mayport onboard the U.S.S. Wasp and were positioned for deactivation by 10:00 a.m. e.s.t. December 20. Spacecraft 6 was deactivated first.) Deactivation of spacecraft 7 was completed at 8:00 a.m. e.s.t. December 21. Upon receipt of the spacecraft, there was no visual indication of vapors from any of the sixteen RCS thrust chamber assemblies (TCA). The RCS shingles had been previously removed on board the carrier by contractor personnel.

Before the pressurant in each ring was relieved to atmospheric pressure, the landing and safing team obtained pressure readings of source pressure from test point 1 (A package) of both rings and regulated lock-up pressure from test point 6 (B package) of both rings. Source pressure readings of 1025 psig and 1040 psig (ambient dry bulb temperature of 56° F) were obtained from A and B rings, respectively. Regulator lock-up pressure readings of 300 psig and 295 psig were obtained from A and B rings, respectively. The pressures in each ring were then relieved to atmospheric pressure. Immediately following the source pressurant draining operation, the pressurant upstream of the propellant bladders and downstream of the system B package check valves was relieved through test points TP-4 and TP-6 by venting through separate propellant scrubber units.

Following the preceding operations, nitrogen pressure of 50 psig was utilized to force the remaining propellants of both rings into the proper propellant holding containers. When these steps were accomplished, the propellant motorized valves were left in the closed position so that propellant loss would be minimized. The propellant solenoid valves did not leak vapors or flush-fluids at any time. All the RCS valves appeared to function normally. Approximately 1 tablespoon of fuel was removed from ring A but there was insufficient quantity for analysis. There were only fumes in ring B. Neither ring A nor B contained liquid oxidizer. No sample was available for analysis.

TABLE 6.3-I.- RECOVERY SUPPORT

Landing area	Access time, hr:min		Support
	Aircraft	Ship	
Launch site area:			
Pad			4 LARC (amphibious vehicle) 1 LCU (large landing craft) with spacecraft retrieval capabilities
Land	0:10		2 LVTR (amphibious vehicle) with spacecraft retrieval capabilities
Water (if flight crew ejects)	0:02		3 M-113 (tracked land vehicles)
Water (if flight crew is in spacecraft)	0:15		4 CH-3C (helicopters) (3 with rescue teams) 1 MSO (mine sweeper) with salvage capabilities 1 boat (50 ft) with water salvage team
Launch abort area:			
A	4:00	12:00	1 CVS (aircraft carrier) with onboard aircraft capabilities, 3DD (destroyers), 1 AO (oiler), 1 ATF, (fleet tug) and 5 aircraft on station (5HC-97) (See fig. 6.3-1)
B	3:00	3:00	
C	3:00	14:00	
D	3:00	14:00	
Primary landing area:			
West Atlantic (end-of-mission area 207-1)	1:00	4:00	1 CVS (aircraft carrier) from area A, station 3 2 HC-97 (search and rescue) 5 JC-130 (3 telemetry and 2 communications relay) 6 SH-3A helicopters (3 location, 2 swimmer, and 1 photo) 2 S-2E (on-scene commander and backup) 2 EA-1F (Navy communications relay - 1 primary, 1 backup) 1 EA-1E (radar search)

TABLE 6.3-I.- RECOVERY SUPPORT - Concluded

Landing area	Access time, hr:min		Support
	Aircraft	Ship	
Secondary landing areas:			
West Atlantic (Zone 1)	30 min strip alert	6:00	1 CVS (carrier) from station 3
East Atlantic (Zone 2)		6:00	1 DD (destroyer) from station 6[a]
West Pacific (Zone 3)		6:00	2 DD (destroyer) (rotating on station)
Mid-Pacific (Zone 4)		6:00	1 DD (destroyer)[b]
Contingency			26 aircraft on strip alert at world-wide staging bases
Total (including MSO's)			10 ships, 6 helicopters, 31 aircraft

[a]In addition an oiler (AO) was assigned to this area for logistic purposes.

[b]In addition an oiler (AO) was assigned to the area for logistic purposes and an additional destroyer (DD) was assigned to cover the launch of Gemini VI-A.

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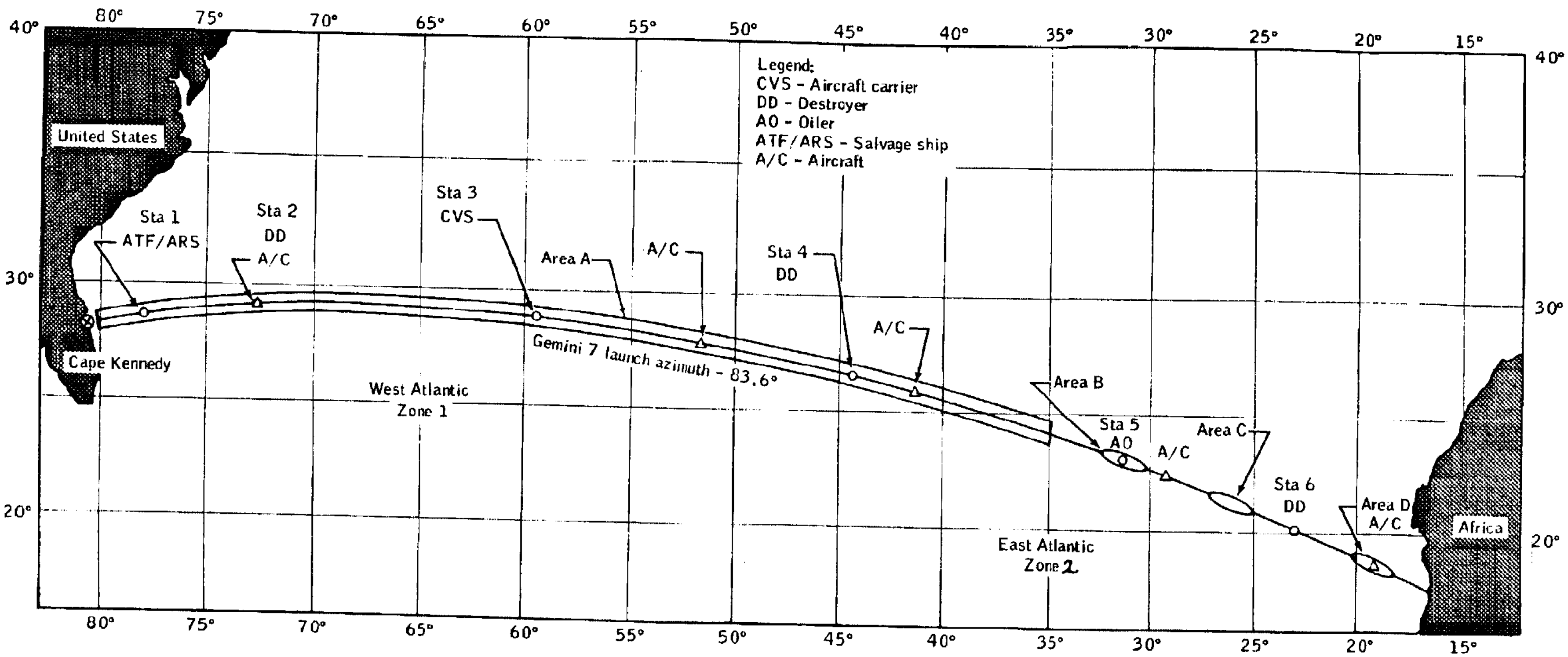

Figure 6.3-1 Gemini VII launch abort areas and recovery force deployment.

NASA-S-66-88 JAN

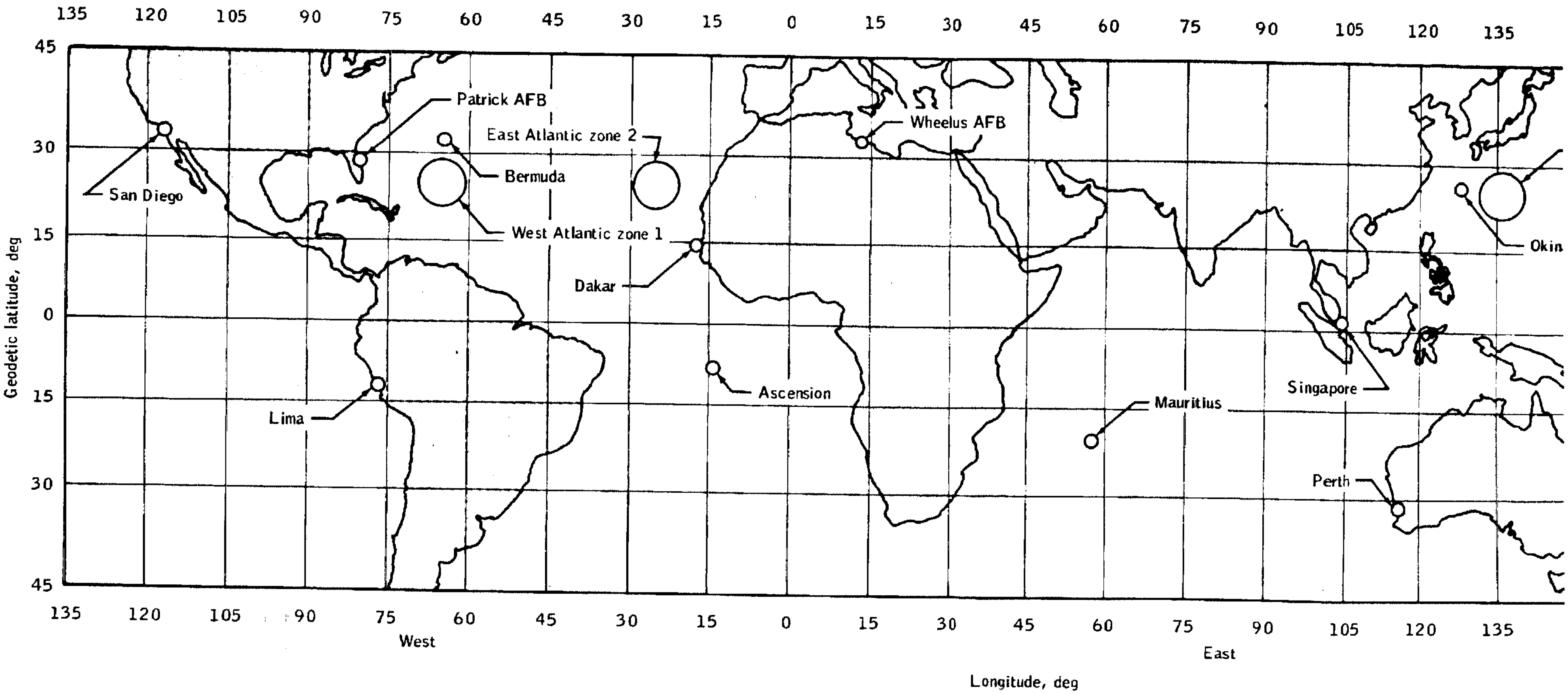

Figure 6.3-2. -

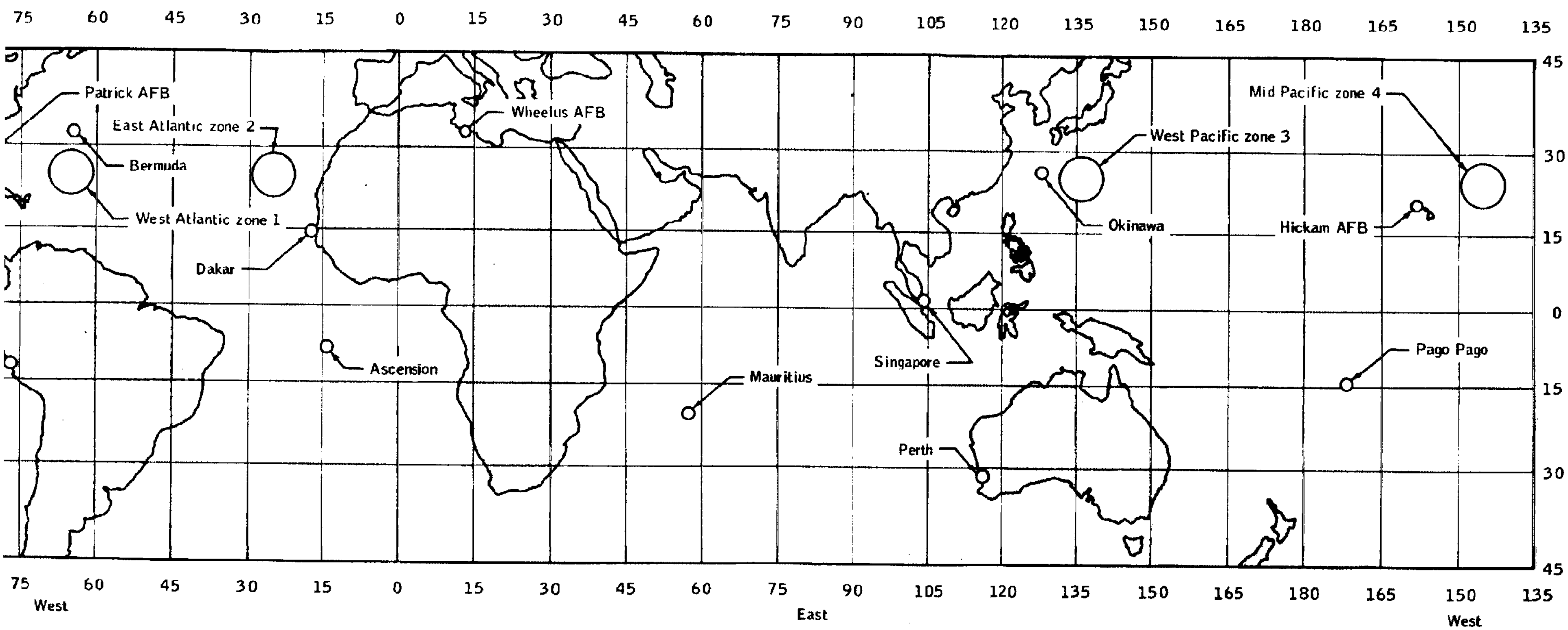

Figure 6.3-2. - Landing zones and aircraft staging bases.

[redacted] [redacted]

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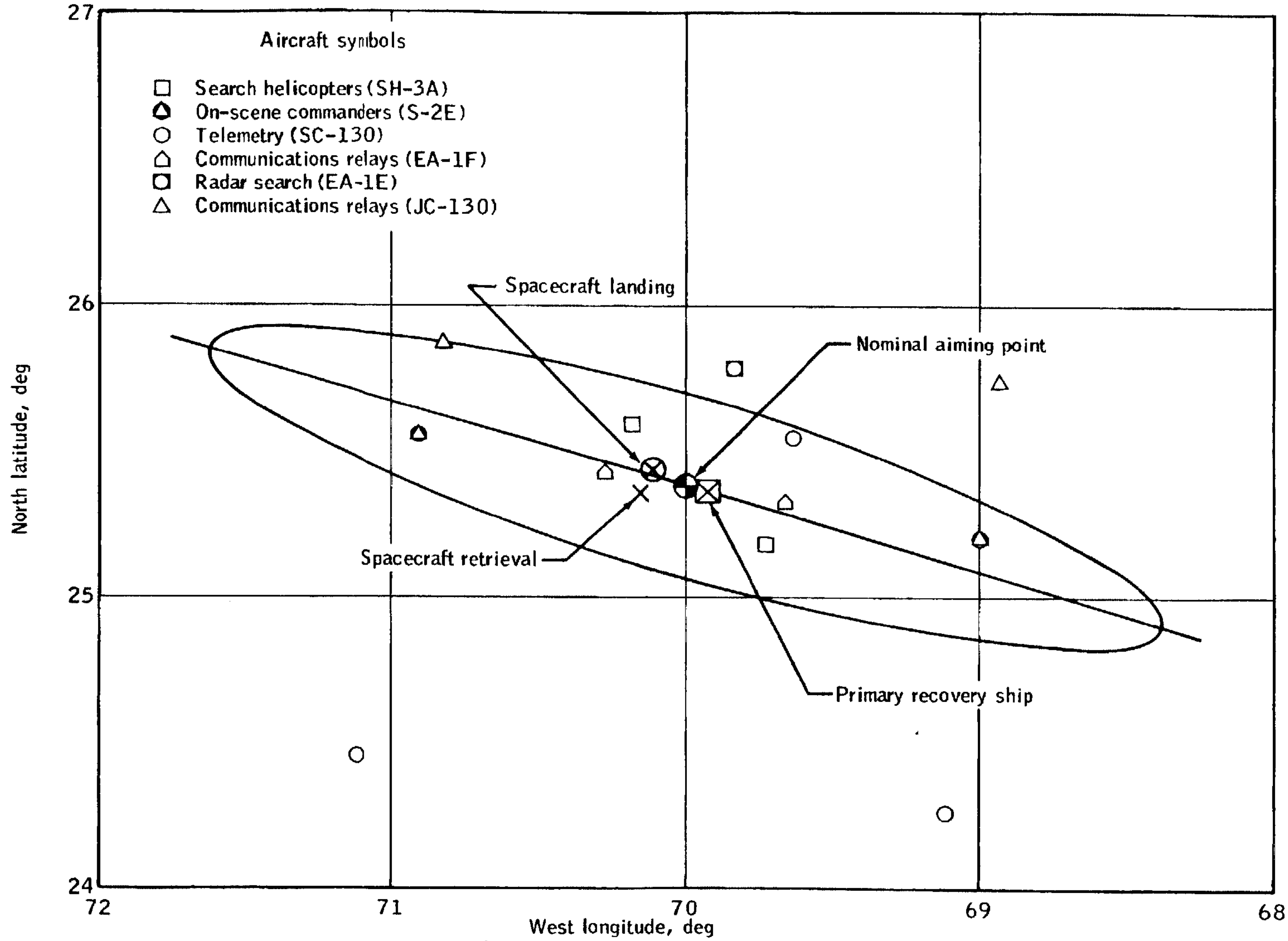

Figure 6.3 - 3. - Details of primary landing areas.

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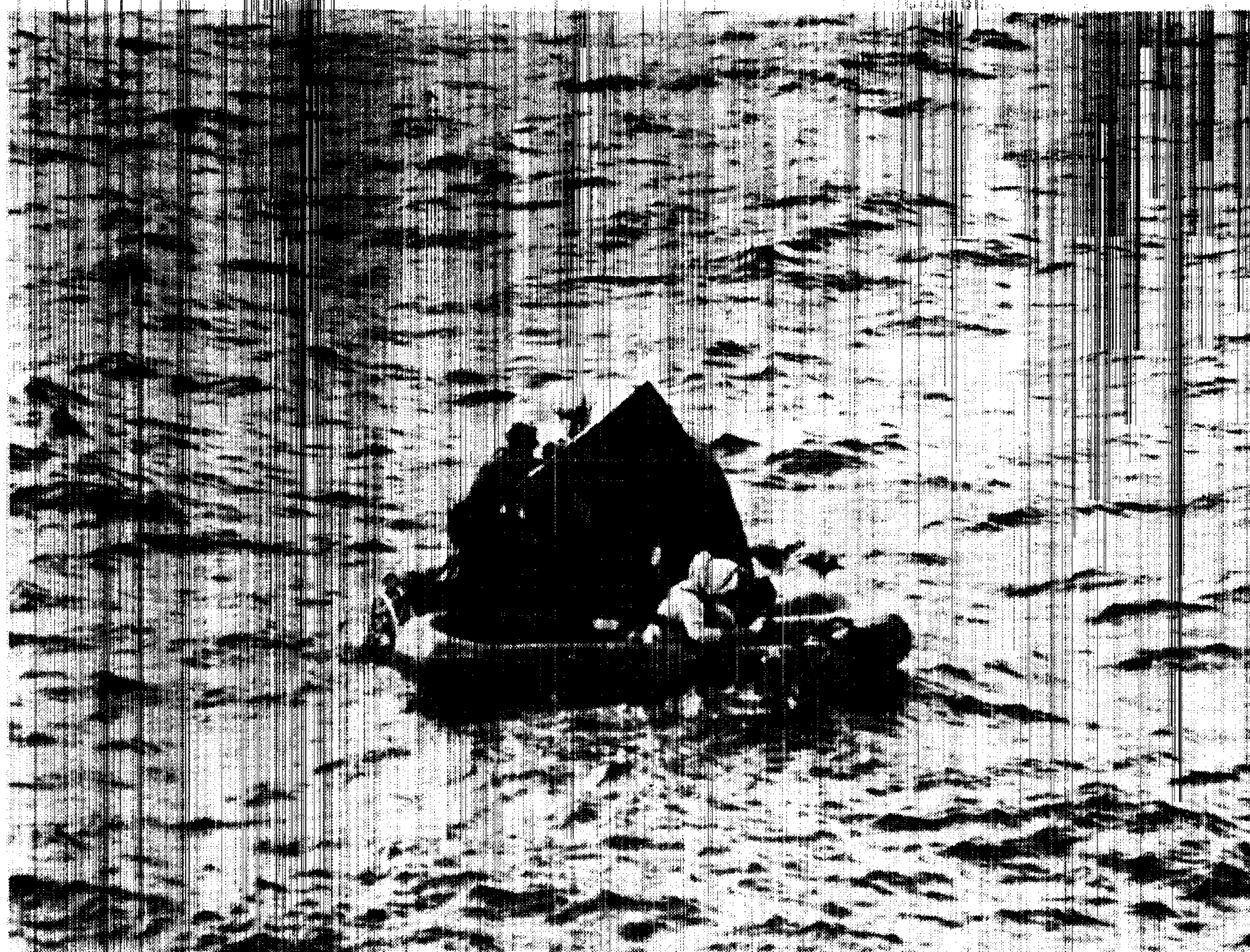

Figure 6.3-4. - Pilot egressing from Spacecraft 7.

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NASA-S-66-228 JAN

Figure 6.3-5. - Pilot being hoisted aboard helicopter.

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NASA-S-66-79 JAN

Figure 6.3-6. - Flight crew coming aboard U.S.S. Wasp.

NASA-S-66-1115 FEB

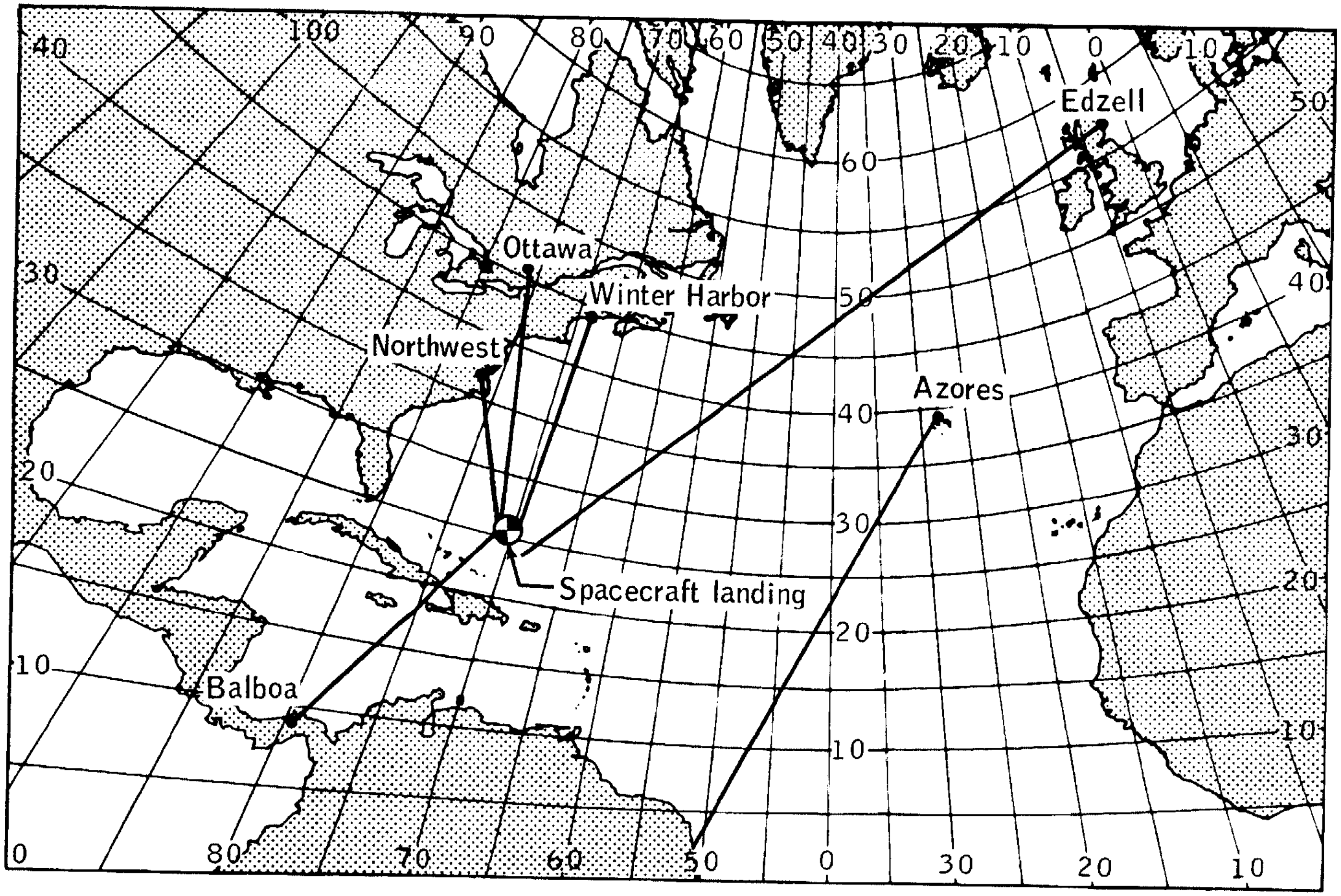


Figure 6.3-7. - HF-DF network station bearings to the spacecraft after landing.

7.0 FLIGHT CREW

7.1 FLIGHT CREW PERFORMANCE

7.1.1 Crew Activities

The results of this flight provide further evidence that a well-prepared crew can, within the confines of the Gemini spacecraft, perform a large number of experiments involving somewhat complicated crew procedures in addition to the required operational tasks for a 14-day flight. The crew attained all of the major mission objectives with the exception of several experiments which were not completed because of adverse weather conditions or because of experiment equipment problems. A complete and detailed flight plan, as actually carried out, is presented in figure 7.1-1.

The crew performed station keeping with the second stage of the launch vehicle promptly after insertion. During station keeping, the rate of fuel consumption was slightly higher than planned because of the necessity to maneuver more than predicted. The second stage had angular rates and translations that were probably caused by a high degree of fuel venting from the second stage. This station keeping was terminated several minutes early to hold the total fuel consumption to the flight-plan budget. The subsequent station keeping with the stable spacecraft 6 was considered to be a very simple task.

Orbit adjust maneuvers to establish the proper position for the Gemini VI-A rendezvous were performed very well. The only spacecraft problems requiring extensive attention from the crew involved the fuel cells and the deterioration of orbital attitude and maneuver system (OAMS) thrusters 3 and 4 during revolution 177. The retrofire and reentry were accomplished nominally with a resultant miss distance of 6.4 nautical miles.

No significant crew training inadequacies were reported by the crew nor were any indicated by their flight performance. No significant physical problems were evidenced. As in the Gemini V flight, the most demanding crew task during this mission was that of accomplishing routine housekeeping.

7.1.1.1 Prelaunch, powered flight, and insertion.- The crew entered the spacecraft at the scheduled time and completed all prelaunch operations on time. Powered flight was nominal and no crew problems or unexpected events occurred. The pilot, however, was unable to depress the 145-second digital command system (DCS) light until after insertion. Lift-off was apparent to the crew through a combination of noise, vibration, and visual cues. Although the spacecraft windows were clean prior to lift-off, a yellowish film appeared to collect on them during staging. This film on the windows seriously obscured vision when the sun was at an oblique angle to the window.

The crew received an insertion "go" prior to separation, and the pilot read very near to nominal insertion parameters from the inertial guidance system (IGS). Spacecraft separation was initiated by the pilot at second-stage engine cutoff (SECO) + 31.9 seconds, and the command pilot reported that he translated away from the launch vehicle for only 2 seconds in order to remain close to the vehicle and simplify the task of maneuvering back to it for the station-keeping requirement. The spacecraft separated from the launch vehicle without any noticeable angular rates.

7.1.1.2 Launch vehicle station keeping.- The command pilot initiated a yaw-right turnaround using the pulse control mode immediately after the 2-second separation translation maneuver. The direct mode was subsequently selected to expedite the turnaround, and the rate command mode was utilized to terminate the maneuver and maintain spacecraft control during the 5-second thrust required to close with the launch vehicle. At the completion of the turnaround maneuver, the launch vehicle was approximately 150 feet from the spacecraft and was observed to be venting at 90° to its longitudinal axis. This venting caused the second stage to translate as well as rotate, which increased the difficulty of the station-keeping task.

In order to obtain photographs of the launch vehicle immediately after the turnaround maneuver, the pilot had attached the 16-mm camera bracket at staging and placed the camera on the bracket at SECO. The pilot started photographing the launch vehicle as soon as it came into view. The crew reported that distance was difficult to determine with the vehicle tumbling. On several occasions, the spacecraft was closer to the launch vehicle second stage than the crew desired, and they had to back the spacecraft off. Distance determination was extremely difficult at night when the entire launch vehicle was not illuminated.

The spacecraft was positioned north of the launch vehicle to maintain a more favorable sun condition for obtaining photographs. All control modes were checked and utilized during the station-keeping maneuver. On one occasion, the platform mode was selected, which yawed the spacecraft away from the launch vehicle causing the crew to lose sight of it momentarily until the spacecraft was reoriented using the pulse mode.

Station keeping with the second stage was terminated at 21 minutes after lift-off (2 minutes earlier than planned) when the pre-established cutoff point of OAMS fuel remaining (88 percent) was reached. The crew was able to maintain good position with the launch vehicle throughout this maneuver, in spite of the increased difficulty of determining and holding the proper distance at night because of the launch vehicle rotation, inadequate illumination of the launch vehicle body, and perhaps because of some translation caused by fuel venting.

7.1.1.3 Crew housekeeping.- The extended length of the mission, as well as the large number of experiments requiring crew-operated equipment, resulted in an extremely crowded cockpit and necessitated very careful management of house-keeping activities. The most critical tasks involved anticipating equipment requirements well in advance and being prepared for a contingency reentry.

As a result of Gemini V experience, the Gemini VII crew followed a realistic work-eat-rest cycle that coincided with the cycle to which they had been accustomed during their preflight training period. The pilot had no difficulty in obtaining adequate sleep; however, the command pilot did have some difficulty initially because of the noise of the M-1 experiment equipment, an uncomfortable suit temperature, and the bright sunlight through the window.

Stowage presented no unexpected problem except that the centerline stowage container cover was difficult to shut because the container bracket was sprung approximately three-fourths of an inch.

Crew monitoring of systems' operation was very satisfactory throughout the flight. They reported that toward the end of the flight their monitoring was less intensive as a higher degree of confidence in the spacecraft was developed. Cockpit lighting was generally adequate; however, the digital clock was inadequately illuminated, the polaroid filters did not block the sunlight adequately for sleep, and more red lighting should have been available for optimum night visibility.

The crew expressed some doubt as to whether they would have been as effective in completing all the planned tasks if they both had been required to wear pressure suits during the entire mission. After the first 2 days of the flight (during which time both crew members were suited), the crew were uncomfortably warm and experienced irritation of the eyes and nose. This condition improved when only one crew member was suited, and disappeared after both crew members removed their suits at 191 hours 48 minutes g.e.t. With the suits off, the crew felt as though the cockpit was much larger. Although the crew reported no problems with the suits themselves, they did note that the suit hood interfered with communications and impaired peripheral vision.

7.1.1.4 Operational checks.- The scheduled operational checks were completed according to the flight plan, except for the Apollo landmark investigation which was hindered throughout the flight by weather. The operational checks, in addition to control system and platform procedures, are discussed in the following paragraphs.

7.1.1.4.1 Apollo landmark investigation: The Apollo landmark investigation on Gemini VII consisted of obtaining photographs of preselected landmarks that are intended to be acquisition aids for Apollo landmark navigation. Of nine landmarks logged by the crew, only one primary target was photographed. However, the crew took photographs of some alternate targets and pointed out prominent features along the African coastline.

Although the acquisition data that were given to the crew through real-time experiment updates were reported as being very good, the photography was hindered by adverse weather conditions and by the film on the windows of the spacecraft.

The crew commented that the onboard Apollo maps and landmark photographs were generally satisfactory, and they were able to identify areas using the landmark photographs. In addition, they commented that these areas were also readily identified from the maps. This was not the case on earlier missions when the crew did not have orbital photographs of the areas to study prior to the flight. The crew stated that the larger maps provided a better approach to the targets than the orbital map on the plotboard, and that a map package containing the large maps cut into four equal sections, accompanied by small-scale maps of the specific areas, would be sufficient.

7.1.1.4.2 General purpose photography: All objectives of the general purpose photography were fulfilled during the Gemini VII mission. All available film was expended prior to retrofire, and many good photographs were obtained, although some were affected by the film on the spacecraft windows, adverse weather conditions, and fuel conservation constraints. The rendezvous photographs taken of spacecraft 6 were generally good even though spacecraft 7 was usually in a position having a poor sun angle for photography.

7.1.1.4.3 HF tests: Two scheduled air-to-ground HF tests were accomplished. The first test was performed for one revolution using the horizon sensors for attitude control. The test operation was nominal except that during the first air-to-ground station pass, some difficulty was experienced in contacting the crew on UHF radio. This was probably because the crew did not have the exact acquisition of signal (AOS) time for the station and could not hear the ground station transmit on UHF until after switching the mode selector switch out of the HF-DF position. The second HF test was accomplished while in drifting flight, and was started at an earlier time to provide different reception data to the prime ground stations participating in the test.

Periodically throughout the mission, HF music was transmitted from various ground stations. The crew commented that HF voice and music reception was poor, and that it was readable only when the spacecraft was over the transmitting station.

7.1.1.4.4 Platform alignments: The platform alignments were accomplished using the OAMS attitude control platform mode for all situations except the final alignment for retrofire. This alignment was performed manually because of the degraded operation of OAMS TCA 3 and 4. Although the computer and platform data were lost due to the PCM recorder failure, the results of the retrofire and reentry indicate a very accurate alignment of the platform.

The crew commented that the manual alignment seemed to be more accurate than the automatic (platform mode) alignments because this method of control resulted in a smaller deadband. The available data, however, show small torquing currents during the automatic alignments which indicate very good alignment in this mode also.

7.1.1.5 Control system.- Operation of the OAMS was nominal until the 12th day when attitude thrusters 3 and 4 failed to operate normally. However, the crew was able to maintain attitude by substituting maneuver thruster 12 for yaw control or by accepting the degraded output of thrusters 3 and 4. Final platform alignment was accomplished in pulse mode and it was observed that thrusters 3 and 4 produced about one-fourth their normal thrust. In the direct mode, these thrusters produced no thrust.

The crew used fuel very conservatively in performing experiments while in the pulse mode. The direct mode of control was found to be necessary for the D-4/D-7 measurement of the ballistic reentry because of the very high closing rate between the two vehicles. This resulted in a rather high fuel usage for the measurement.

The spacecraft was controlled within a few degrees of the intended attitudes which provided good results for all attempted experiments and orbit-adjust maneuvers. Even though the first and second perigee adjust maneuvers were made without the use of a platform, the crew held attitudes very accurately by using a star reference and the reticle. The resultant changes in velocity were within 1 foot per second for both translations and the desired ephemerides were obtained. A detailed discussion of the orbit-adjust maneuvers is presented in section 4.

During the latter part of reentry, the crew elected to use the rate command mode of control rather than the reentry rate command mode to achieve a smaller deadband. The direct mode was selected for reentry but was subsequently found to be unsatisfactory because of over control in reducing oscillations even on only one RCS ring.

7.1.1.5.1 Controls and displays: The spacecraft cockpit controls and displays were adequate throughout the mission with the exception of the following two items:

(a) The fuel-cell section 2 differential pressure warning light illuminated shortly after insertion and remained on for most of the time during the remainder of the mission. This bright light being on most of the time was a continuing annoyance and presented a problem when it was necessary to adapt the eyes for night vision.

(b) The altimeter needle oscillated drastically during reentry. The crew was prepared to deploy the main parachute according to the barostat-operated warning light or a T_R + time for main parachute deployment (depending on which occurred first). However, prior to reaching either of these cues, the altimeter needle steadied, allowing a normal readout for main parachute deployment.

All other controls and displays including the OAMS regulated pressure readout and propellant quantity readouts worked properly throughout the mission.

7.1.1.6 Experiments.- Although the crew was hampered by a film on the windows, weather obscurement of ground areas, failure of some experiment equipment, and spacecraft attitude maneuvering constraints imposed by improper operation of the fuel cell and OAMS thrusters 3 and 4, approximately 71 percent of the total desired experiments were completed. Nearly all of the medical experiments were completed. Low fuel quantity during the last 2 days limited the number of experiments accomplished during this period.

The star occultation photometer used for experiments D-5 and MSC-12 did not operate properly during the flight. After several hours of troubleshooting by the crew, it was determined that the equipment could not be repaired in flight, and the D-5 and MSC-12 experiments were deleted.

The crew could not use the sequence of stars that was called up to them for the fifth D-9 experiment attempt. The sequence they did use was not satisfactory because of the stars' close proximity to the moon; however, later in the mission, it was possible to schedule another experiment D-9 attempt which was satisfactory.

Crew performance during the laser experiment was very satisfactory. Completion of the experiment was hindered, however, by ground equipment problems and clouds over the ground sites during most of the mission. The crew reported that the pulse mode was satisfactory for this tracking task, but locating the exact position of the laser beam was difficult because of adverse weather or lack of terrain features, or both.

A degradation of the OAMS yaw-right TCA 3 and 4 on the 12th day limited the spacecraft controllability and precluded the planned attempt to obtain photographs of the spacecraft 6 retrofire. Some of the synoptic terrain (S-5) and weather (S-6) photography was unsatisfactory because of the degraded visibility through the spacecraft windows and the lack of fuel needed for steady tracking.

Failure of the PCM tape recorder necessitated altering experiments MSC-2 and MSC-3. Instead of completing the scheduled tests in the South Atlantic anomaly which required real-time telemetry, the experiment spectrometer-magnetometer switch was turned on for the remainder of the mission and data were received through real-time telemetry when the spacecraft was over all subsequent network stations. Prior to the loss of the PCM tape recorder, a considerable amount of data were obtained concerning the South Atlantic anomaly.

7.1.1.7 Retrofire and reentry.- Stowage of experiment and operational equipment was initiated approximately 1 day prior to retrofire. Activities were held to a minimum during this period to conserve the remaining OAMS fuel for the final platform alignment and for positioning the spacecraft in the proper retrofire attitude. The platform was powered up and aligned at T_R - 2 hours with no problem, in spite of the degraded operation of the OAMS thrusters 3 and 4. The preretrofire events were completed normally and the crew's description of them was similar to those of previous Gemini flight crews.

The retrorockets fired automatically and the pilot backed up the sequence manually approximately 1 second after first retrorocket ignition. The command pilot used the rate command control mode and controlled the spacecraft to within 1° of the nominal retrofire attitude. He reported no significant misalignment torques except in yaw during thrusting of retrorocket 4. The spacecraft attitude had to be maintained by reference to the flight director indicator (FDI) because retrofire occurred during the night side. Just prior to retrofire the crew noted that there were no available stars for out-the-window reference and, like previous flight crews, reported that the earth horizon (airglow layer) was completely obscured by the thruster plumes. The incremental velocity indicator (IVI) showed changes in velocities of 298 ft/sec aft, 112 ft/sec down, and 3 ft/sec left which were very close to nominal.

Shortly after a nominal retrograde section jettison, the crew was given information by the ground station to fly a 35° left bank angle until reentry guidance initiate. This caused the crew some concern because the proper bank angle, based on the retrofire conditions, had been determined by the crew from onboard data cards to be a 53° left bank angle. Therefore, the crew requested and received verification from the ground station of the 35° bank angle. (It was subsequently determined that the 35° left bank angle was not correct, but flying it did put the spacecraft very close to the proper position at guidance initiate.)

The spacecraft was initially rolled to 55° and then to 35° using the pulse mode. The spacecraft was controlled between 35° and the full-lift position using the pulse mode until guidance initiate. The direct control mode was selected at guidance initiate; however, the command pilot had a tendency to over-control and therefore he selected rate command for the remainder of the reentry. Single-ring control authority was utilized until late in the reentry (to approximately 150K ft) at which time the command pilot elected to use both thruster rings because the oscillations appeared to be diverging. The fuel in the reentry control system was depleted prior to drogue parachute deployment at 50K ft, and the spacecraft oscillated approximately ±10° until the drogue parachute disreefed.

The drogue parachute stabilized the spacecraft prior to main parachute deployment. The main parachute deployed nominally with good correlation between the altimeter and the 10.6K-ft barostat warning light. Single-point release caused no concern to the crew, and they thought it was very similar to the single-point release demonstrations during preflight training. Upon opening of the snorkel inlet valve at 26K feet, the pilot had serious difficulty in seeing for a brief period because of fumes in the suit loop. The command pilot did not have this problem because his hood was open.

The crew procedure for manually flying the reentry was to: (a) fly the constant bank angle relayed to them by the ground station up to guidance initiate, (b) fly 1 needle width high on the reentry footprint to the 3g level keeping the crossrange nulled by frequent bank angle reversals, (c) null the down-range indicator needle, and (d) fly the roll indicator needle after the 3g level for proper bank angle until termination of guidance. The reentry proceeded exactly according to the planned reentry practiced during training simulations. The resultant landing miss distance was less than 7 miles.

The crew technique for reentry control was to have the command pilot monitor the FDI exclusively and the pilot monitor the out-the-window horizon to the extent possible, and call out this information to the command pilot for FDI cross-check purposes. Much of the reentry occurred during earth nighttime conditions and the pilot had considerable difficulty in determining the horizon position. The pilot had a further difficulty in that the pitch needle of the FDI assumed a new null (approximately 1 1/2 needle widths) after retrofire, which gave him the initial impression that the spacecraft was not being flown correctly to reach the intended landing position. In addition, crew discussion was hampered during the reentry when an air whistle was picked up by the command pilot's microphones.

7.1.1.8 Recovery.- The spacecraft landed with a slight drift to the right rear, causing the spacecraft to roll right and briefly submerge the pilot's window. Recovery weather conditions were very good, and the spacecraft flotation attitude was satisfactory. There was no apparent water leakage.

The crew conducted all the scheduled postlanding tests; however, the pilot stated that some of these tests were difficult to accomplish because of the blood-pressure cuff. The crew members were hot, uncomfortable, and tired, and they achieved some relief by opening the cabin repressurization valve for cooling.

They thought that removing the suits would be unnecessary, particularly since they knew their recovery situation and that egress was imminent. They had observed a recovery aircraft during descent on the main parachute. They also had good communications with recovery forces at the time, although communications with the Mission Control Center were poor. The pararescue swimmers approached the spacecraft approximately 5 minutes after spacecraft landing and attached the flotation collar promptly. The crew made a routine egress through the left hatch. They were then hoisted to the helicopter and flown to the prime recovery ship.

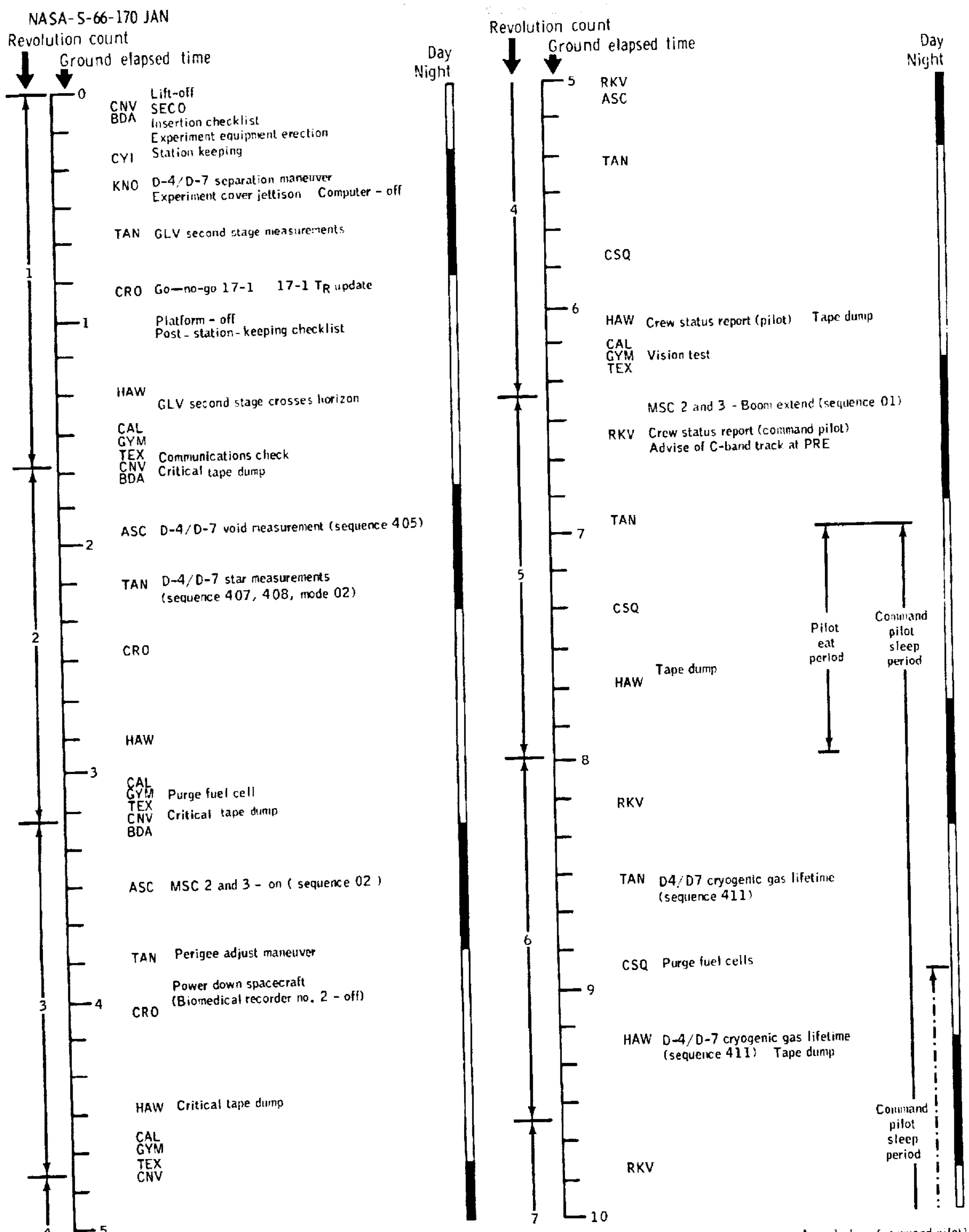
7.1.1.9 Training.- The Gemini VII crew training was conducted as outlined in the crew training plan. A summary of the Gemini VII crew training program is shown in table 7.1-I.

The average crew training time was 7.8 hours a day, 7 days a week throughout the training period. Overall crew training was quite satisfactory as indicated by flight performance and by crew postflight debriefing. Some training improvements are required particularly in the area of experiments training and crew participation in the integrated network simulations. To a limited extent, training for some experiments was not completely adequate because of equipment changes or the late arrival of training units, or both.

Crew training benefits (from their participation in the launch, reentry, and simulated network simulations) were limited by interface problems between the Gemini mission simulator and Mission Control Center, Houston. The Cape Kennedy Gemini mission simulator out-the-window simulation was excellent, but quite late in becoming operational. The primary station-keeping training and reentry training was accomplished on the contractor engineering simulator. The crew stated that a final stowage review should be accomplished approximately 10 days prior to all flights.

TABLE 7.1-I.- CREW TRAINING SUMMARY

Activity	Training time, hr	
	Command pilot	Pilot
Spacecraft tests	84.0	85.5
Gemini mission simulator	110.0	116.5
Experiments	100.5	100.0
Dynamic crew procedures trainer	6.5	5.0
Mockup	24.0	24.0
Planetarium	21.0	21.0
Egress and slide wire	9.0	9.0
Systems briefing	63.0	63.5
Parachute training	10.0	10.0



(a) 0 to 10 hours g.e.t.

Figure 7.1-1.- Summary flight plan.

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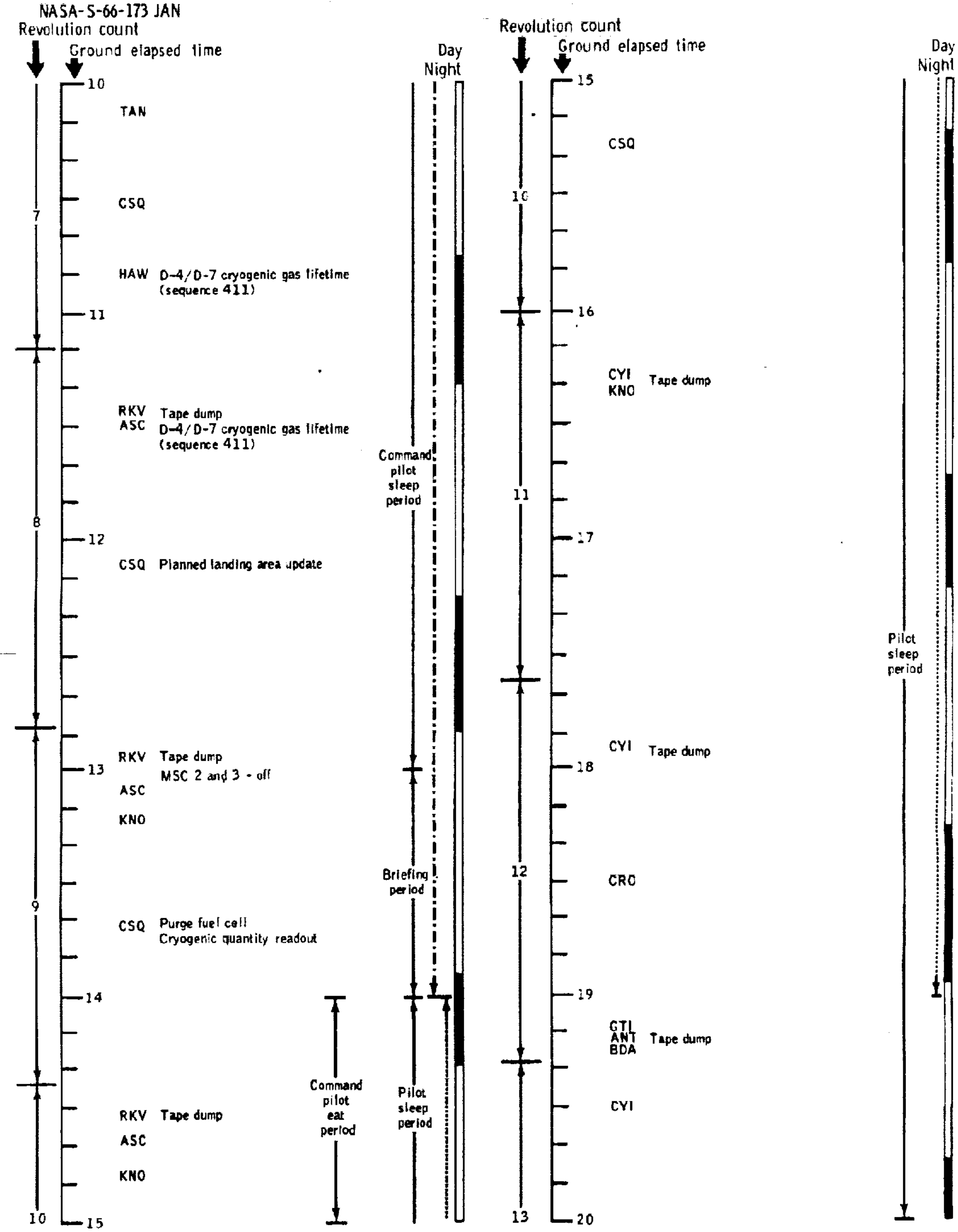
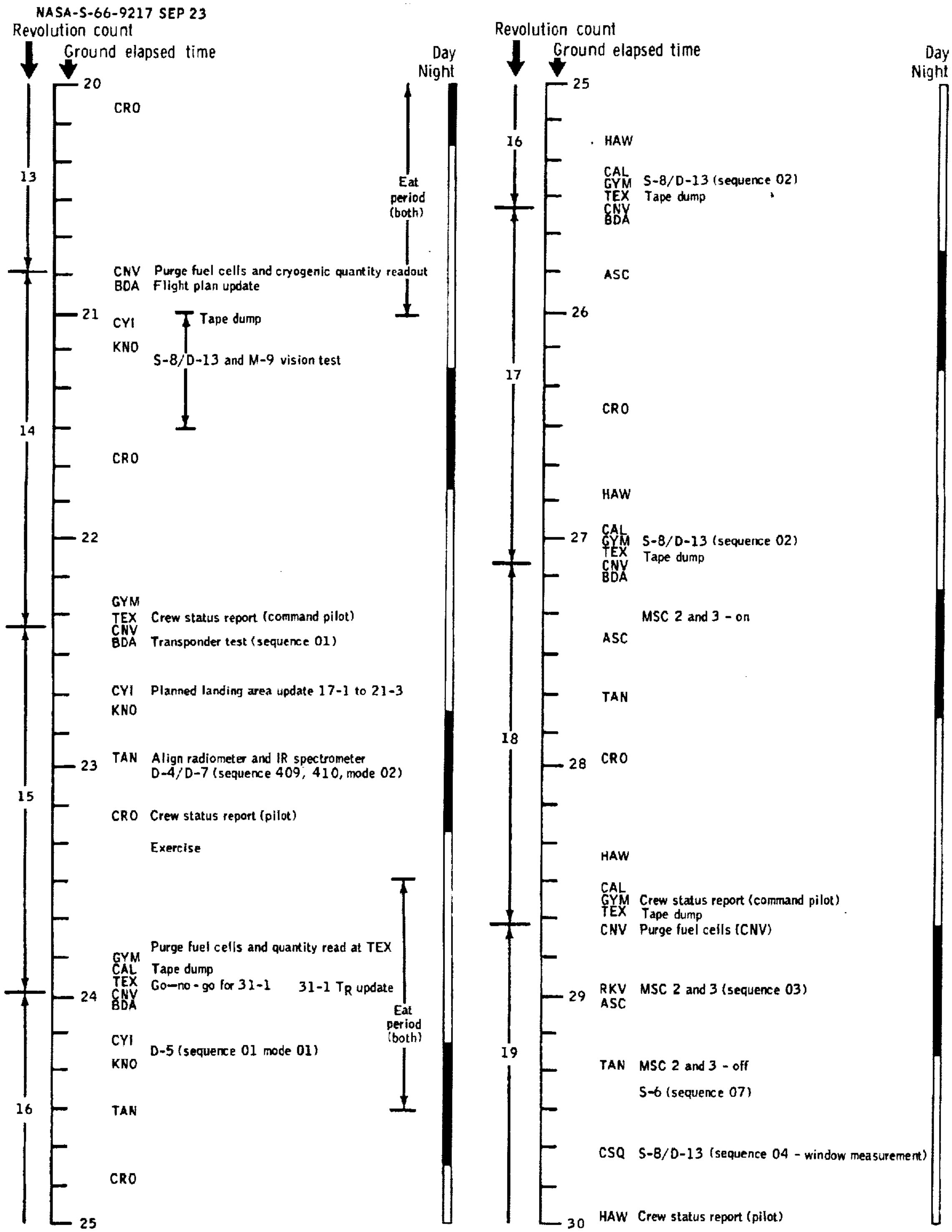


(b) 10 to 20 hours g. e. t.

Figure 7. 1-1.- Continued.



(c) 20 to 30 hours g. e. t.

Figure 7. 1-1.- Continued

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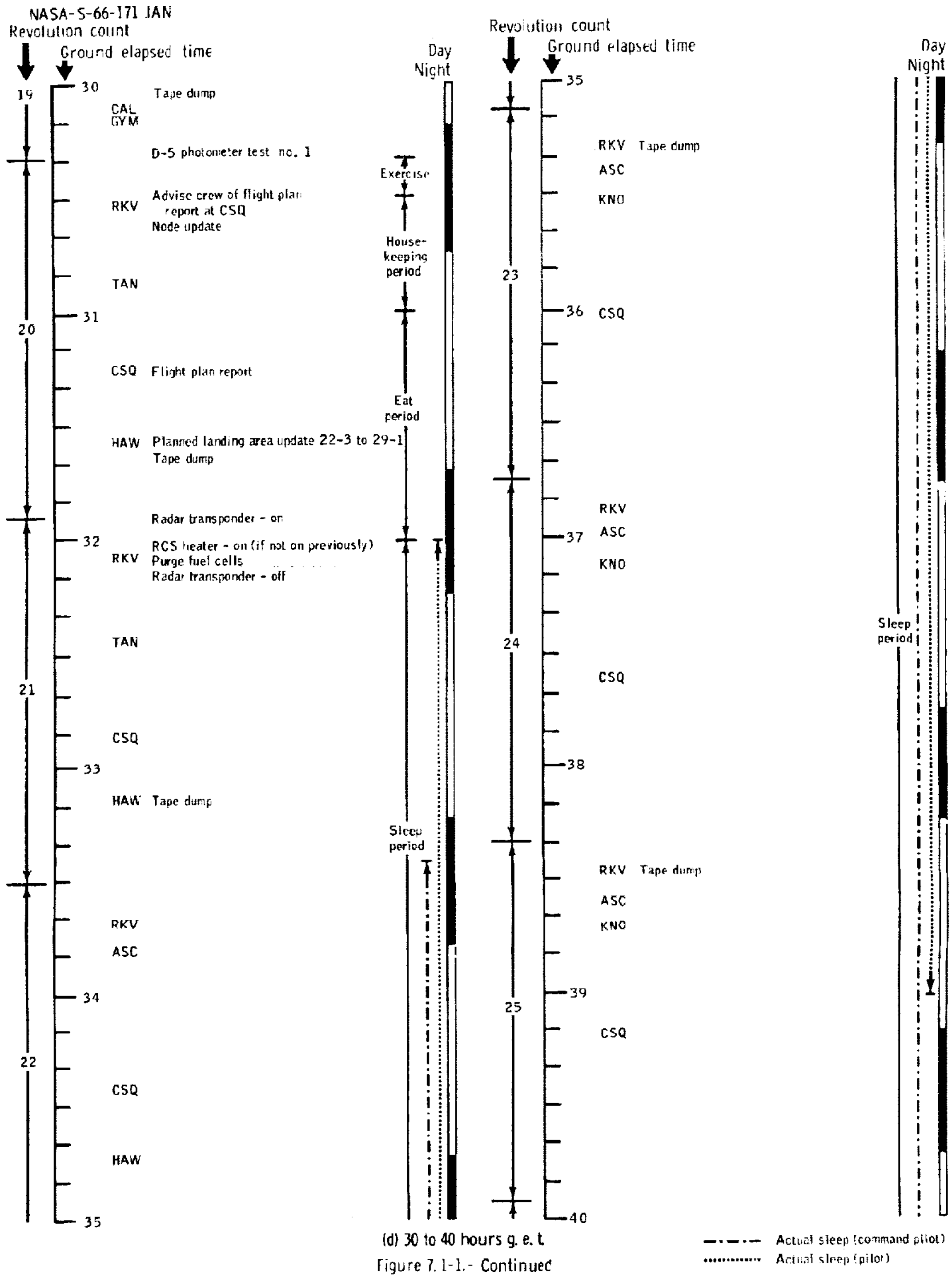
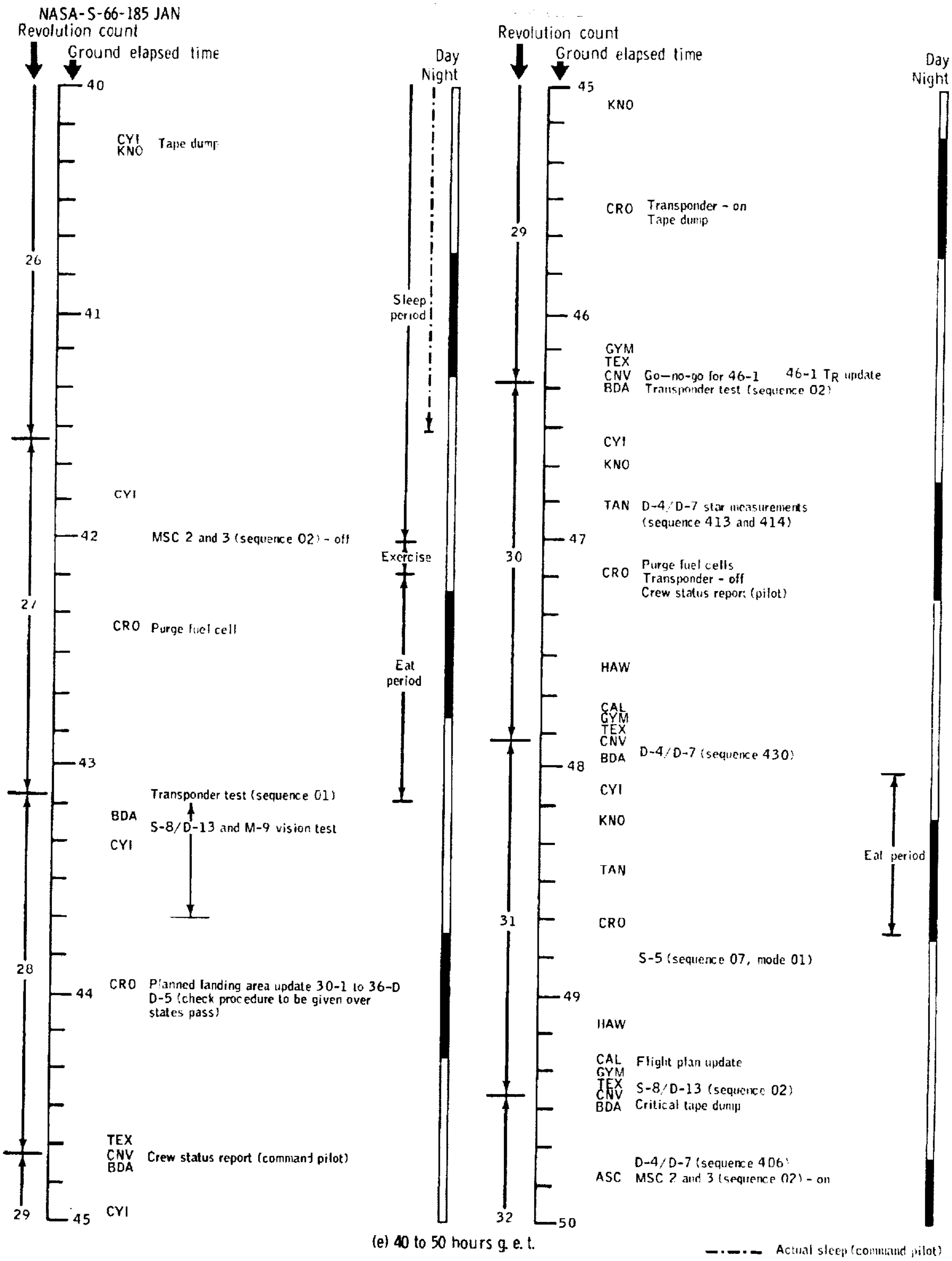


(d) 30 to 40 hours g. e. t.

Figure 7.1-1.- Continued



(e) 40 to 50 hours g. e. t.

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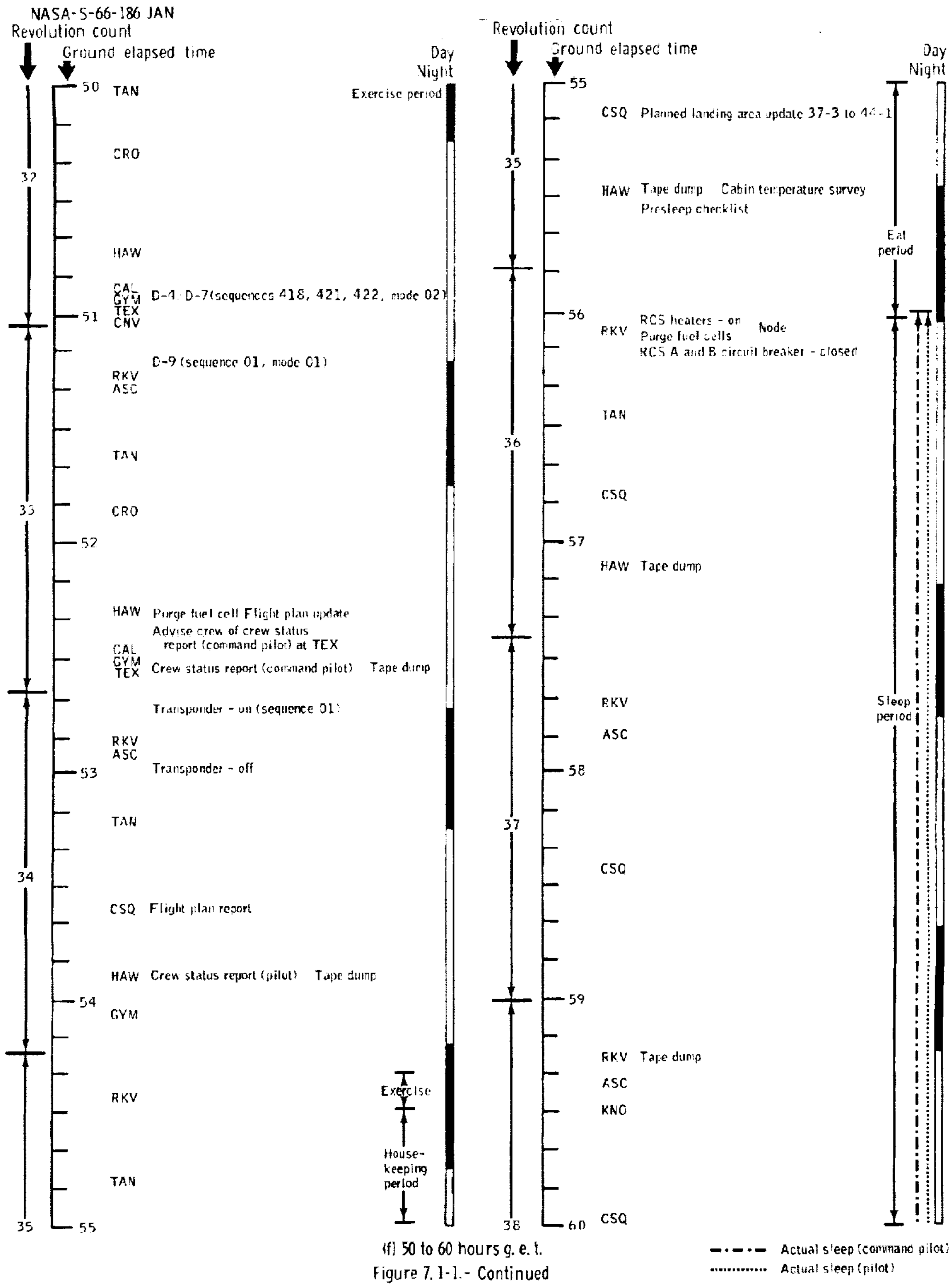

(f) 50 to 60 hours g. e. t.

Figure 7.1-1.- Continued

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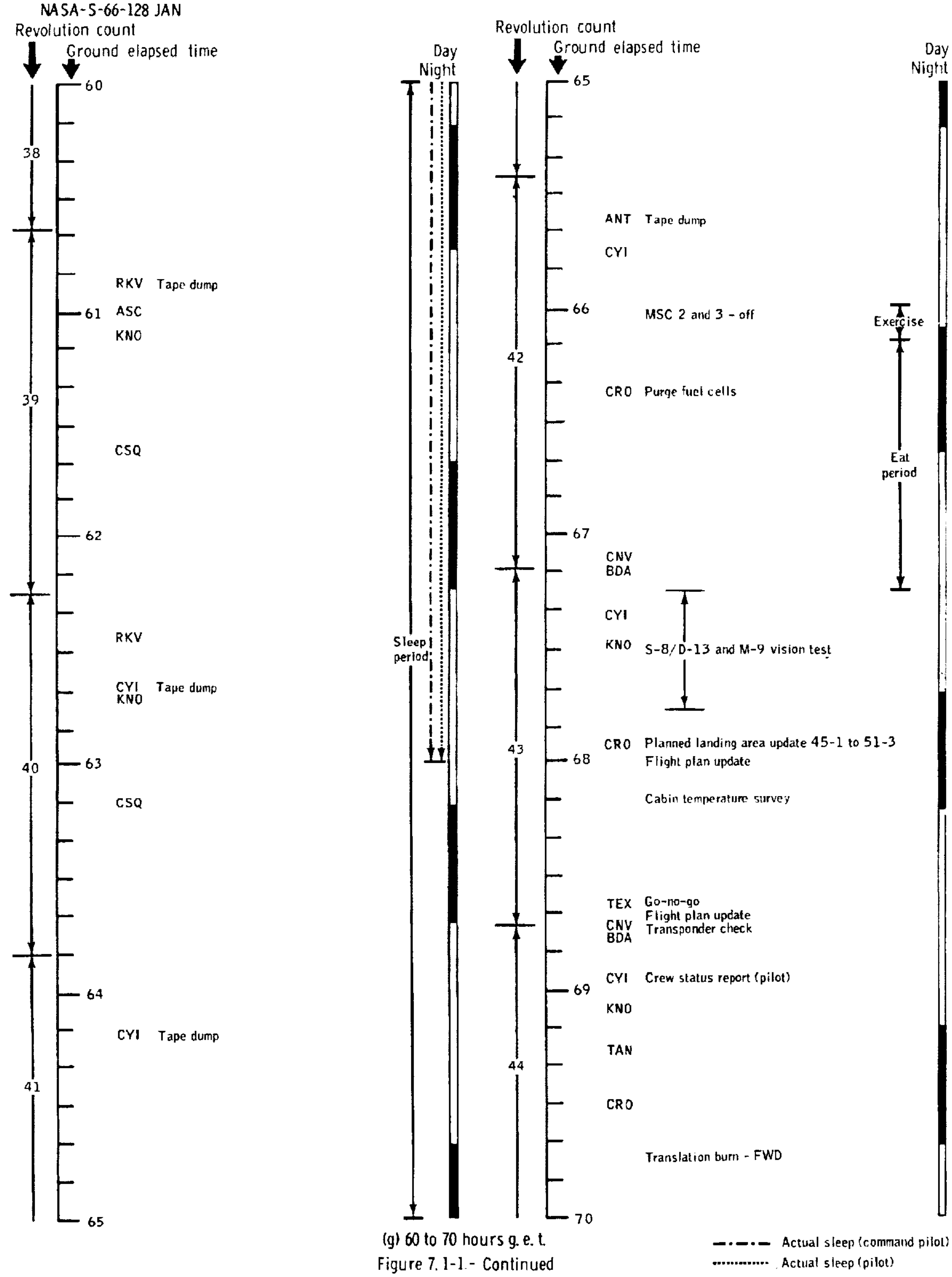
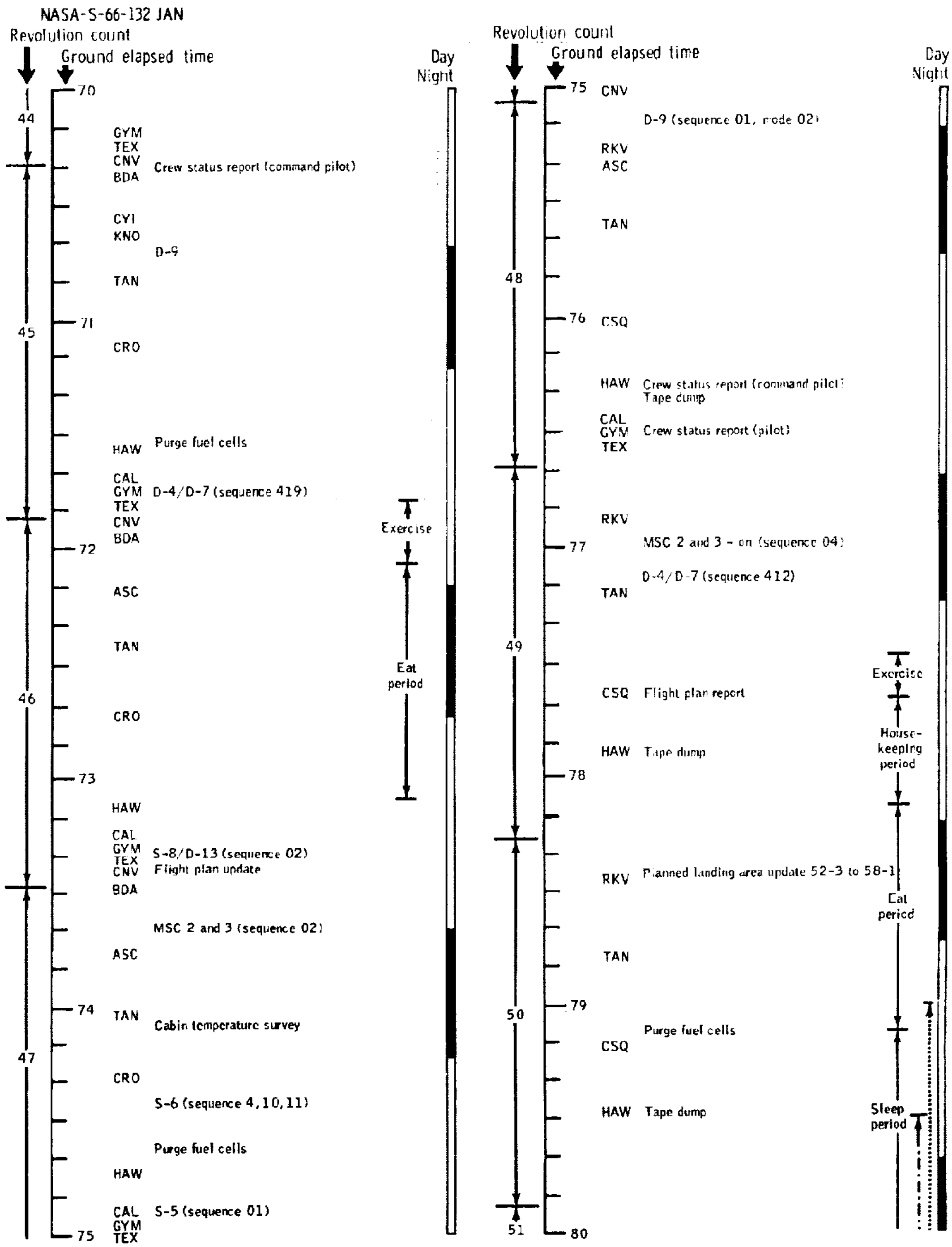


(g) 60 to 70 hours g. e. t.

Figure 7. 1-1.- Continued

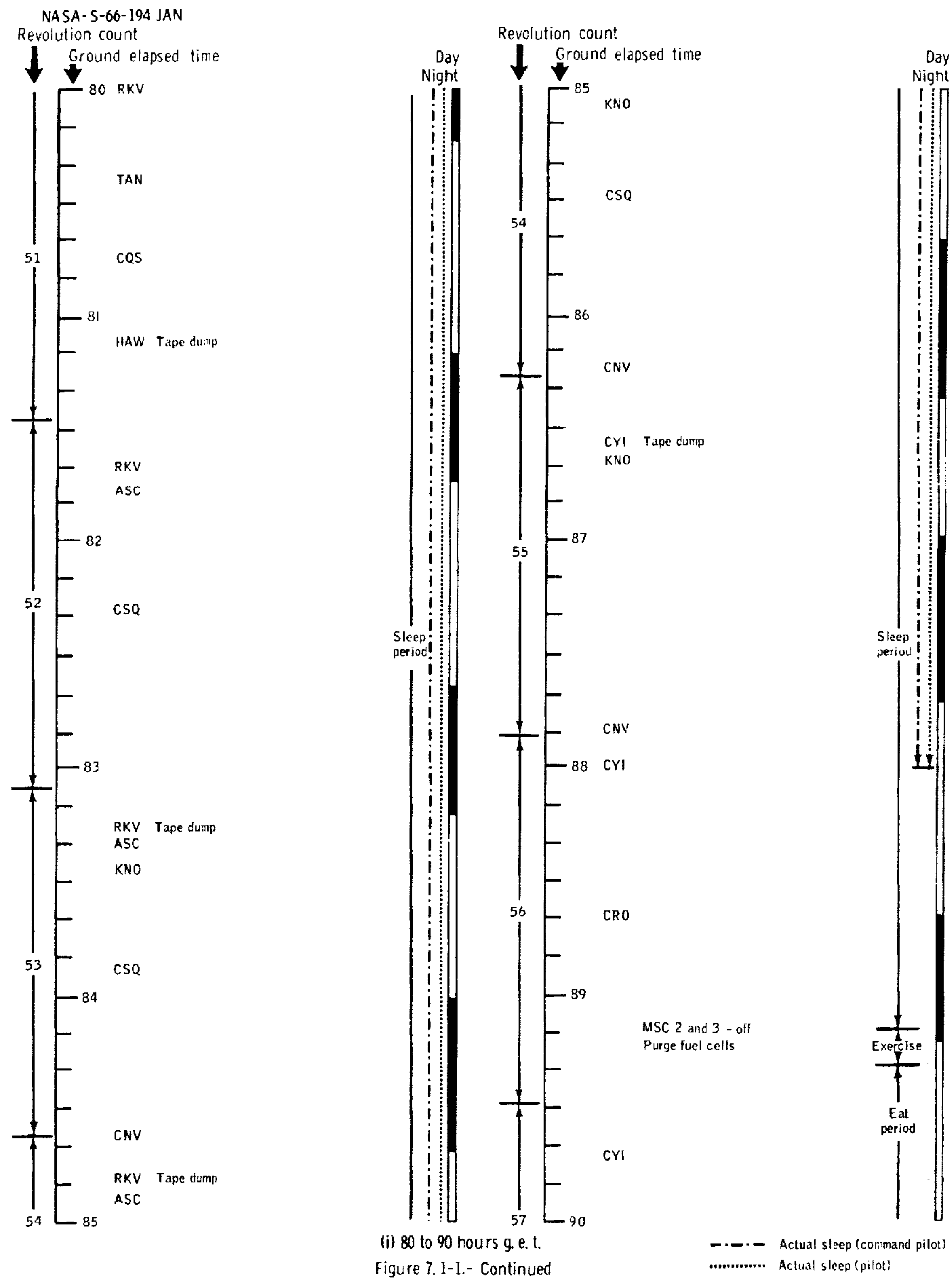


(h) 70 to 80 hours g. e. t.

Figure 7.1-1.- Continued

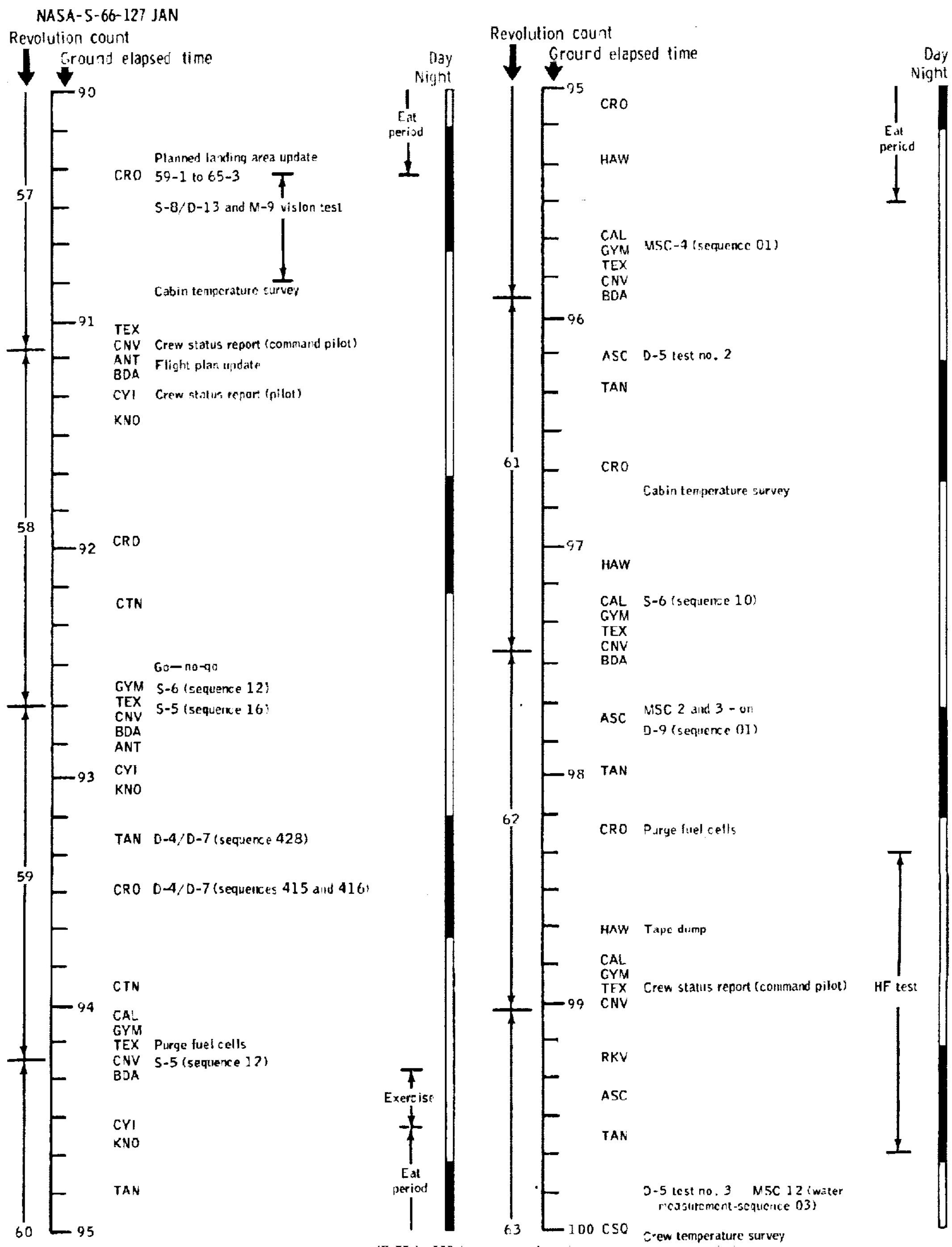
—·—·— Actual sleep (command pilot)

·········· Actual sleep (pilot)



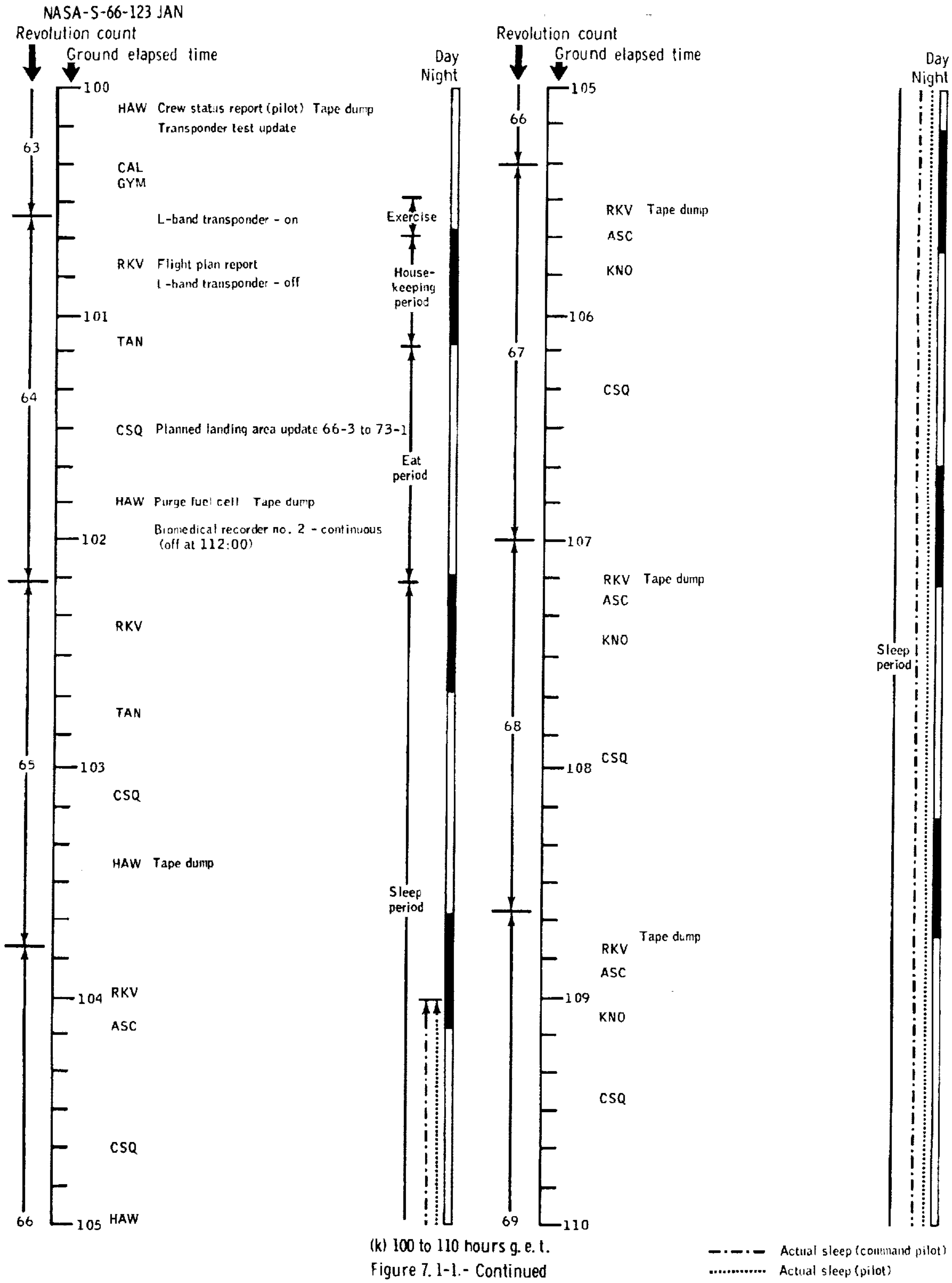
(i) 80 to 90 hours g. e. t.

Figure 7. 1-1.- Continued



(j) 90 to 100 hours g. e. t.

Figure 7.1-1.- Continued



(k) 100 to 110 hours g. e. t.

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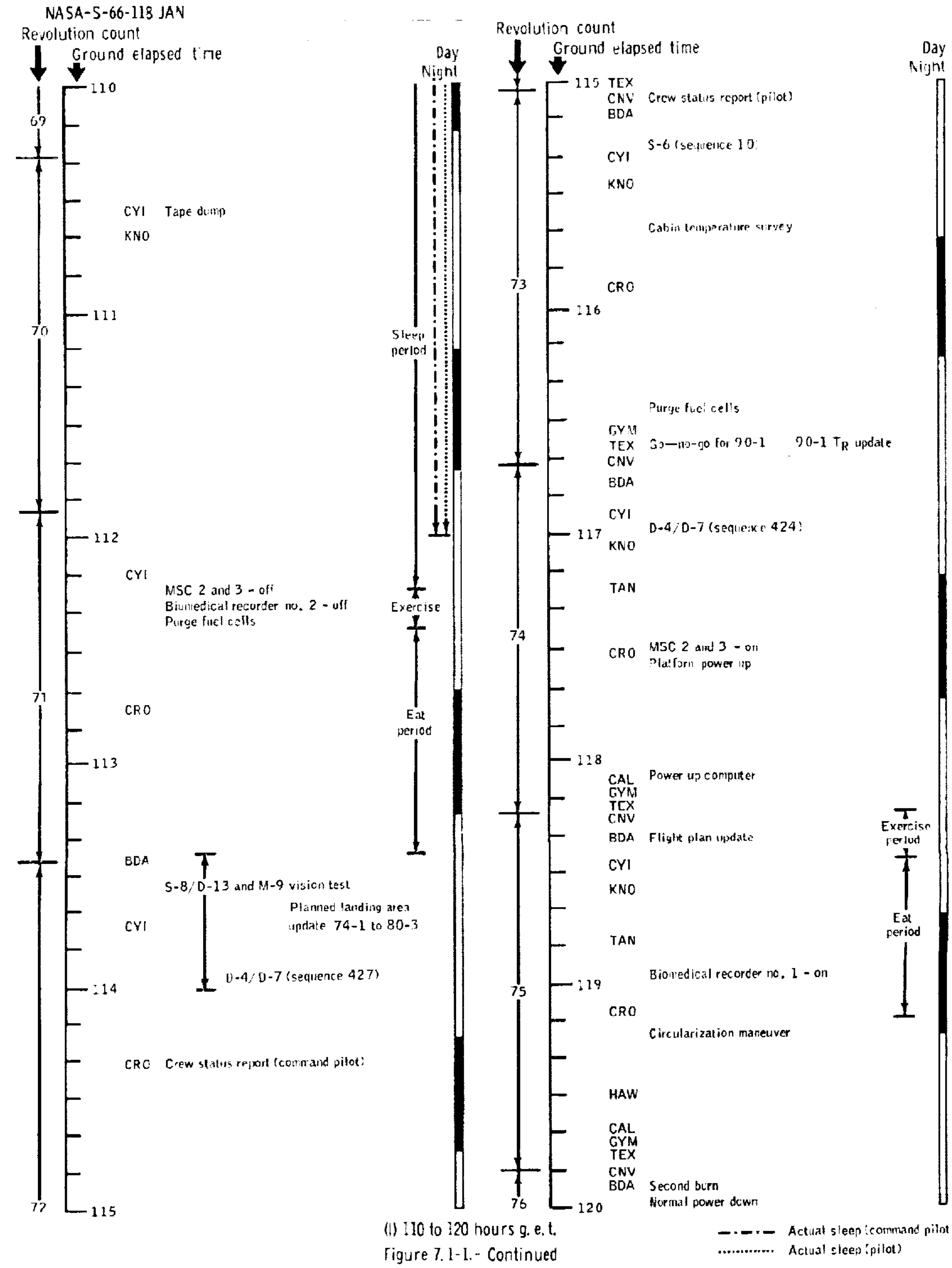

(l) 110 to 120 hours g. e. t.

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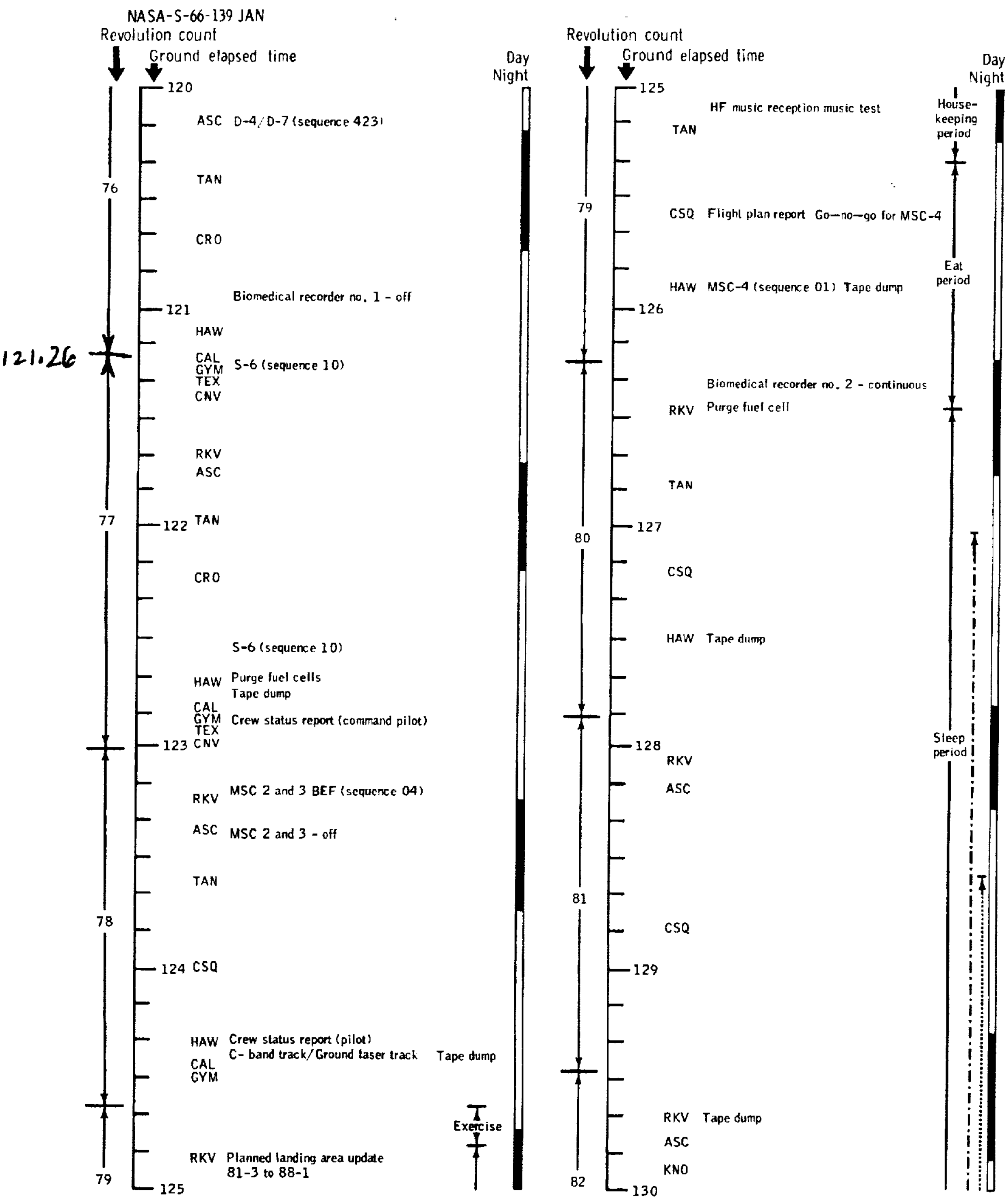

(m) 120 to 130 hours g. e. t.

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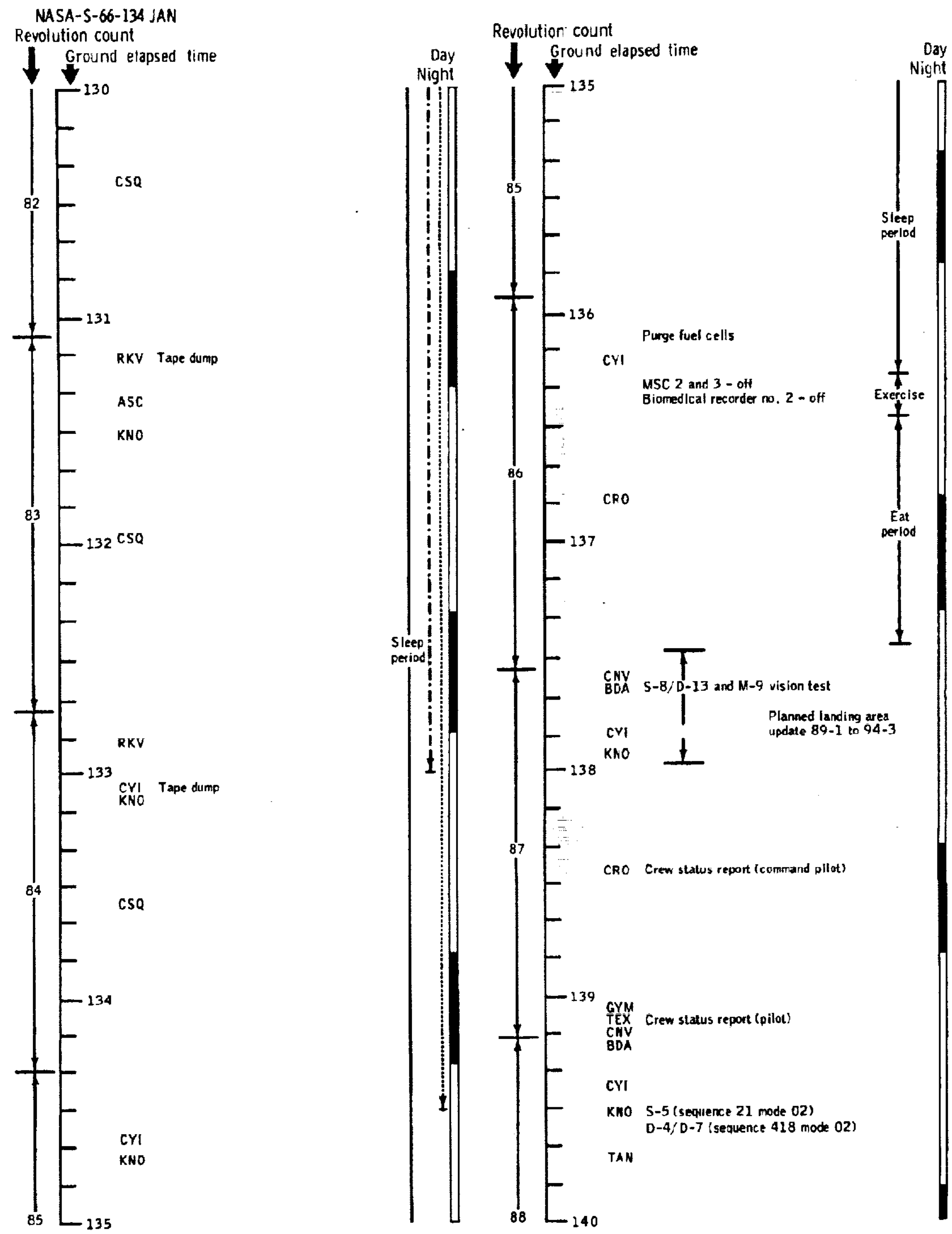
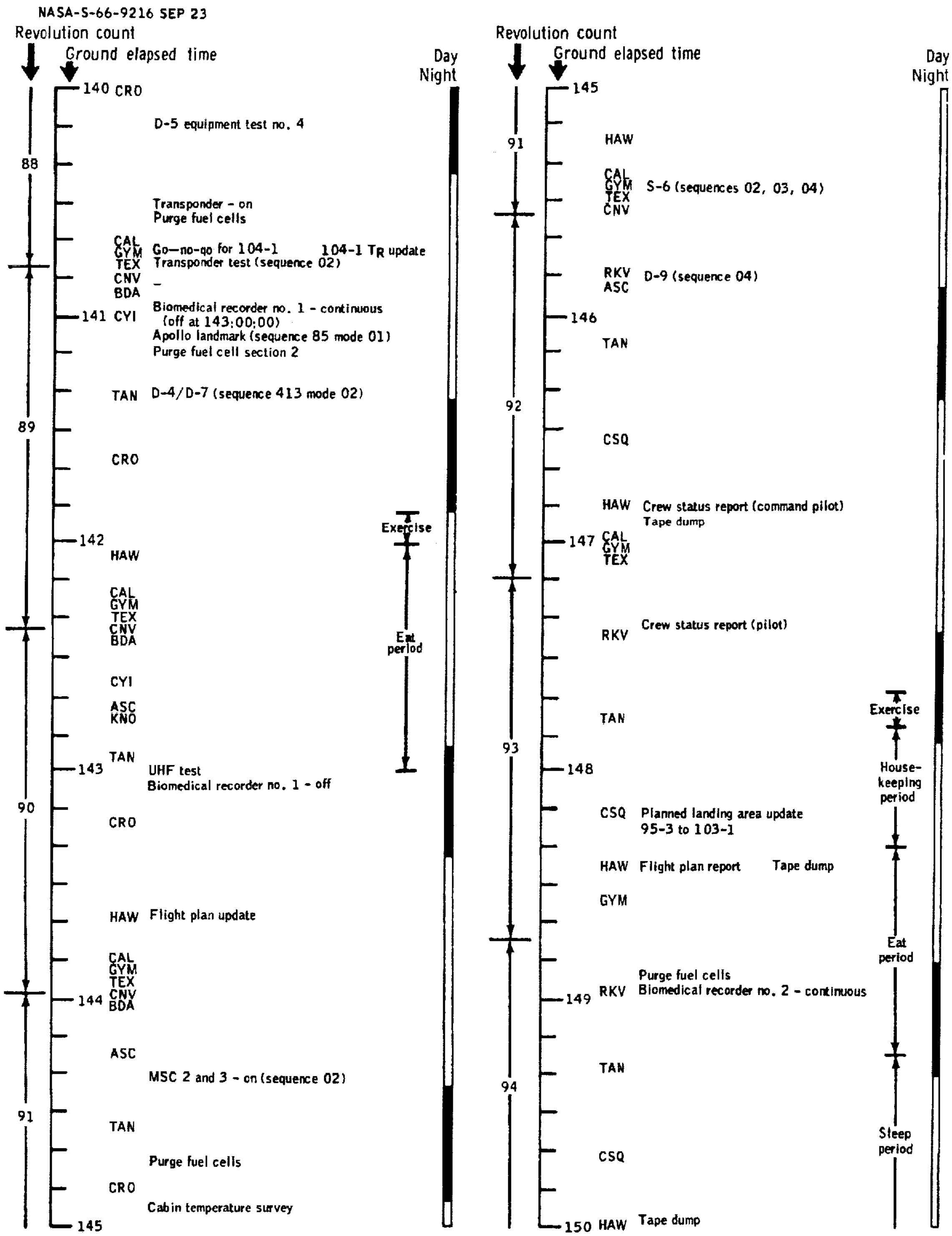


(n) 130 to 140 hours g. e. t.

Figure 7. 1-1.- Continued



(o) 140 to 150 hours g. e. t.

Figure 7. 1-1.- Continued

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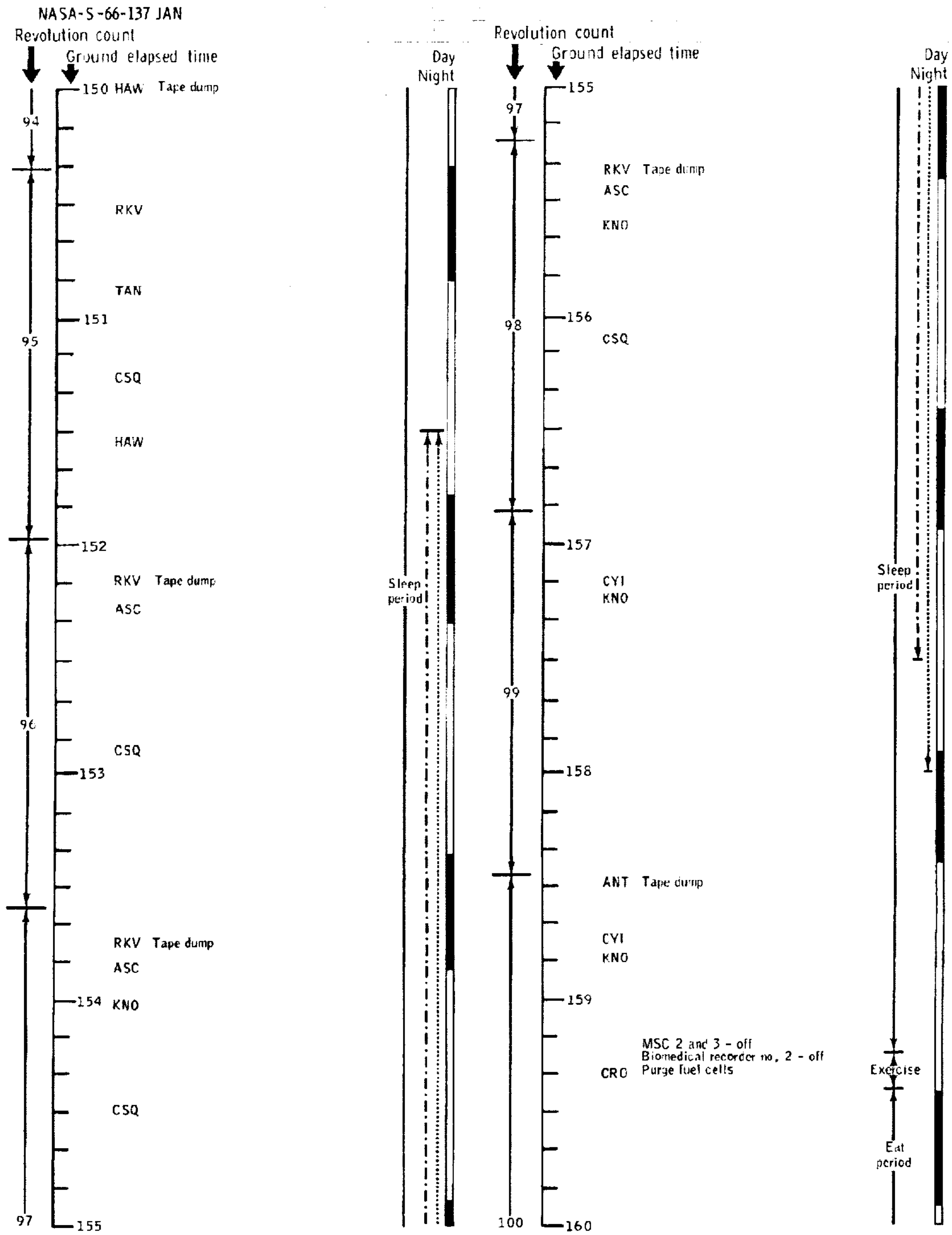

(p) 150 to 160 hours g. e. t.

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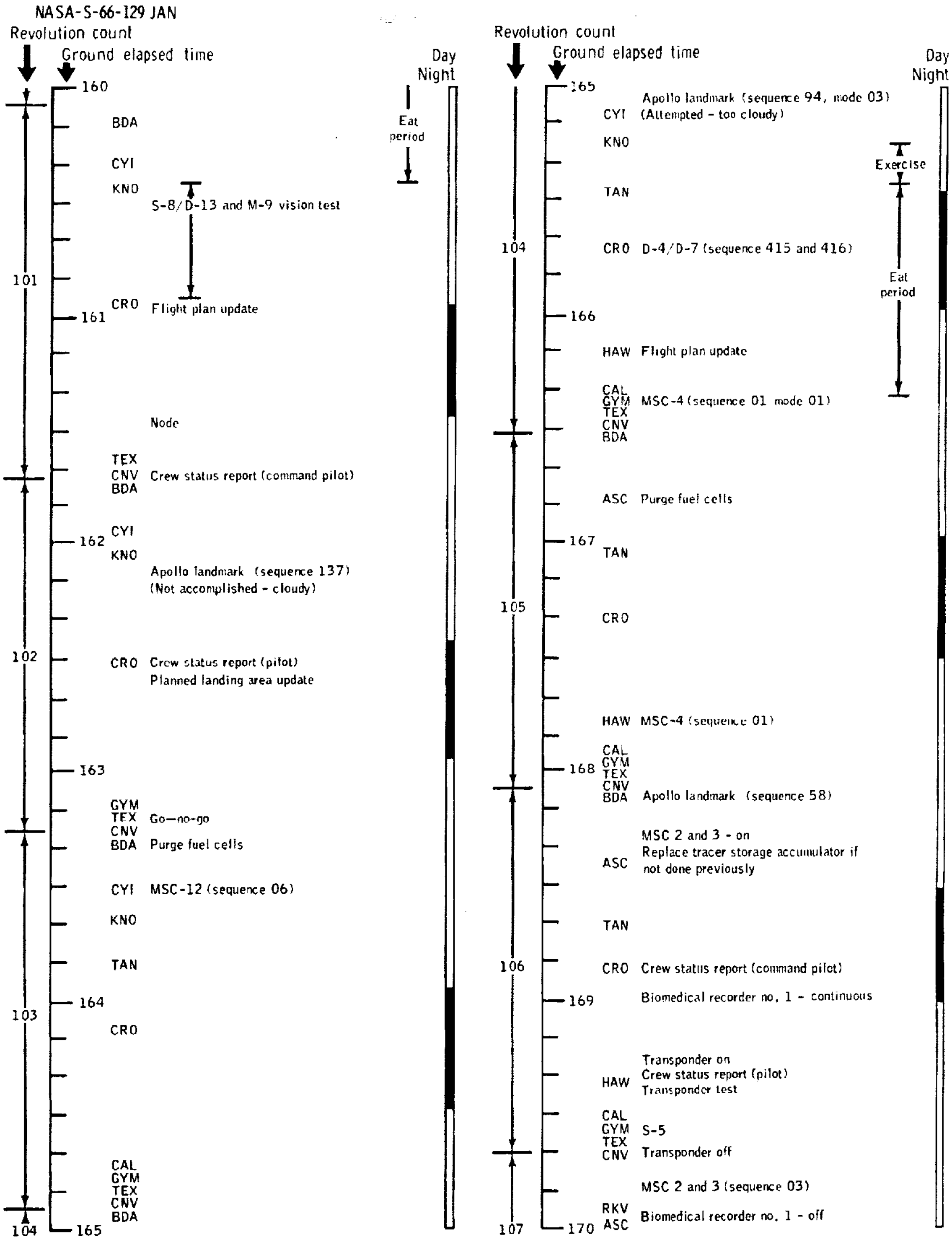

(q) 160 to 170 hours g. e. t.

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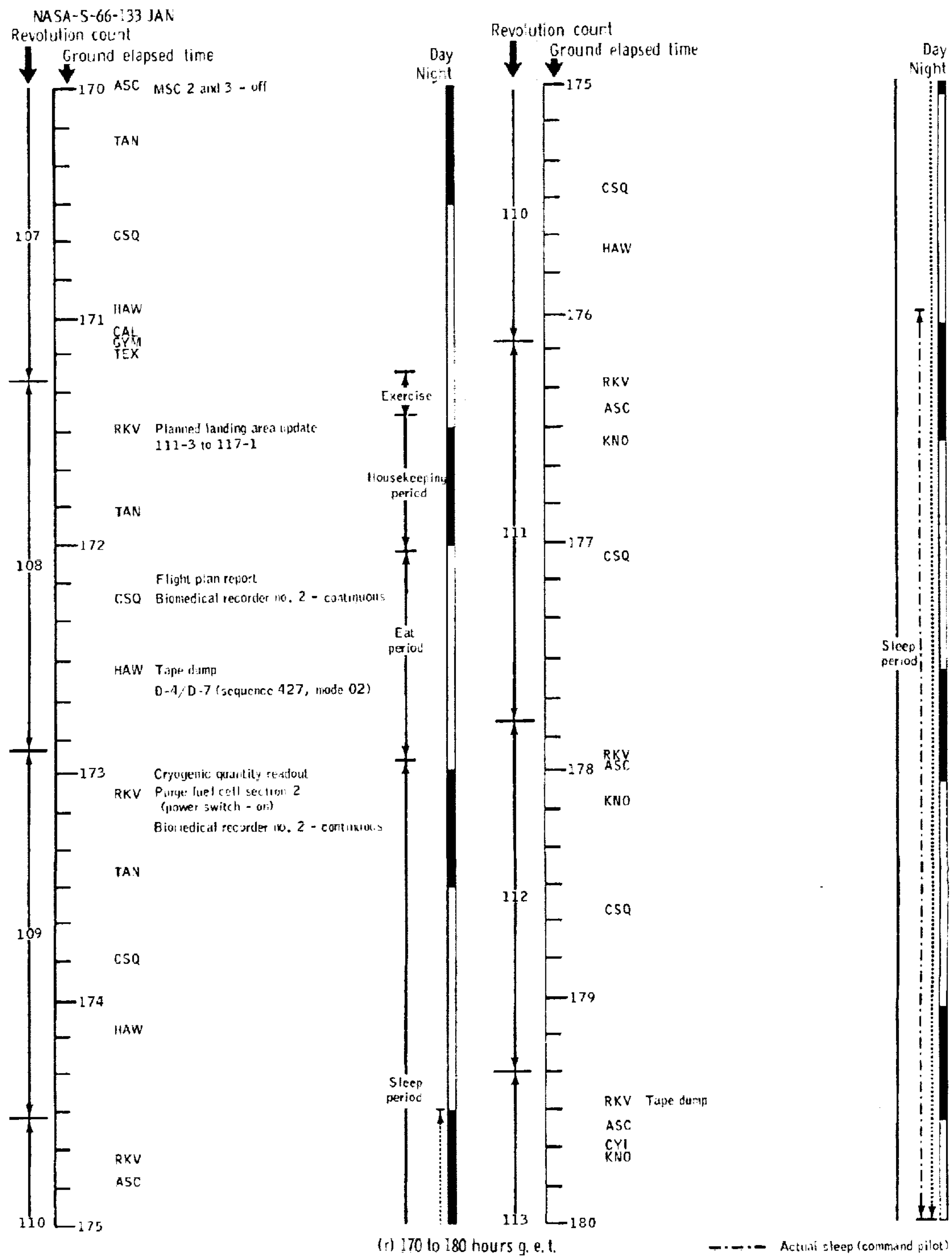

(r) 170 to 180 hours g. e. t.

Figure 7. 1-1.- Continued

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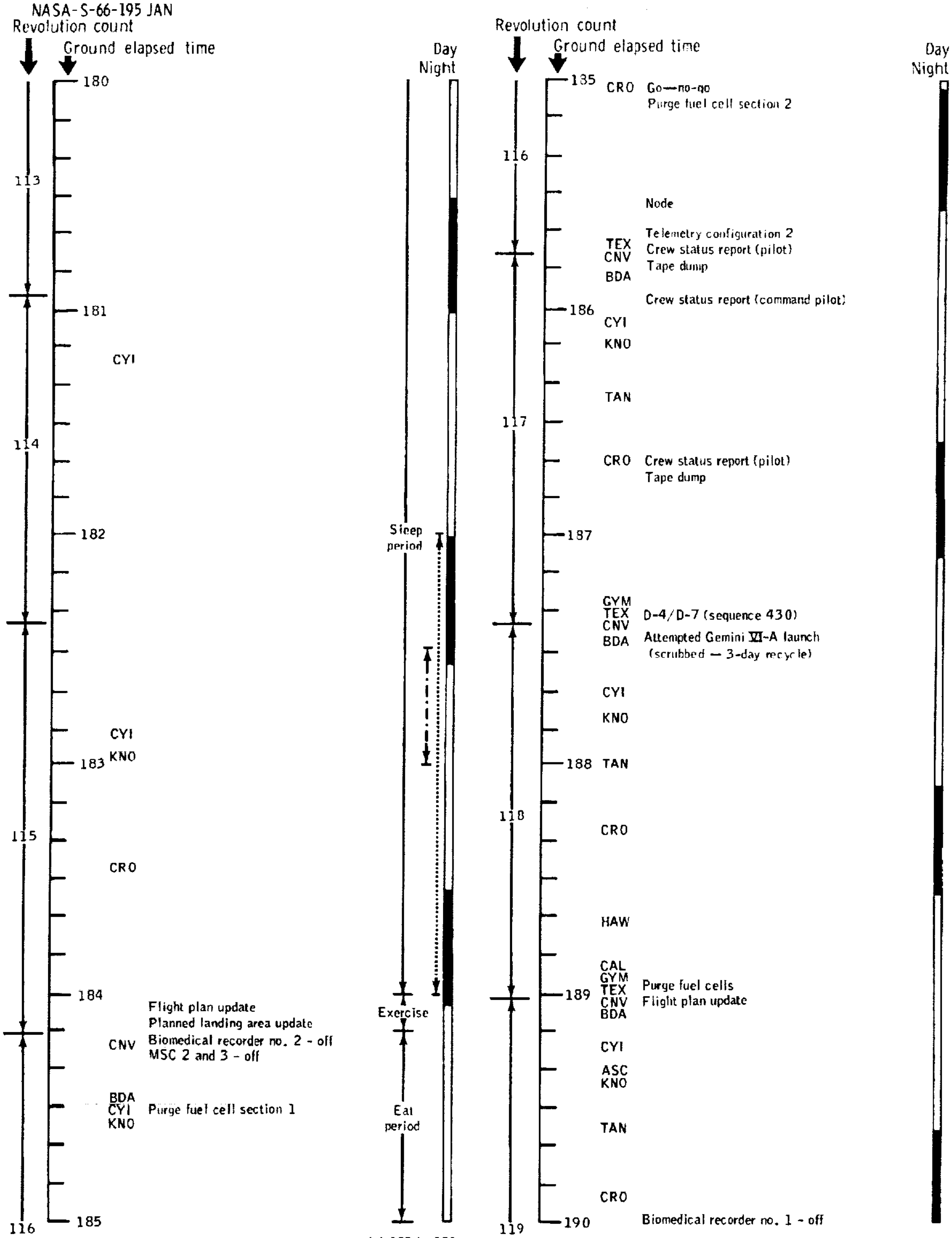

(s) 180 to 190 hours g. e. t.

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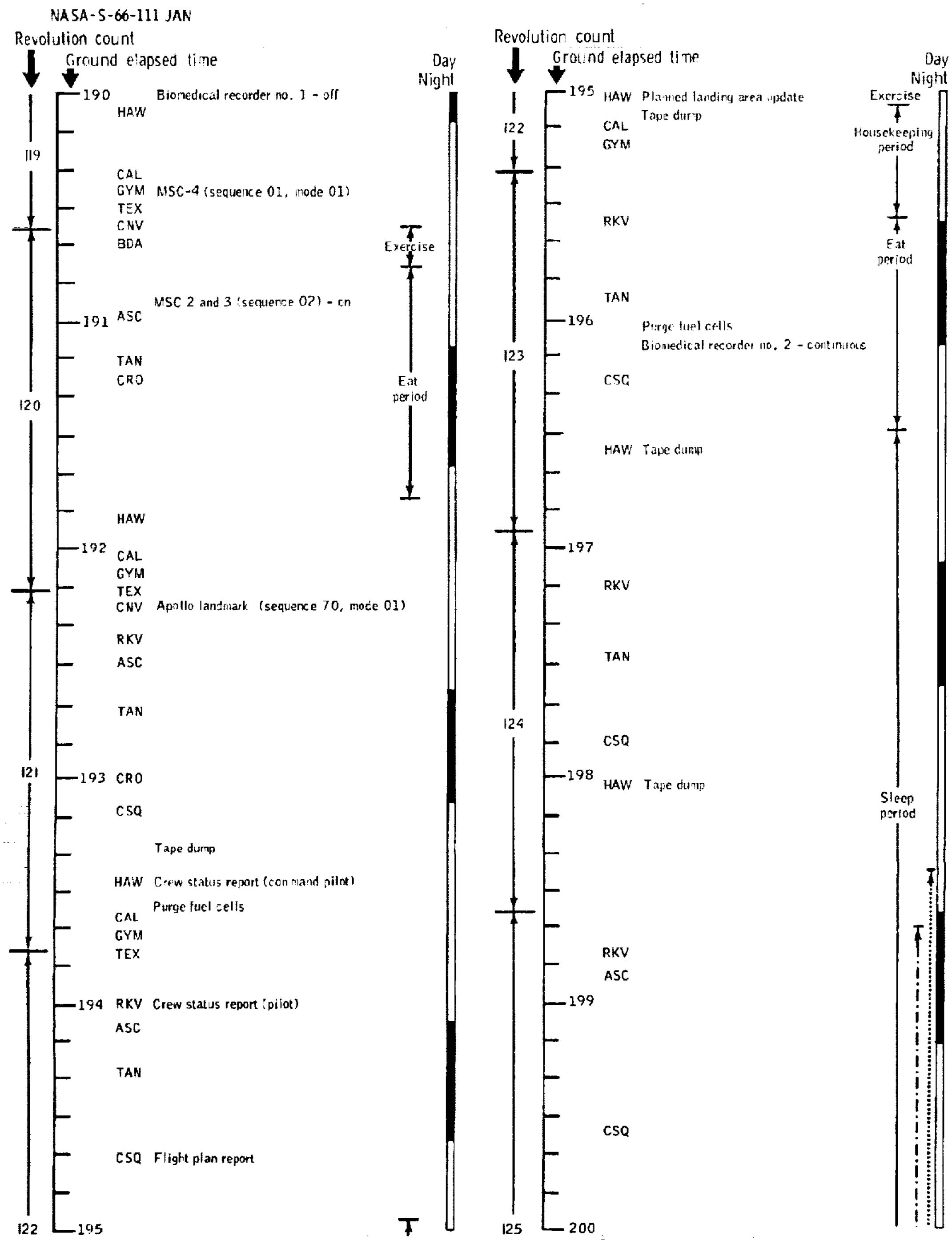

(t) 190 to 200 hours g. e. t.
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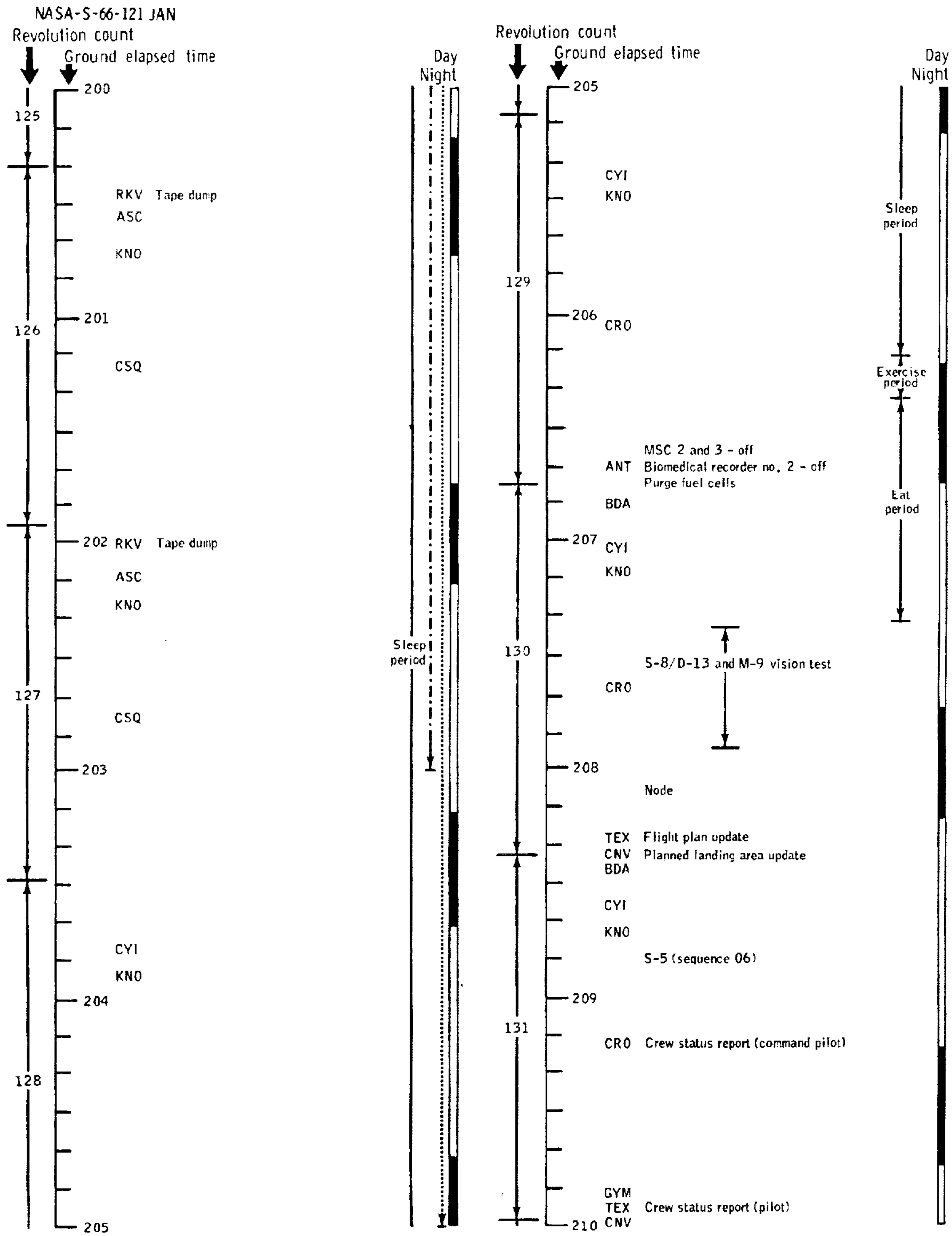

(u) 200 to 210 hours g. e. t.
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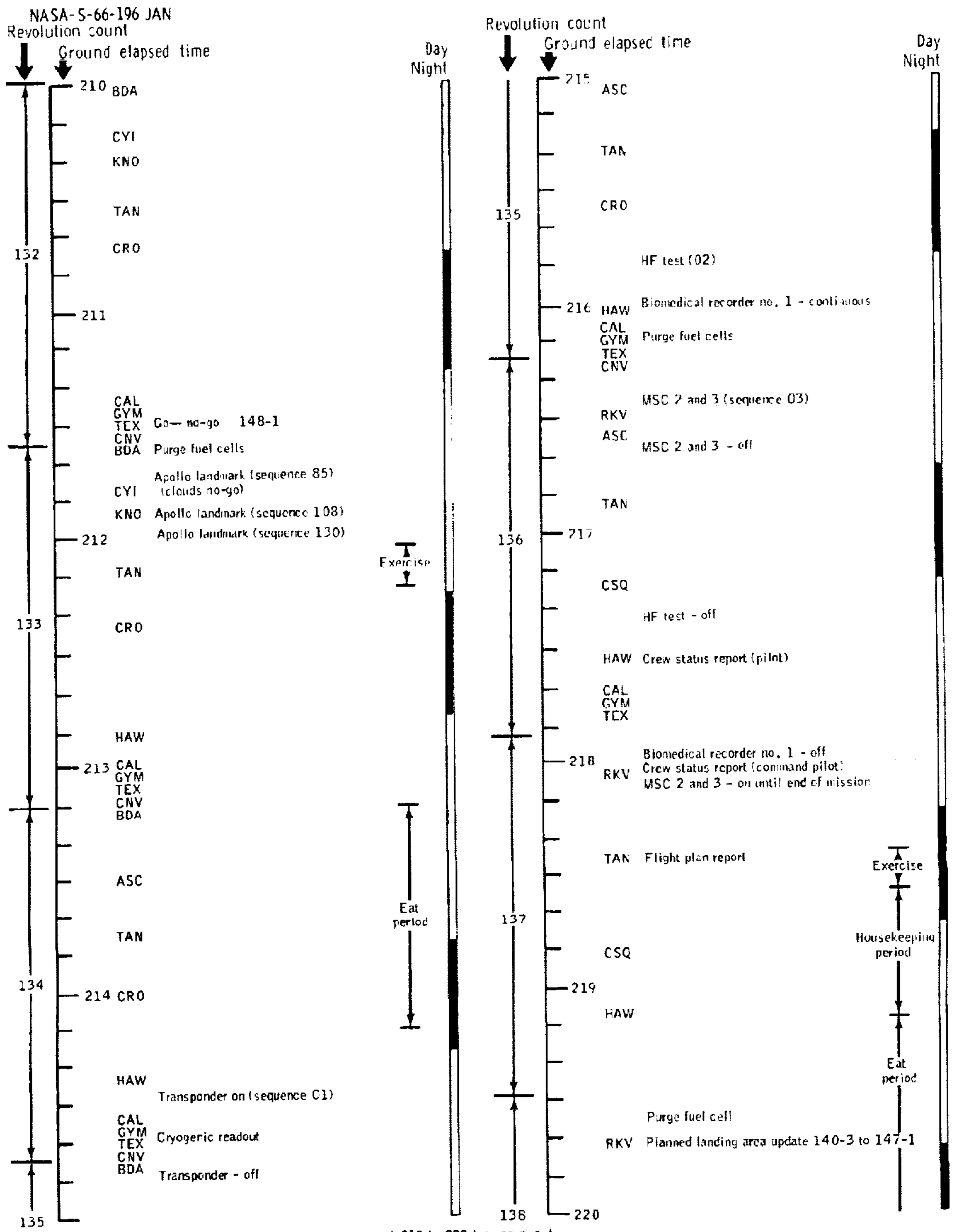

(v) 210 to 220 hours g. e. t.

Figure 7.1-1.- Continued

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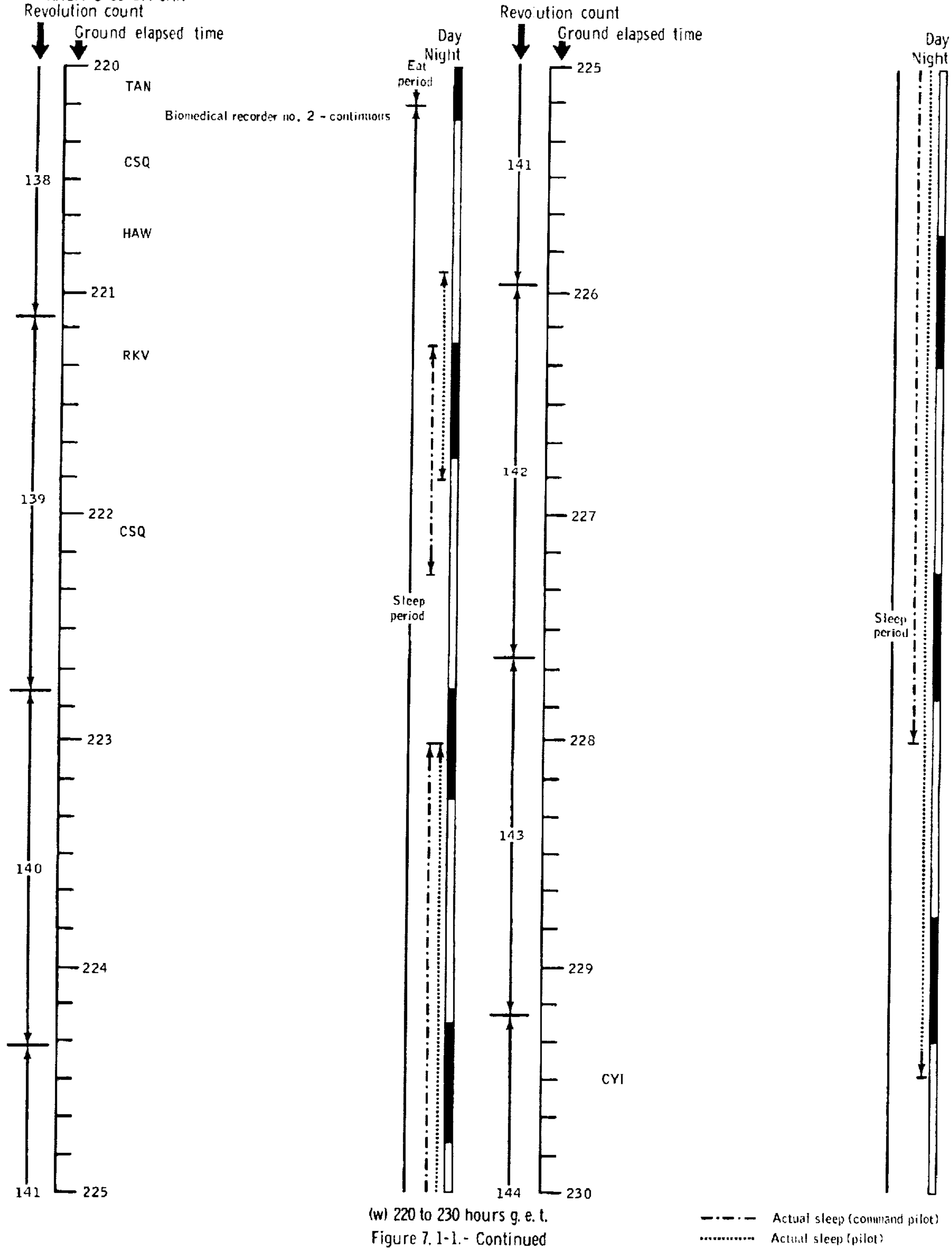

(w) 220 to 230 hours g. e. t.

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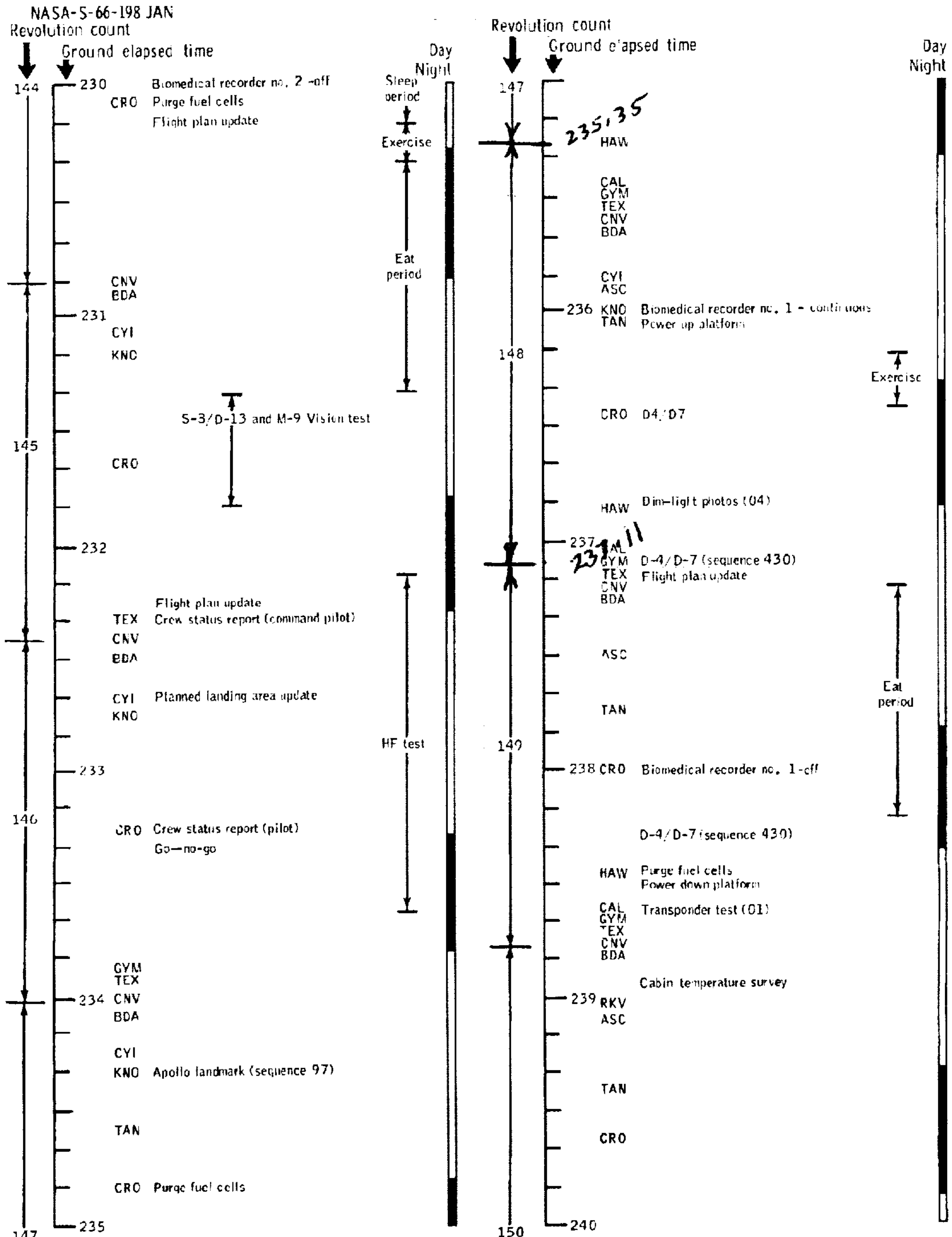

(x) 230 to 240 hours g. e. t.
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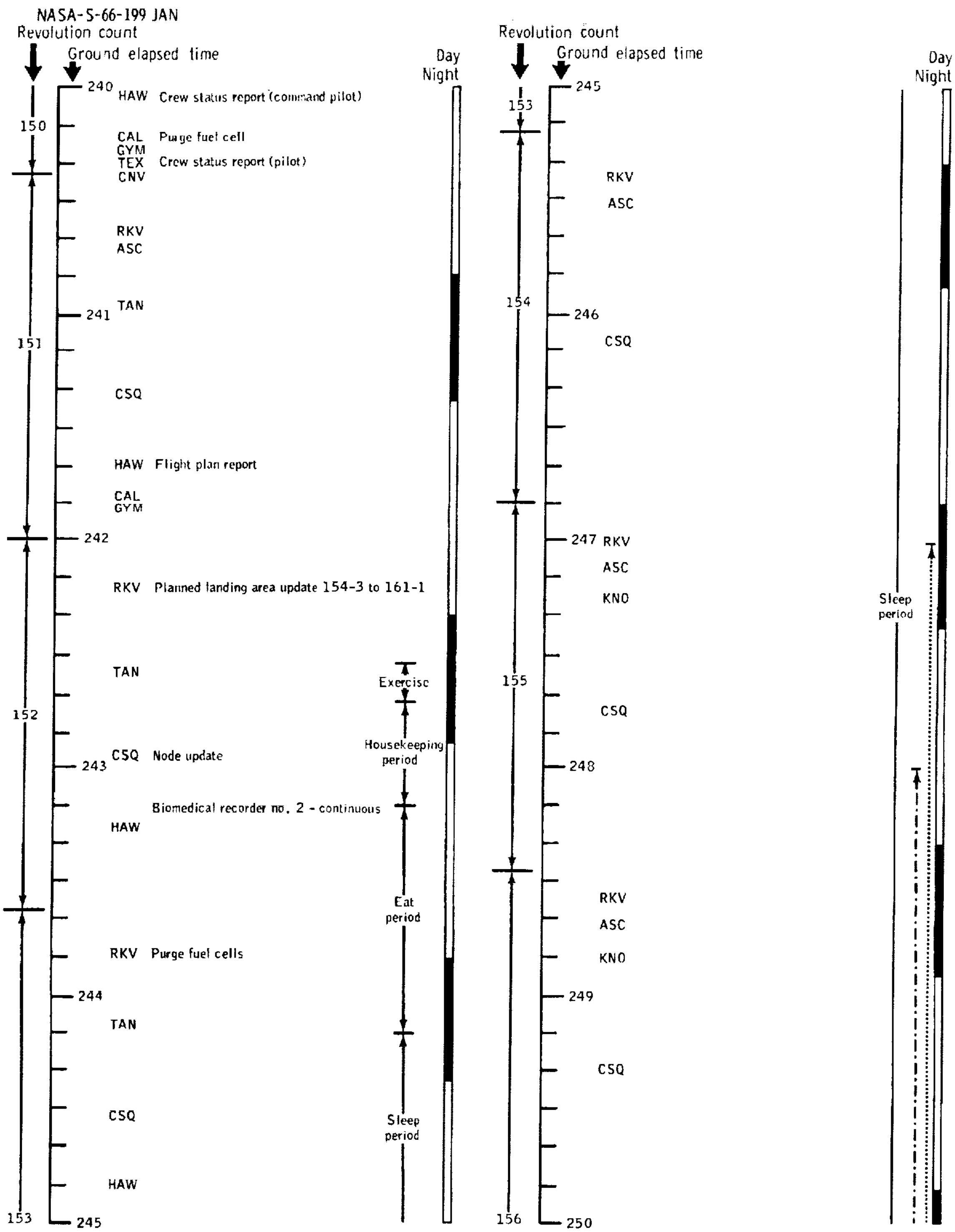

(y) 240 to 250 hours g. e. t.

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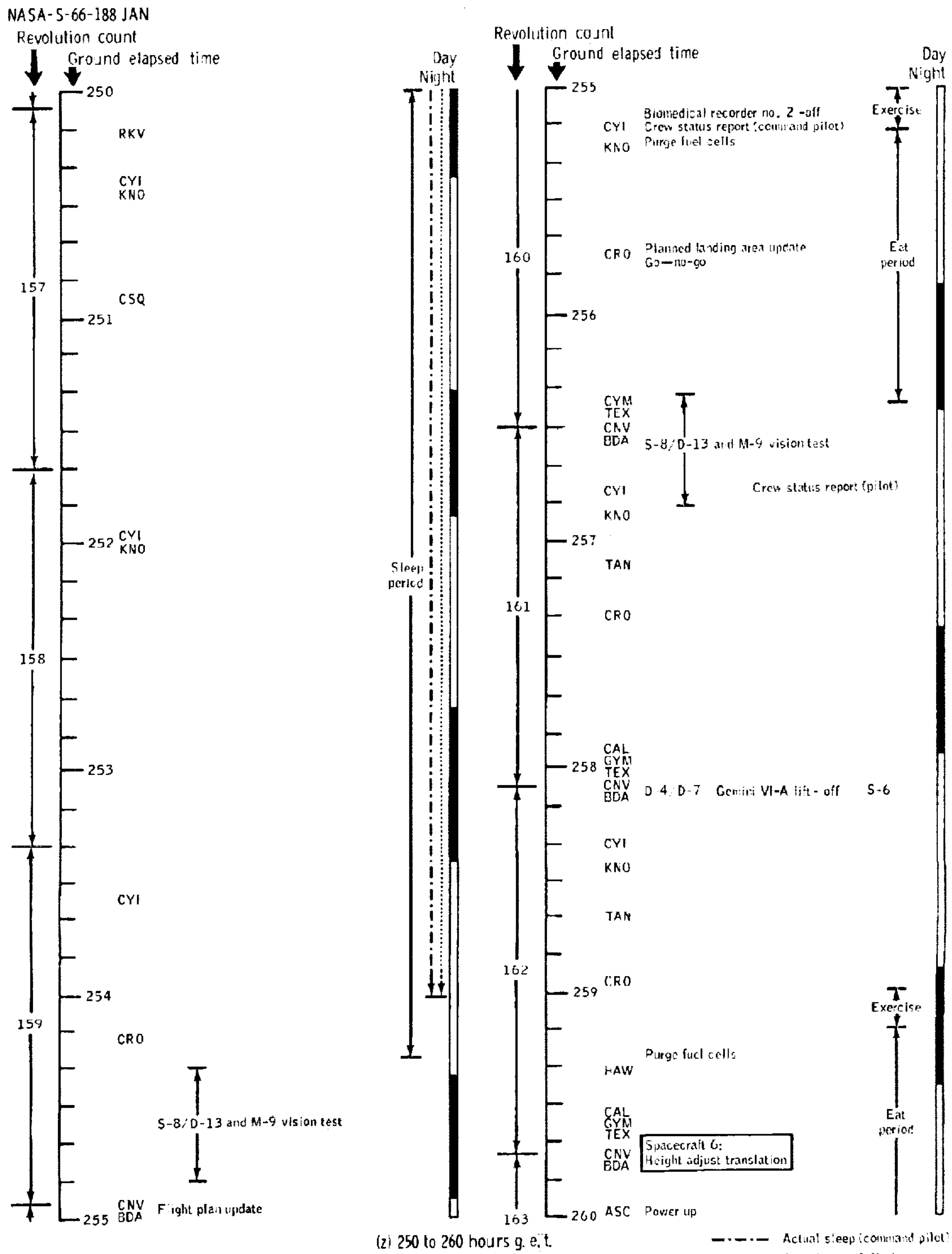

(z) 250 to 260 hours g.e.t.

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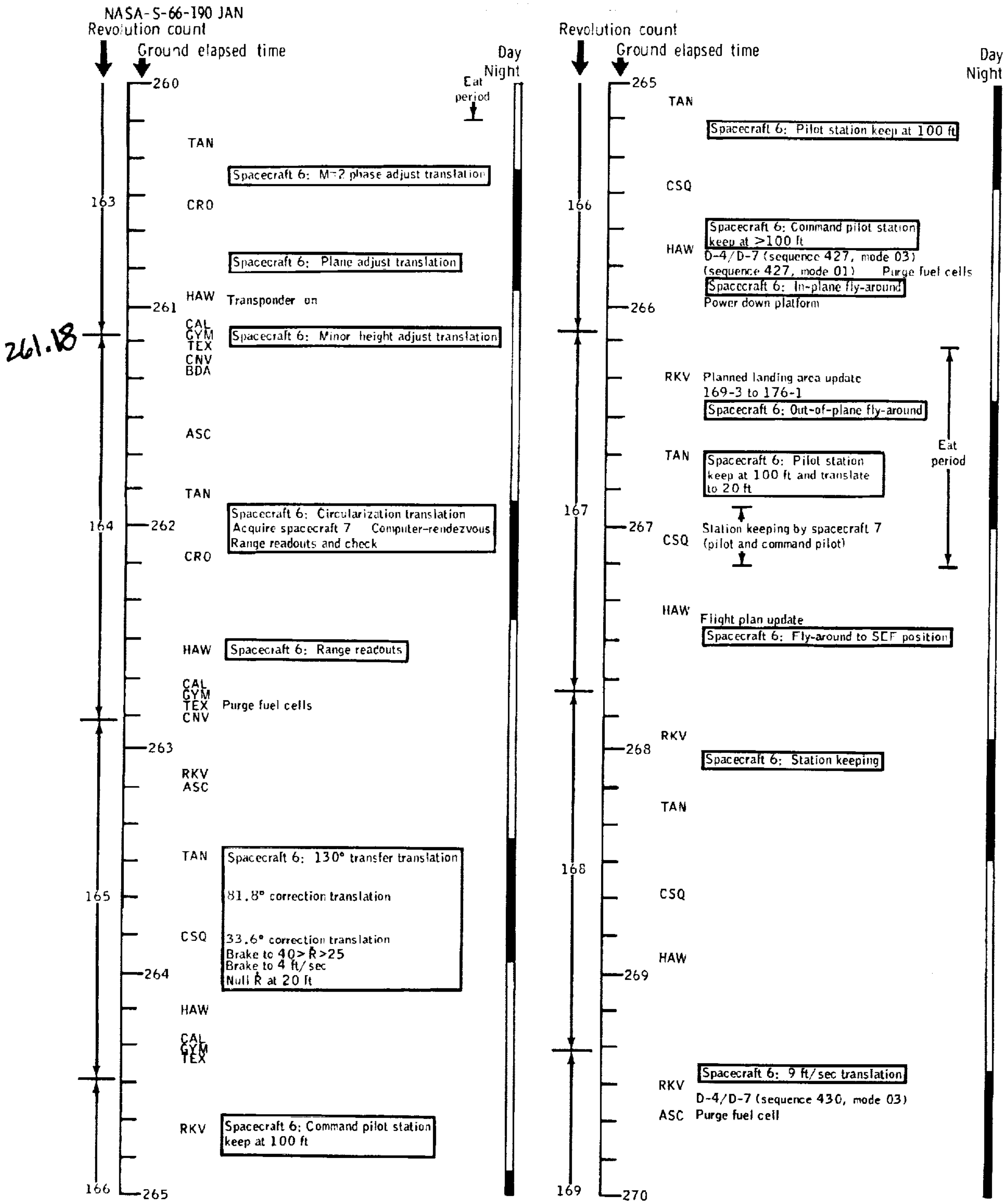

(aa) 260 to 270 hours g. e. t.

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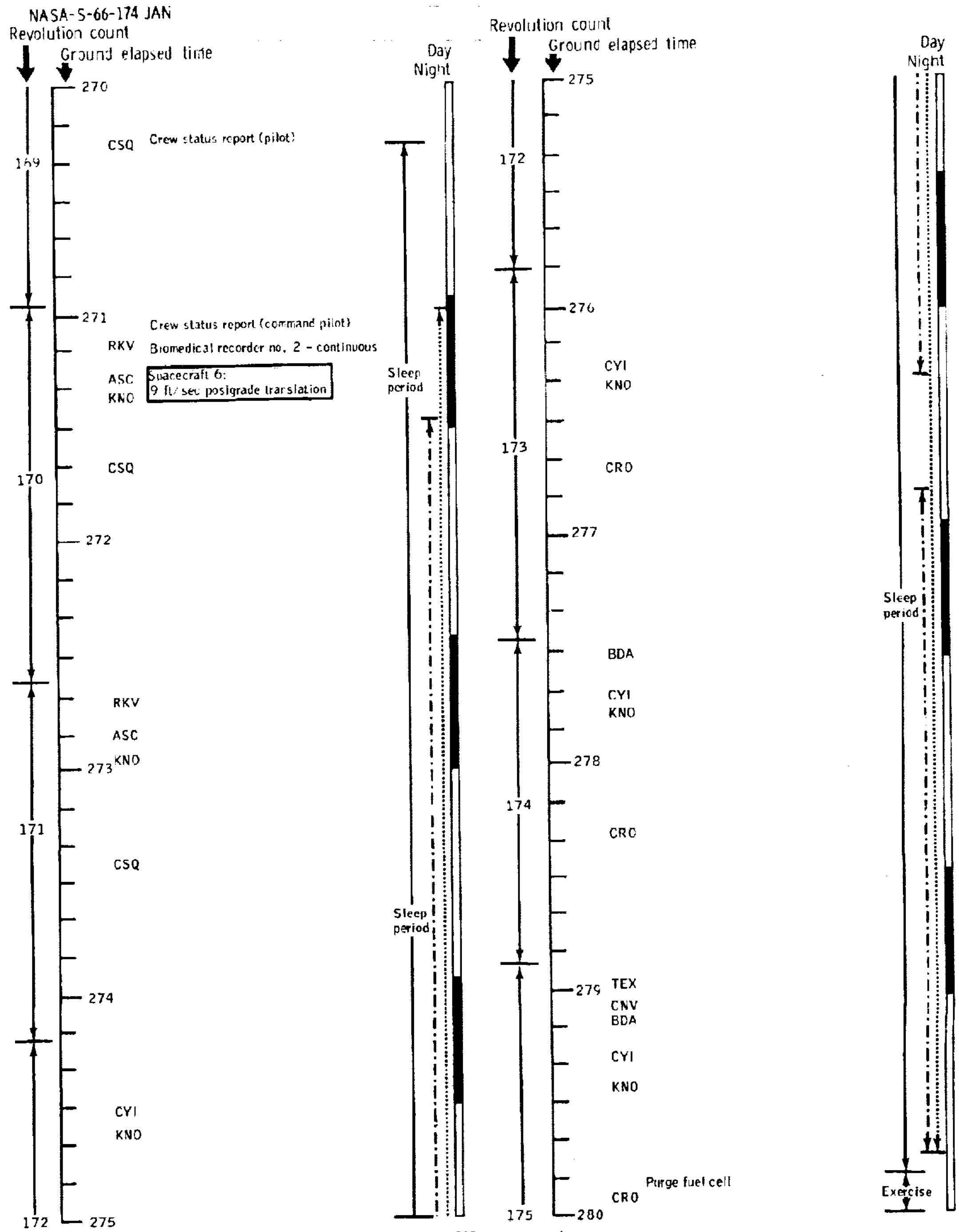

(bb) 270 to 280 hours g. e. t.

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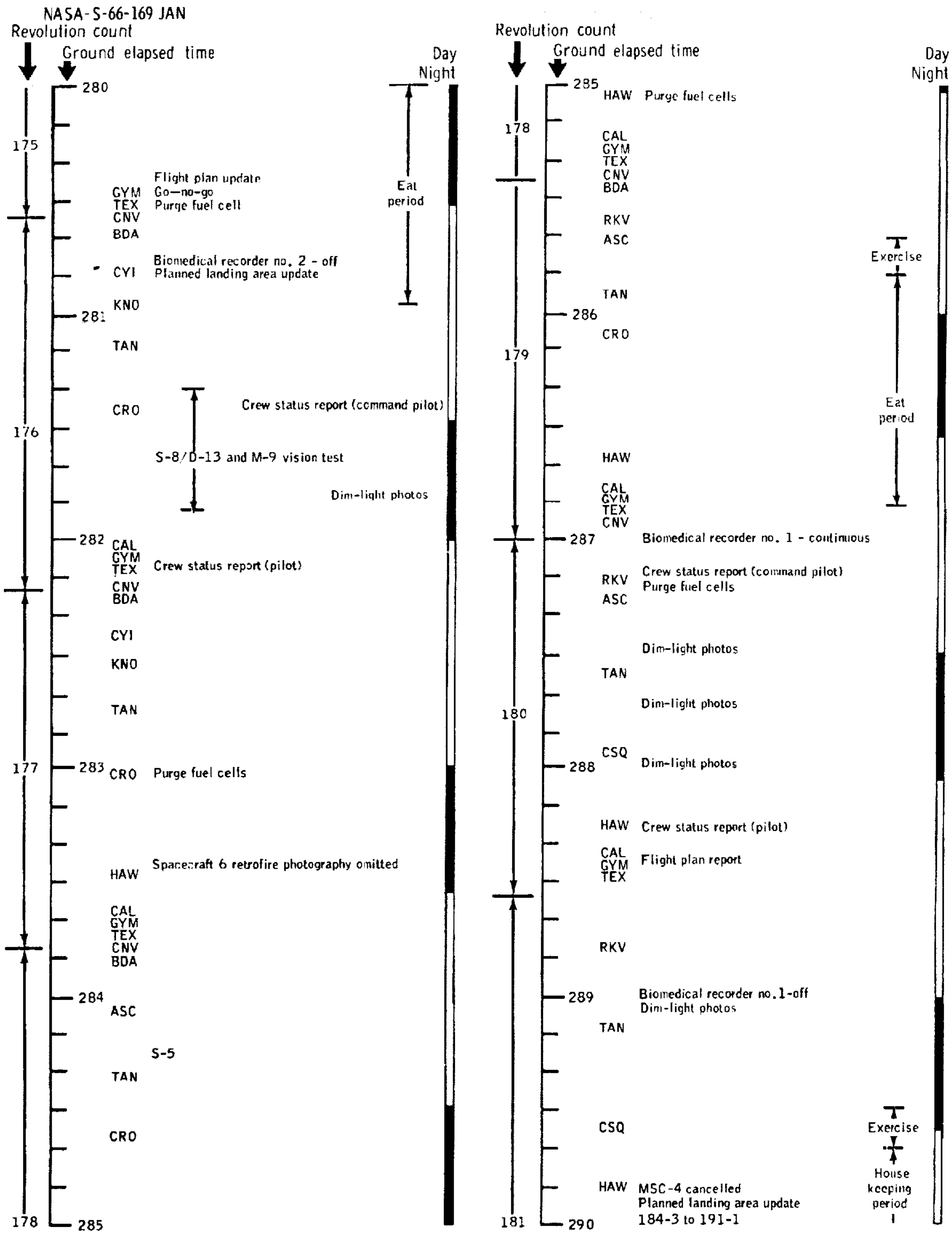

(cc) 280 to 290 hours g. e. t.

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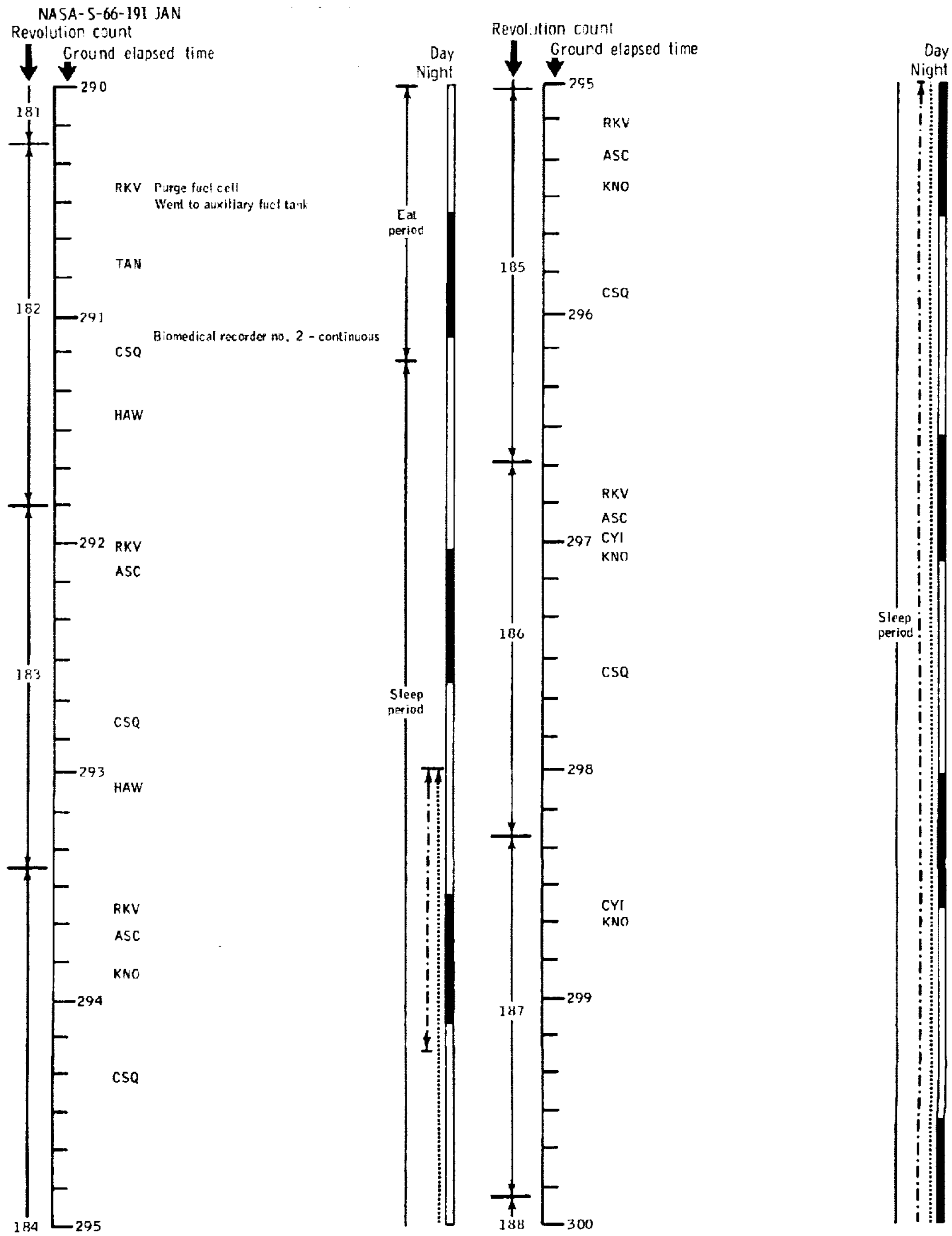

(dd) 290 to 300 hours g.e.t.

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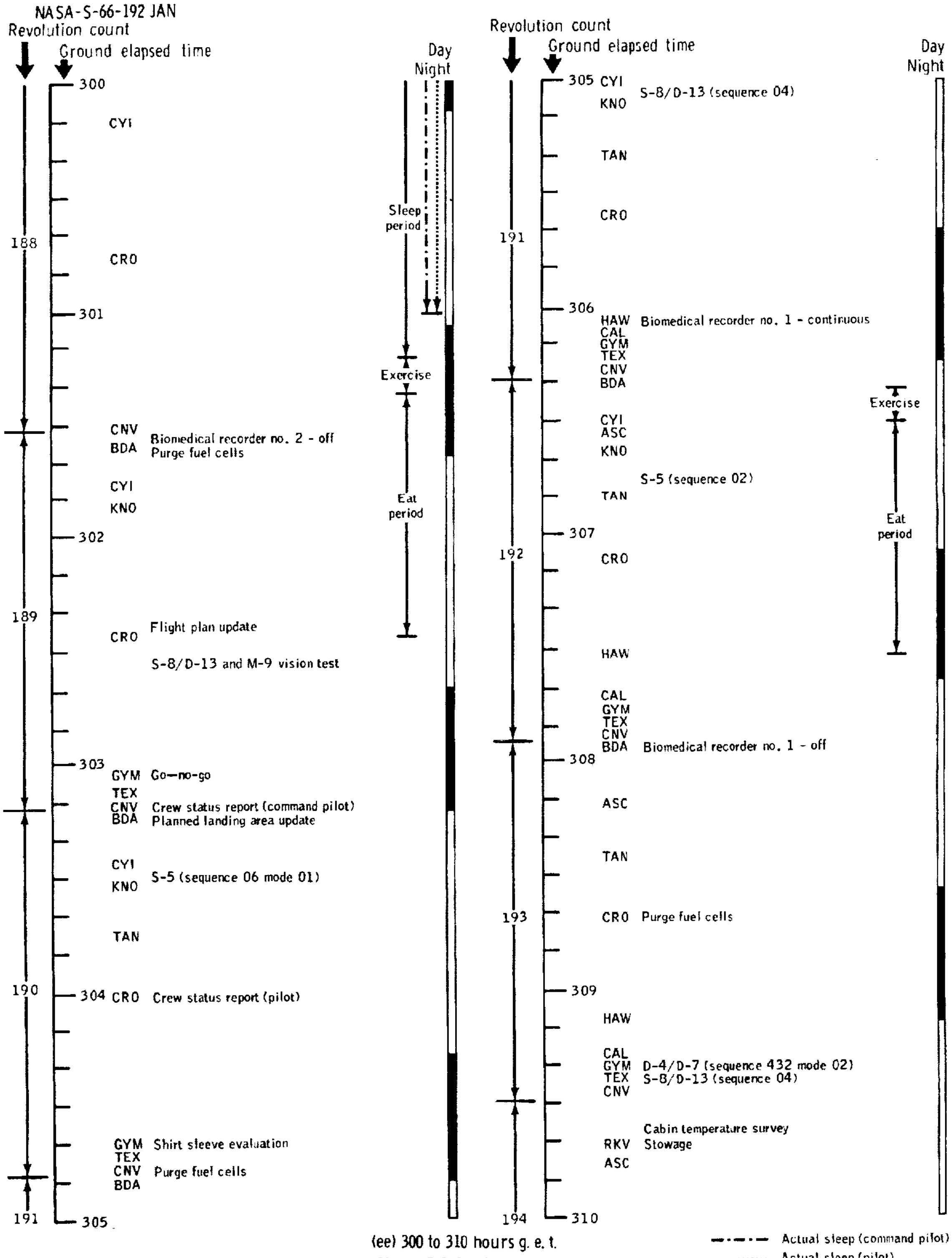

(ee) 300 to 310 hours g. e. t.

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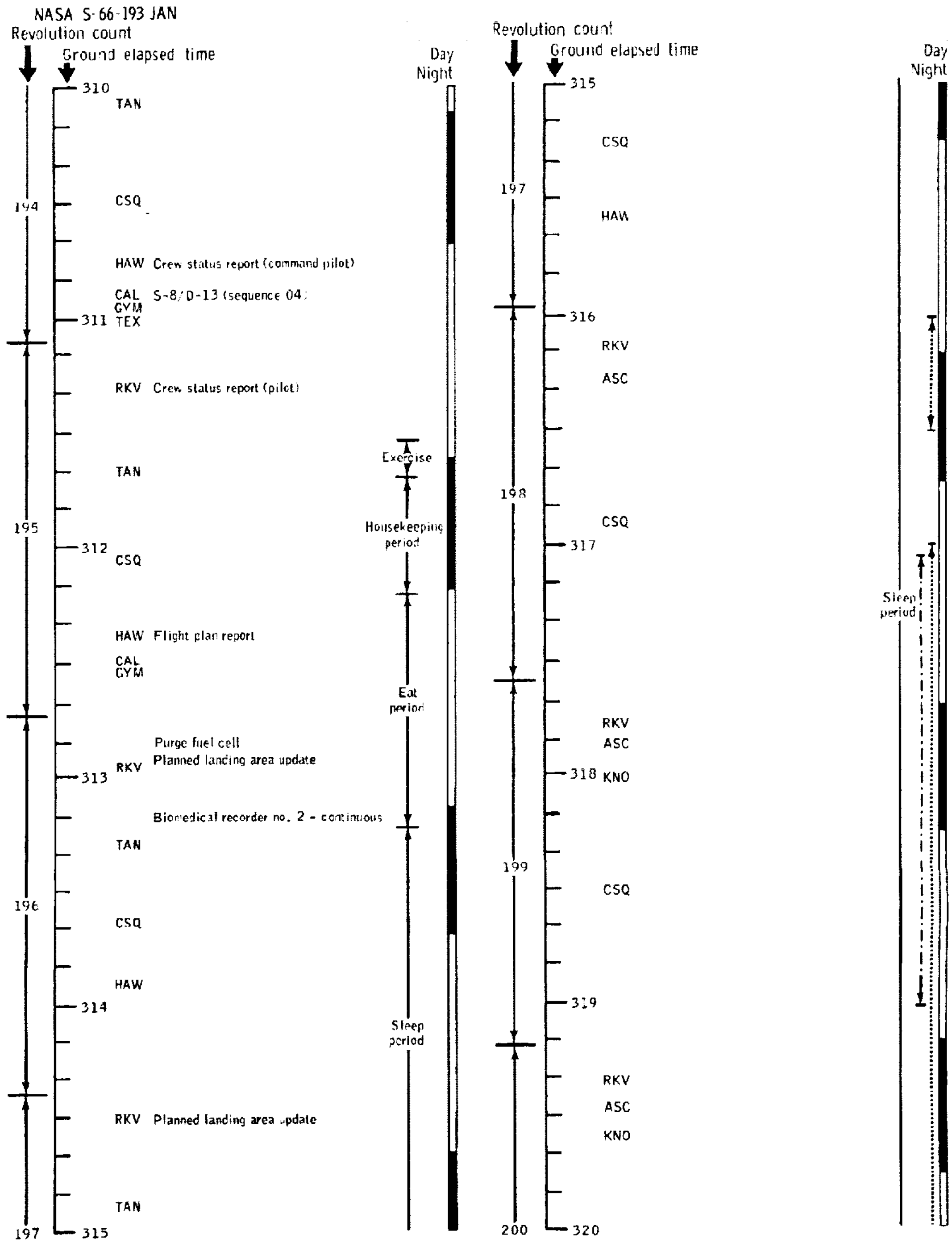

(ff) 310 to 320 hours g. e. t.

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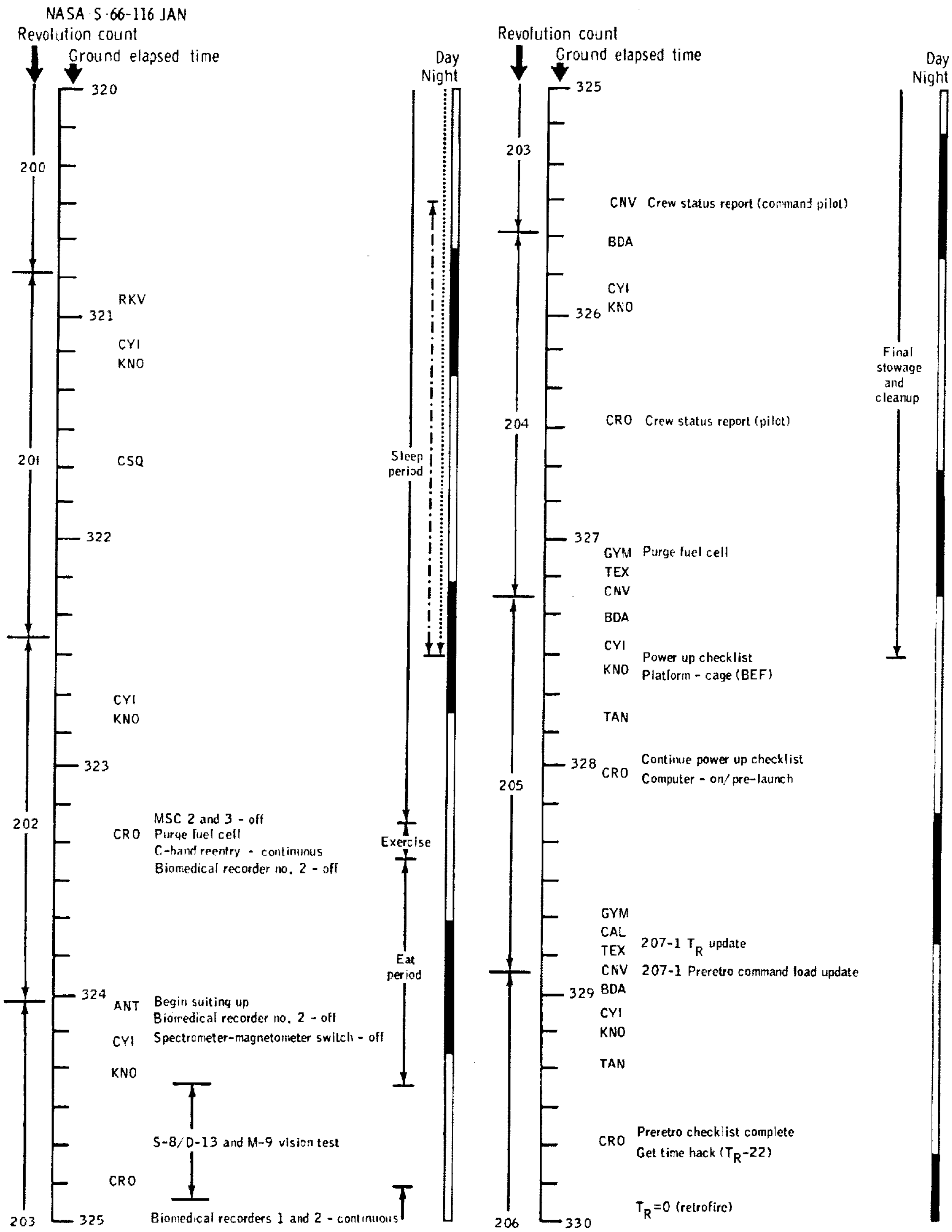

(gg) 320 to 330 hours g. e. t.
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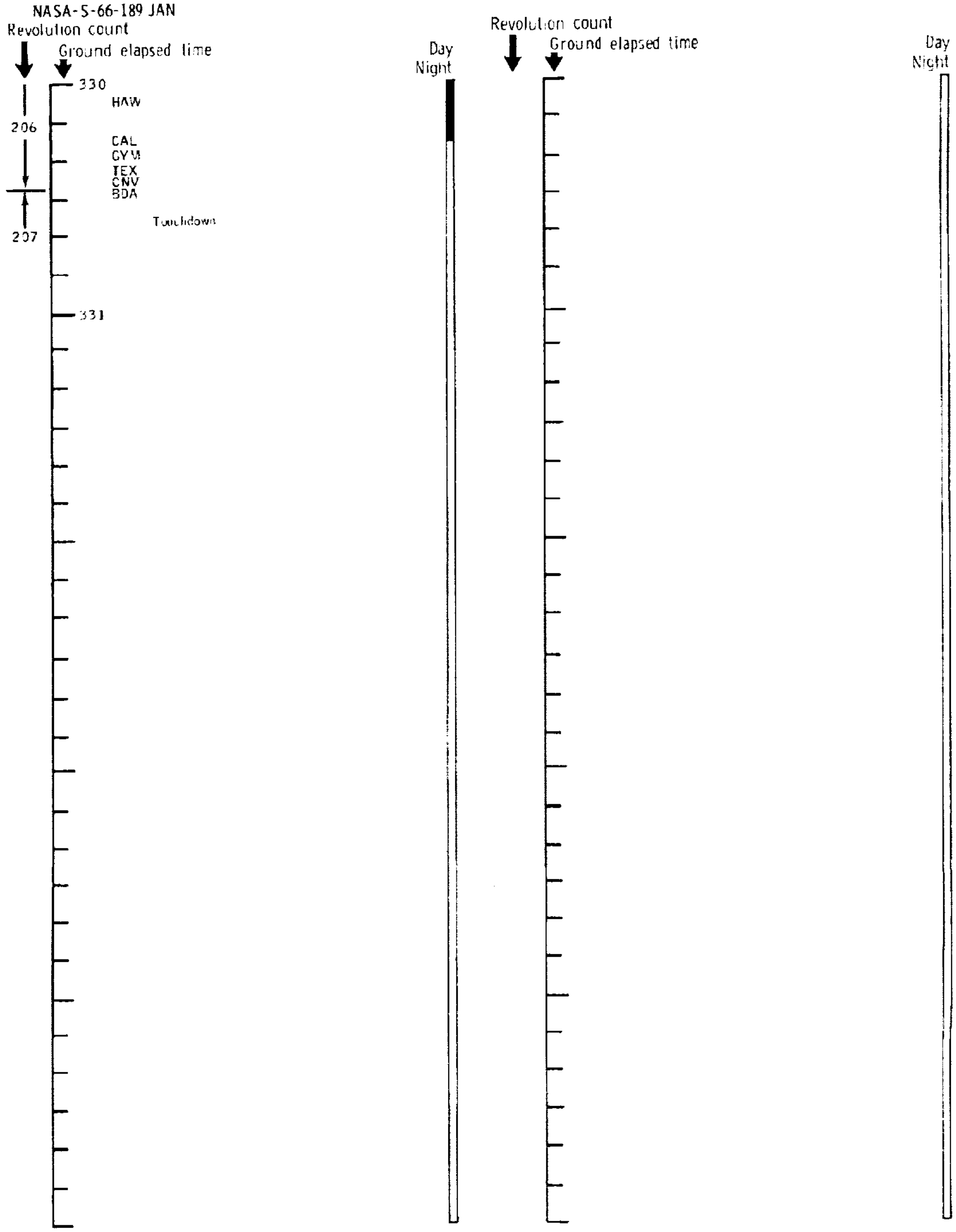

(hh) 330 to 331 hours g. e. t.
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Astronaut Frank Borman, Command Pilot, and Astronaut James A. Lovell, Jr., Pilot.

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7.1.2 Gemini VII Pilots' Report

7.1.2.1 Prelaunch.- The final prelaunch phase of the Gemini VII flight started with the arrival of the flight crew at Cape Kennedy on November 8, 1965. Because of the experience gained in launch preparations for previous flights, it was possible to reduce certain test elements in the launch preparations for the Gemini VII flight. Among the eliminated tests was the Wet Mock Simulated Launch. The crew does not believe that either the reduction of the test elements or the lack of the Wet Mock Simulated Launch hindered their performance in the flight. It is believed that with the level of confidence now established in the Gemini vehicle, it will be acceptable to continue with a similar test approach, taking into account the configuration differences in the remaining spacecraft.

An interesting facet of the crew preparation was the use of a Training Coordinator for scheduling all activities at Cape Kennedy. He arrived at Cape Kennedy 1 week before the flight crew and set up the initial training schedule. The Training Coordinator scheduled the simulators and prepared for the crew participation in the various tests of the launch vehicle and the spacecraft. This organization worked very well and eliminated many of the pressures and demands for time imposed on the crew in the prelaunch phase.

Another important prelaunch item in the Gemini VII mission was the preparations for the M-7 medical experiment. The preparations involved a 10-day rigid diet, complete with the collection of all body waste and two controlled distilled water baths. The diet went very well and the food was well prepared and tasty. The collection of the body wastes caused some minor annoyances, but no particular problems. The waste containers were placed at the simulator, at Complex 19, and, of course, at the crew quarters. The cooperation of all the people involved resulted in a minimum number of problems for the crew.

The training equipment was nearly all available at Cape Kennedy, including the Hasselblad camera and backup and training units for all experiments. The training at Cape Kennedy progressed logically and effectively. The only late arrival of training equipment was the Maurer camera. The camera was late because of problems with the qualification tests. Another important training item at Cape Kennedy consisted of a very regular and rigorous exercise program. The crew daily ran over 1 mile, lifted weights, and engaged in a general workout in the crew gymnasium.

On the day of the launch, the crew countdown went very well. There was ample time allocated for all the activities and the early afternoon launch allowed a rather leisurely day. The radio discipline during the final countdown was very good. The flight crew had no difficulty at any time in following the proceedings. The last 10 seconds of the countdown were well handled and the blockhouse communicator was the only person transmitting during that time. There were no unusual or unexpected noises, vibrations, or other disturbing occurrences during the countdown. Briefings from previous flight crews had prepared the Gemini VII crew for all the sensations and noises that were encountered during the prelaunch phase.

7.1.2.2 Powered flight.- The flight crew could hear and feel the engine start and there was a definite sensation of acceleration and release at lift-off. The noise continued to build up prior to the time the spacecraft reached supersonic velocity, and dropped off as the vehicle speed became supersonic. The noises heard during the launch phase were similar to what the crew had expected and were well duplicated in the dynamic crew-procedures trainer at the Manned Spacecraft Center. Two minutes 5 seconds after lift-off, the command pilot noticed a slight longitudinal oscillation (POGO). It was very slight and was not noticed by the pilot. Intermittently throughout the powered-flight phase, the pilot reported that the fuel-cell differential pressure lights were coming on and going off. Both lights were noticed prior to the first-stage engine shutdown, and both lights were again noticed twice during the second-stage flight. At staging, the spacecraft was surrounded by a bright orange flame, and it appeared that the spacecraft was flying through a ring in the flame. Second-stage flight was very smooth. The inertial guidance system (IGS) indicated essentially no trajectory lofting. The attitude needles initially deflected 2 or 3 needle widths to the right in yaw and down in pitch but then zeroed where they remained throughout the rest of powered flight. The crew noticed that the guidance during second-stage flight was very tight from LO + 309 seconds $\left(\frac{V}{V_R} = 0.8\right)$ to second-stage engine cutoff (SECO). The nose of the spacecraft appeared to be hunting just slightly with a control deadband of a tenth of a degree or less. All basic instruments within the spacecraft operated properly during powered flight. The cabin vent relieved initially at 5.5 psi, and then slowly bled down to a stable value of 5.1 psi. This value was not reached during powered flight, but the downward trend was noticed. Digital command system (DCS) updates were received on time and the pilot was able to install a camera bracket after guidance initiate and before the acceleration buildup in second-stage flight. The maximum acceleration noted on the onboard accelerometer was 7.2g. At SECO, the pilot read the velocity calculated by the onboard computer and recorded a value of 25 804 ft/sec which was exactly nominal. The incremental velocity indicator (IVI) indicated values of 17 ft/sec up, 20 aft, and 12 left.

No rates were noticed prior to spacecraft separation. The second stage was extremely stable while the spacecraft was on it. Spacecraft separation and fairing jettison were performed as planned. The pilot noticed some debris from the fairing jettison; however, the command pilot was looking at the attitude indicator and did not notice any debris at spacecraft separation. The aft-firing thrusters could not be heard by the crew and the spacecraft separation switch was pushed solely on the command of the command pilot as he thrusted. The separation thrust was applied for approximately 2 seconds and an immediate turnaround was performed as planned, with the spacecraft remaining in the 90° right bank. It was noticed at this time that the right window, in particular, was badly coated. As the spacecraft pitched up through 180° (in a right bank), the expended second stage of the launch vehicle was sighted, and it appeared to the crew that the spacecraft was slightly north and below the launch vehicle. The 1-A landing area time was called up and the crew received a "go" between SECO and spacecraft separation.

7.1.2.3 Orbital phase.-

7.1.2.3.1 Station keeping: No difficulty was encountered in setting up the initial station keeping with the second stage of the launch vehicle. Procedures developed at the spacecraft contractor's facility were used including a 2-second initial separation thrust and a 4-second thrust back toward the second stage after turnaround. A minimum amount of time was used for the turnaround to prevent large separation distances by pitching through 180°, making the 4-second thrust toward the second stage, then rolling 90° to a heads-up position. After completing the turnaround maneuver, the spacecraft was north of the second stage and about 100 feet from it. The second stage was tumbling and venting profusely from what appeared to be a vent valve at the base of the fuel tank.

The initial spacecraft control mode selected was platform blunt end forward (BEF), and attitude control PLAT. However, switching to this configuration caused the crew to lose sight of the second stage and the attitude control mode was switched to DIRECT with the platform in ORBIT RATE. This mode was utilized for a portion of the station keeping after which attitude control was changed to PULSE.

No difficulty was encountered in maintaining position with the second stage of the vehicle. The distance from the spacecraft to the vehicle varied from approximately 60 to 150 feet. The venting fuel from the second stage caused it to translate as well as tumble, and more spacecraft fuel was expended than originally planned to maintain position. An added problem to station keeping was the setting sun which near the end of the daylight phase made viewing the second stage very difficult.

In order to conserve fuel, the separation maneuver was started at approximately 22 minutes 17 seconds ground elapsed time (g.e.t.) rather than the nominal 26 minutes. A pitch-down attitude of 25.9° was established and the downward maneuver was shortened to 20 seconds to save fuel. The spacecraft was then aligned on the second stage to start the D-4/D-7 experiment. The docking light was turned on, but did not illuminate the second stage. The acquisition lights on the second stage worked satisfactorily, but it was impossible for either crew member to estimate the range by observing only the acquisition lights.

7.1.2.3.2 Orbital adjust maneuvers: Four orbital adjust maneuvers were accomplished during the mission. The first two were made by the pilot without using the platform for attitude reference. Spacecraft yaw attitude was established by means of a star reference obtained by ground updates and the celestial chart. Roll and pitch attitudes were maintained with respect to the horizon which was quite visible to the night-adjusted eye. Because the spacecraft was completely powered down (i.e., no platform, computer, or rate indicators), it required two people to complete the maneuver. The pilot made the maneuvers maintaining attitude on the star using attitude control and rate command. The command pilot timed the thrust. The first thrust period was started at 3:47:59 g.e.t. and lasted for 1 minute 17 seconds. The star Spica was used as a reference. The thrust was momentarily interrupted when the command pilot believed the spacecraft was encountering debris from the launch vehicle. When thrusting stopped, a strap-like object struck the spacecraft just in front of the right window. Later observation by the Gemini VI-A crew members showed this material was attached at the separation plane between the spacecraft and the launch vehicle. The crew observed similar material on spacecraft 6.

A second maneuver was made by the pilot with the thrust period starting at 69:43:19 g.e.t. and had a duration of 16.5 seconds. The star Arcturus was used as a reference. No unusual difficulty was encountered in performing both maneuvers without using the platform and the crew considered this procedure acceptable. The command pilot performed two height-adjust maneuvers to place the spacecraft into a 161 nautical mile circular orbit, and utilized the platform in ORBIT RATE and the computer for references. The first maneuver was started at 119:11:55 g.e.t. and resulted in a velocity change of 61.2 ft/sec which had been inserted into the onboard computer. This posigrade maneuver was made utilizing the IVI's but with timing as a backup. Attitudes were maintained by monitoring the flight director attitude indicator (FDAI) and utilized the attitude control mode of rate command. A platform retrograde maneuver with a velocity change of 12.1 ft/sec was started at 119:55:01 g.e.t. using procedures similar to those described for the first height-adjust maneuver. No unforeseen difficulties were encountered during all maneuvers when the platform was used for reference.

7.1.2.3.3 Pressure suit operation: Pressure suit operation varied with both crew members fully suited at times, or fully suited with hoods and gloves off, with one crew member out of the suit, and with both crew members out of the suits.

Fully suited operations were conducted during the launch, rendezvous, and reentry phases of the flight. It was noted that with the hoods on, considerable noise was generated in the intercom system because of the airflow in the hood. Visibility during the launch phase was acceptable. The visibility during reentry, however, was marginal. This was a result of dirt and scratches which had accumulated on the visors during the 2-week mission. In addition, the first portion of the reentry was at night and the hood visor made it more difficult to see the night horizon. The command pilot was forced to remove the hood during reentry. In the fully suited condition, it was very difficult to observe and operate switches in the overhead and water management panels. During the fully suited condition, the environmental control system (ECS) configuration was: A pumps on, suit temperature at maximum cool, cabin temperature at maximum heat, and maximum flow for both suits.

After receiving the "go" for the 17-1 landing area, it was decided at approximately 1 hour g.e.t. to operate partially suited and the suit hoods and gloves were removed, and the wrist dams were installed. The bypass outlet hoses were installed at 2:32:00 g.e.t., and the harnesses were removed. This configuration was maintained for approximately 2 days, and it was noted that there was a definite loss in suit cooling efficiency. Most of the suit flow was being lost through the large neck opening or being vented through the now unused hood vent. Intercommunication noise was considerably reduced with the hoods off. During this portion of flight, B coolant pumps were in operation and it was noted that some areas were not receiving sufficient cooling. The lack of adequate cooling was especially noticeable in the crotch area, and the zipper had to be opened to maintain comfort in that area. Mobility was restricted during suited operation, primarily because the stowed hood on the back of the neck restricted head movements, and also because of the general bulk of the suit when restricted to such a small volume as the spacecraft cockpit.

On the second day, the pilot removed his suit and noted a definite improvement in comfort. The bypass hose was replaced in a stowed position with a screen over the opening. The inlet hose was attached with velcro vertically along the side of the centerline stowage box. The ventilation appeared adequate, and the skin was kept dry. The pilot did not feel an area of stagnant air at any time. During periods of extreme activity involving exercise, the inlet hose was placed horizontally along the center pedestal to provide more direct flow to the pilot. During this period, ECS controls were: B pumps on, cabin at maximum heat, suit at maximum cool, command pilot suit flow at full increase, and the pilot's suit flow at the minimum position. Even with the pilot's suit-flow valve at the minimum position, the command pilot had to resort to using the primary A pump occasionally to increase his cooling. In addition to increasing pilot comfort, the suit-off configuration increased mobility. It was much easier to exercise, unstow equipment, and perform flight plan activities. It was also possible to check and repair biomedical instrumentation.

Near the end of the 8th day, ~~On approximately the 6th day~~, both pilots went to a suits-off configuration. One apparent improvement was the increase in humidity, resulting in less dryness of the skin and stuffiness of the nose. Measurements indicated that the dew point of the cabin with the suits-off configuration was raised about an average of 10° F over the suits-on configuration. In addition, comfort was maintained using only the B pumps when both suits were off.

The transition from a suit-on to a suit-off configuration took about 20 minutes including the time required to place plugs in the suit openings in case emergency donning was required. The suit configuration required the assistance of the other crew member to help open the zipper and, in some instances, to help get the suit over the shoulders. The suits were doubled up with visor covers installed and stowed behind the seats with the visor and feet wedged between the seat and the hatch. Suit stowage, though not desirable, was acceptable in view of the limited volume in the Gemini spacecraft.

7.1.2.3.4 Rendezvous: Spacecraft 7 essentially played a passive role in rendezvous. The main contribution it made was to maintain the correct attitude for L-band radar transpoder operation during the final stages of rendezvous. Excellent UHF communications with spacecraft 6 allowed proper attitude of spacecraft 7 to be verified. Attitude control was maintained with the platform using the PULSE control mode. Spacecraft 7 turned on its docking and acquisition lights in an effort to aid spacecraft 6 make an early acquisition. Spacecraft 7 acquired spacecraft 6 visually as a point of reflected light against the dark earth background just prior to sunset at a range of 2 to 3 miles. As the range closed to about one-half of a mile, the crew could see the thruster firings which appeared as thin streams of light haze shooting out approximately 40 feet from the spacecraft. Station keeping with spacecraft 6 was accomplished by both crew members of spacecraft 7 during approximately a 10-minute period. The station-keeping task was not difficult and was judged to be similar to, but less difficult than, that experienced in the docking trainer.

7.1.2.3.5 Experiments:

M-1 experiment – The M-1 experiment was activated at 2:39:00 g.e.t. and, except for brief periods of doffing and donning the suits or for waste management, was left on continuously for the duration of the flight. No difficulty was encountered in operating the M-1 experiment in conjunction with the oxygen repressurization system. However, the hose was difficult to unstow from the launch position. The noise caused by the cycling of the regulator was a continual source of annoyance to the crew. Attaching the inlet hose to the cuff of the right leg routed the hose across the lap of the pilot which was also undesirable.

M-3 experiment – The inflight exerciser worked properly and was used for all medical passes. Additional exercise was performed at 32 evenly spaced times throughout the mission and consisted of planned dynamic and isometric tasks. The crew believe that the exercise periods were adequate and were necessary for a flight of this nature.

M-4 experiment – No problems were encountered with the inflight phonocardiogram.

M-5/M-7 experiments – The waste management procedure, though operationally possible, had the following problem areas:

(a) A urine sample bag leaked. (The leak was probably caused when the bag was placed on the sample connection.)

(b) Both crew members had difficulty with leaking receivers.

The orifice in the receiver was large enough; however, it was believed that back pressure developed when the urine entered the bag. Repeated use of the same receiver caused the material to lose its elasticity and become loose which increased the leakage problem. Ten spare receivers were carried, but it is thought that a new one per man per day would be more desirable. The crew realized the need for accurate measurement and recording of urine output, but they believe the hardware procedures and marking system were not satisfactory.

The urine flowmeter was installed on the first day and operated satisfactorily from a crew standpoint. On several occasions, however, the crew failed to turn on the recorder when dumping urine. The filter was changed on the 10th day when a slowing down of urine dump rate was noted. Use of the new filter resulted in an improvement in urine flow rate.

Defecation bags were used 15 times without any major problems. The defecation procedure is greatly simplified with the suits removed. It was necessary to make a small cut in the disinfectant bag in order to get the liquid out of the plastic bag. Urine and defecation bags were stowed satisfactorily in the aft food boxes with the majority being placed in the right hand box.

M-8 experiment – The electroencephalogram (EEG) harness was unsatisfactory in that it was not firmly attached to the command pilot's head. One lead fell off after the second night and, after the helmet had been removed, the remainder of the leads pulled off when the wires caught on the ejection seat. It was not possible to reattach the leads with equipment which was on board for the electrocardiogram (ECG) sensors.

M-9 experiment – This experiment was satisfactorily conducted simultaneously with the onboard portion of the S-8/D-13 experiment.

D-4/D-7 experiment – All equipment appeared to be operating normally. Procedures and control hardware in the cockpit were satisfactory. Correct and timely flight plan updates were essential for successful completion of the active target portion of this experiment. All targets were tracked in the PULSE mode except the reentry vehicle which required switching to the DIRECT control mode.

D-5/MSC-12 experiment – The star occultation photometer, used for experiments D-5 and MSC-12, did not operate properly and the crew was unable to verify proper calibration. Ground-suggested tests were performed in an attempt to determine the failure. The equipment was stowed after these tests proved that the photometer was not working.

D-9 experiment – Star-to-horizon sextant measurements were made with angles of up to 50°. It was not possible to use the green or blue filters for any star-to-horizon shots. The filters completely blanked the horizon from view and all shots were therefore made without the use of filters. The moon had a considerable effect when taking sextant measurements. During full moon conditions, it was difficult to use stars near the moon. In addition, the moon washed many lower magnitude stars from view. The best horizon to use during full moon conditions was the apparent earth horizon below the airglow band. With no moon, many more stars could be seen, and the sharpest horizon was the upper portion of the green airglow. The sextant had an 80-20 split in the intensity of the light between the telescope and the prism. This split appeared to hamper star-to-star measurements and calibration measurements on the same star. One image was too dim compared with the other to get accurate superimposing. The 80-20 light split also made measurements from the moon-limb to a star difficult. Even with the use of filters on the moon image, the star was lost from view as it approached the moon. The instrument was easiest to handle when the shots were taken vertically, and for some of the star-to-star shots, the spacecraft was rolled so they could be taken vertically referenced to the spacecraft axis. It was found that the best stars to use were those that could be easily identified within the sextant field of view. The light on the angle readout was too bright making dark adaptation impossible.

S-8/D-13 experiments – The vision tester for the S-8/D-13 experiments was operated every morning and worked satisfactorily. Crew procedures utilizing the window photometer were exactly as planned. Evidence that the photometer was working was indicated by needle deflections on the gage with variations of light intensity after instrument warmup. The crew had considerable difficulty in locating the proper area for the visual ground-observation portion of the experiment. Although the crew had a photograph of the area taken by the Gemini V crew, most of the time over the target was used in trying to acquire the squares.

MSC-4 experiment – The laser experiment was troubled by weather, fuel shortage, and equipment problems throughout the flight. During one daylight pass over the Island of Kuaui in the Hawaiian train, the ground laser beam was spotted by the command pilot with the naked eye; however, the pilot was unable to acquire the beam with the laser telescope. The green filter on the telescope prevented seeing the target terrain and the location at which the ground beam should have been located could not be identified. The safety glasses were worn at first when attempting beam acquisition, but were soon found to be a hindrance. A good daylight pass was made over the White Sands area, during which the weather was excellent, and the crew had a photograph on board to help pinpoint the exact location of the laser beam. The pilot on this pass tried utilizing the sextant telescope to help acquire the laser beam but neither crew member could acquire the beam. Weather prevented any more attempts at performing the MSC-4 experiment. In the brief period the laser was spotted during the Hawaiian pass, the command pilot thought the light source was much smaller and weaker than training had indicated that it would be.

7.1.2.3.6 Operational checks: High frequency (HF) communications - HF communications were very poor during the flight. A listening check, sequence 02, for transmissions from Hawaii resulted in good reception when near Hawaii only. Most of the music broadcast for the Gemini VII crew was either not received or was not identifiable, except when within line of sight of the transmitter.

Apollo landmarks – Good photographs for Apollo landmarks were difficult to obtain as a result of poor weather. A 2-week observation of the earth in the latitudes between 28° north and 28° south indicated that the only areas of consistently good enough weather for landmark use were the deserts of North Africa and the Saudi Arabian peninsula.

Dim-light photography — One film pack of 70-mm high-speed black and white film was taken on this mission to attempt celestial photography under dim-light conditions. This requirement was added to the flight too late for adequate training. The shortage of fuel resulted in most of the pictures being taken in drifting flight. For the long exposures necessary, this meant that the camera had to be panned, which compromised the quality of the pictures.

7.1.2.3.7 Flight plan updating: A long flight of this nature required real-time flight planning. Flight plan updates were recorded in the experiments log sheets of the procedures books. They were then recorded in chronological order in the flight plan book. At the end of each day, the experiments log sheets were checked to insure that all tasks had been completed and properly logged.

7.1.2.3.8 Sleeping, eating, and housekeeping: A primary ground rule adapted for this flight was to operate on a schedule based on Mission Control Center (Houston, Texas) time. A daily work and rest schedule was adhered to which was comparable to that which the crew had been accustomed to on the ground. To support this schedule, both crew members slept simultaneously except during the first night. The ground was instructed not to communicate except for an emergency. The 10-hour rest cycle set aside for night proved adequate and necessary. The work-day cycle was broken up primarily by three meals. The meals were adequate and palatable for the 14-day flight, but greater variety would have been appreciated. The favorite foods were juices and puddings, and the rehydratable food far outweighed the bite-sized foods in popularity. Food packaging in general was satisfactory but it was noted that the spout diameters for semi-fluids such as shrimp, sauce, and tuna salad were too small to easily remove the food, although it was adequate for juices and puddings. Several times the disinfectant pill crumbled while getting it into the bag. Small pieces of the pill floating in the cockpit proved to be a hazard because periodically they got into the eyes and caused burning. It was noted in this flight, as in past missions, that the beef bites crumbled excessively and also contaminated the cockpit.

Waste stowage was taken care of at the end of each day. Waste paper from each meal was replaced and packed tightly in the outer meal wrappings and then placed behind the ejection seats. Waste food packages for approximately 9 days were stored in that area. The remainder of the packages were stowed in bags on top of the seats. The crew felt that the extensive preflight training in housekeeping was responsible for keeping the spacecraft in a livable condition. An added bonus to the suits-off configuration was that the bypass exhaust hose could be used as a vacuum cleaner for removing floating crumbs and small debris. Screens over the ends of the hoses prevented contaminants from getting into the ECS system.

7.1.2.4 Preretrofire and retrofire.- Preparation for retrofire was begun approximately 2 hours prior to its accomplishment. The suits had been donned approximately 5 hours prior to retrofire and the major preparations consisted of assuring that all the final stowage had been accomplished and that the platform was adequately aligned. The platform was not aligned using the platform mode of the control system, but was aligned manually because thrusters 3 and 4 had been degraded and were providing less than one-quarter of the impulse that they normally provide. A very close check of the stars was made in the first nighttime pass while the platform was being aligned. This was accomplished to assure that the crew would have a good idea of the proper attitude on the final pass for retrofire.

The updates from the ground were received on time. The computer was loaded in prelaunch as planned and everything proceeded according to the mission plan until the final 26-minute check prior to retrofire. At that time $(T_R - 26)$ minutes the crew was unable to contact Carnarvon because of the distance. The contact was finally made at 20 minutes prior to retrofire and the event timer was started down at T_R - 20 minutes on Carnarvon's hack rather than at the planned T_R - 26 minutes. The vent air noise in the helmet hood was very loud and hindered or prevented good crew communication during this time. Some consideration was given to removing the hood for retrofire; however, it was determined that by turning the volume up, the crew could communicate effectively and the hoods were left on. Separation of the OAMS lines produced a significant noise, but no acceleration to the spacecraft. This was also true in the case of separation of the wire bundles; however, the separation of the adapter equipment section produced not only a large noise but also a significant thrust or at least a noticeable acceleration in the positive X direction for a fraction of a second. The retrofire was accomplished within range of Canton Island and the countdown from MCC-H was received. The retrorockets fired automatically and on time. No time elapsed between the thrust of the first, second, and third retrorockets but there was a slight hesitation of less than 1 second between thrusts of the third and fourth retrorockets in the sequence. After retrofire, the IVI readings were 298 ft/sec aft, 3 right, and 112 down. The rate command mode of the flight control system provided excellent control during the retrofire and attitudes were held within $\pm 1^\circ$ of nominal. The retrograde section of the adapter was jettisoned at T_R + 45 seconds and the spacecraft was rolled to a heads-down position. A check of the onboard guidance plots indicated that the backup guidance angle was 50° left bank. This was confirmed by MCC-H.

7.1.2.5 Reentry and landing.- After rolling to a heads-down position after retrofire, the crew immediately began to look for the horizon. The hood on the command pilot interfered with his ability to view the horizon, so he unzipped and removed it and continued to look for the horizon. At approximately 350K feet, the horizon was lit slightly on the pilot's side and he was able to help position the spacecraft by instructing the command pilot as to the location of the horizon. Because of the problem in locating the horizon, the blood pressure measurement that was requested for over Guaymas was not given. Approximately 30 or 40 seconds before guidance initiate, an updated bank-angle command was received from Mission Control Center in which it was indicated that the proper backup angle was 35° rather than 50°. Verification was requested for this instruction, and it was provided. After 400K feet, the spacecraft was rolled to 55° and this attitude was held until guidance initiate. The initial indication at guidance initiate was that the spacecraft was slightly undershooting. The control mode selector was switched to the DIRECT position and the command pilot performed the control functions required to center both the downrange and crossrange needles.

The direct mode, using only the A-ring, worked well until a tendency was noticed to oscillate and overshoot in making corrections; rate command mode was then selected. The rate command mode worked well for the remainder of the reentry. No difficulty was experienced in zeroing the downrange or crossrange error needles before 3g of acceleration had built-up and several control rolls were initiated, all through the full-lift position, to keep the crossrange needle very close to the zero-error position. As the accelerometer indicated 3g, the mode of flying for the reentry was shifted and major concentration was placed on keeping the roll command needle centered. This task was easily done with the rate command flight control mode. The maximum acceleration noted during the reentry was 3.9g.

As the acceleration began to diminish, a pitch and yaw oscillation was noticed and two rings were selected on the RCS. In spite of the fact that both rings were selected, the pitch and yaw rate oscillations continued to build up after 100K feet and prior to the time the drogue was deployed. The landing squib was armed at 100K feet and the drogue was deployed at 50K feet. The oscillations continued to increase. They were very rapid and reached a maximum amplitude of approximately 10° to 20° on each side of the zero position of the spacecraft. The RCS motor valves were closed at 35K feet, but this precipitated an even more rapid and violent oscillation and the control valves were opened again. This slightly dampened the oscillations that were noted. As the spacecraft passed through 29K feet, the oscillations diminished and the RCS motor valves were again closed. The hand controller was then operated to relieve pressure on the lines.

At 26K feet, the snorkle was opened and the pilot immediately experienced a large amount of very acrid smoke and fumes in the suit circuit. The pilot's hood was still closed and the smoke and fumes were directed toward his face. The pilot's eyes were irritated rather severely by the fumes. The command pilot was flying with the hood off, and although he smelled the fumes and sensed the presence of the smoke in the cockpit, his eyes were not bothered.

The main parachute was activated at 10.6K feet and appeared shortly thereafter, in the reefed position. The parachute disreefed and landing attitude was selected immediately after it was determined that the parachute was in a normal configuration. The crew was braced and prepared for the shock of going through the single-point release position. The spacecraft landed while drifting heat shield forward, and the initial impact resulted in a moderate shock. The spacecraft then rolled to the right and the right window went underwater. The parachute jettison control was pressed as soon as the main shock was felt, and the spacecraft righted itself shortly thereafter, and floated very well in the water. After landing, the HF antenna was raised and HF/DF mode was selected for approximately 3 minutes. The HF/DF mode was then turned off and the antenna lowered to prevent damage. The postlanding electrical test required by the flight plan was accomplished, and it was found that the current, indicated on the bus that remained powered by the 1 and 2 batteries, varied with the wave action. The current, indicated on the bus that was powered by batteries 3 and 4 which had been turned off, remained at zero throughout the test. The swimmers rapidly applied the collar and the command pilot unlatched the left-hand hatch. The swimmers assisted with opening the hatch, and the crew made a normal egress into a raft for pickup by the helicopter.

7.1.2.6 Postlanding.- The recovery and postlanding activities were handled well aboard the U.S.S. Wasp. The crew was escorted immediately to the hospital area of the recovery ship, and the extensive medical debriefing and examinations were accomplished. There were no major problems during this time, and the crew was able to complete the medical examinations satisfactorily prior to dinner that evening. After dinner, a request was made for the crew to ride a bicycle to determine their condition. This procedure was not in the flight plan for this time. It had been specifically agreed that the bicycle would not be ridden until 18 hours after recovery, and the next morning, after 18 hours had passed, the ride was accomplished.

7.1.2.7 Systems operation.-

7.1.2.7.1 Malfunction detection system: The malfunction detection system operated properly throughout powered flight. No anomalies were noted.

7.1.2.7.2 Flight control system: The flight control system operated properly throughout the flight, and no problems were encountered.

7.1.2.7.3 Inertial guidance system: The inertial guidance system operated properly during the flight.

7.1.2.7.4 Propulsion system: After 11 days of flight, it was noted that the operation of thrusters 3 and 4 had degraded. Thrusters 3 and 4 provide the yaw-right thrust for spacecraft attitude control, and they had been used more frequently than the other thrusters because of venting which caused the spacecraft to yaw and roll to the left. The initial indication of the degradation was a lack of authority in the pulse mode. Several checks were made, and it was determined that even though the thrusters were firing in the pulse mode, they were not providing normal thrust. In the direct mode, no ignition was indicated; however, some authority was provided and a great deal of venting was taking place judging from the residue seen outside the window. Several checks were made to determine the exact cause of the degradation in the operation of thrusters 3 and 4, but no satisfactory explanation was determined during flight. In order to save thrusters 3 and 4 for platform alignment prior to retrofire, the circuit breaker on maneuver thruster 11 was opened. A gross yaw-right maneuver was then obtained by thrusting aft because of the assymetrical thrust provided by thruster 12. This system worked effectively although it was not satisfactory for tracking. It did provide spacecraft control from the eleventh day until the platform was aligned for retrofire.

7.1.2.7.5 Electrical system: The electrical problems encountered were primarily associated with the fuel cells and they are documented adequately in the fuel cell section of the report. The crew had little or no control over the fuel cell problems. The primary part of the troubleshooting and corrective operations that were required to keep the fuel cells on the line was performed on the ground and transmitted to the crew for execution.

7.1.2.7.6 Communications system: The UHF radios provided satisfactory communications throughout the 14 days. The high-frequency radio provided adequate communications when the spacecraft was within line-of-sight range of the ground stations, but provided rather mediocre reception at other times and did not appear to have any advantage over the UHF communications. The high-frequency transmissions were characterized by a large amount of static and generally unreadable transmissions.

7.1.2.7.7 ECS system: The ECS system operated properly throughout the flight. The cabin differential pressure was maintained at 5.1 psi from the time of insertion until reentry.

Water was present in the suit inlet line twice during the flight. The first time it occurred, the ground transmitted the following corrective action: (a) orient spacecraft broadside to the sun, (b) turn on "A" pumps, (c) use both suit fans, (d) select radiator bypass, (e) turn evaporator heat on, and (f) roll the spacecraft at 8 to 10 deg/sec. This procedure was satisfactory and removed a large amount of water which was witnessed by the spacecraft 6 crew who were standing by during station keeping. (See section 5.1.4.3.) The second occurrence was corrected by using both suit compressors and adjusting for full hot with the suit control valve.

Free water collected on the metal floor immediately in front of both ejection seats, and the insulation on the center pedestal was wet during the last week of flight.

7.1.2.8 Concluding remarks.- In general, the Gemini VII mission progressed essentially as planned. The station keeping with the second stage of the launch vehicle was accomplished without difficulty, and the four orbital adjustment maneuvers were accomplished as planned. Both crew members operated during orbital flight without wearing their pressure suits, and the crew members believe that the resulting improvements in comfort and mobility contributed significantly to the successful completion of the flight.

The main contribution of spacecraft 7 to the rendezvous with spacecraft 6 was to maintain the correct attitude for transponder operation. Both Gemini VII crewmen had no difficulty in performing station keeping with spacecraft 6. All spacecraft 7 systems performed well, with minor exceptions. The PCM tape recorder failure, and the degradation in performance of fuel cell section 2 and the yaw-right orbit-attitude thrusters did not significantly affect the conduct of the mission. The majority of the assigned experiments were successfully carried out. No major difficulties were encountered in performing reentry, and the crew and spacecraft were recovered promptly after landing. The crew members were picked up by helicopter and arrived at the prime recovery ship feeling well, although fatigued, and ready for debriefing and examination.

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7.2 AEROMEDICAL

The 14-day Gemini VII mission was the culmination of a planned series of Gemini space flights for increasing increments of time. It afforded the biomedical community an opportunity to evaluate the significance of changes which had been noted in the postflight condition of the flight crews following the 4-day and 8-day Gemini missions, and to gain a better understanding of the extent to which such changes are dependent upon the duration of orbital flight. The crew was required to participate in a number of biomedical experiments (see section 8) which were designed to exploit this first opportunity to evaluate the impact on human systems of a 14-day weightless flight. The volumes of medical data and large number of specimens collected before, during, and immediately after the flight will require extensive analysis and comparison with results of studies made during earlier flights before the full significance of this flight can be understood. Early analysis of all available data has, however, consistently indicated that the Gemini VII crew maintained a satisfactory state of health and full mental capacity throughout the 14-day mission. There were physiological changes at the end of the mission which were generally consistent with those changes observed and reported in crew members of earlier Gemini flights. The studies and biomedical measurements accomplished as part of the operational support of the Gemini VII mission are presented in this report.

7.2.1 Preflight

7.2.1.1 Medical histories and clinical background data.- The military health records, reports of the comprehensive medical selection examinations, reports of annual medical examinations performed since entry into the NASA astronaut program, and medical observations recorded during special training procedures, such as centrifuge training and altitude chamber systems tests, were reviewed and summarized for each of the Gemini VII crew members. In addition, the flight crew underwent extensive medical assessment during May and early June 1965 while serving as the back-up crew for the Gemini IV mission. Oral test doses of each of the drugs carried aboard the spacecraft were administered to each crew member between July 16 and October 4, 1965. Subjective responses to each therapeutic agent were carefully noted and discussed with the crew members.

7.2.1.2 Tilt-table and exercise-capacity response studies.- Three preflight tilt-table tests were conducted on each of the flight crew members on September 22, October 14, and November 4, 1965. These tests were all performed in Houston by the same medical personnel who were to administer the postflight tilt-table tests. The results of the preflight tilt studies are shown in figures 7.2-1 and 7.2-2. To gain data bearing on the question of the functional capacity of the flight crew to carry out strenuous activity following their 14-day mission, an exercise-capacity test was incorporated into the preflight and postflight medical test procedures. A bicycle ergometer was selected as a source of measured work, and determinations of heart rate, systolic and diastolic blood pressure, and respiratory rate were made for each minute of each test run. Minute ventilatory volume, oxygen uptake, and CO_2 production were also measured at selected intervals during each test run. Preflight tests were accomplished on November 4, 1965, in Houston and on November 24, 1965, at the Manned Spacecraft Operations (MSO) building, Kennedy Space Center (KSC), Florida. Results of the second test which was performed closest to the flight date are shown in figure 7.2-3 as representative of the preflight exercise response of each member.

7.2.1.3 Physical fitness program.- The Gemini VII crew adopted an early position that a high level of physical fitness was important in their training program for the 14-day mission. They started a regular program of vigorous physical activity while serving as back-up crew for the Gemini IV mission, and maintained a consistent program of exercise during the 6 months leading up to their flight. While in Houston, the crew played handball as an overall exercise and also did daily running. The flight crew arrived in Florida on November 8, 1965, for final premission activities. They moved directly into the crew quarters in the MSO Building at KSC and remained there, except for one weekend which was spent at their homes in Houston. While they were in training at Cape Kennedy, the crew intensified the level of activity in their daily routine, concentrating on calisthenics in the gymnasium and running. About 1 hour each day was spent in actual physical conditioning activity.

7.2.1.4 Nutrition and personal hygiene.- The flight crew had participated in the 4-day trial of the inflight food during the Gemini IV premission training period and it was agreed that they had attained sufficient experience in preparing and mixing the inflight food and that the 4-day trial had been adequate to demonstrate that neither crew member was likely to experience gastrointestinal disturbances while on the flight menu. Consequently, time was not scheduled for the crew to subsist on an inflight type of diet during the preflight training period. The nutritional balance requirements of experiment M-7 dictated a 10-day period of dietary control prior to the flight (section 8.9). This period, which had been coordinated among the crew members, the experimenters, and the MSC Medical Operations staff, began on November 21, 1965. The diet which was furnished during this nutritional-balance study proved to be highly palatable and appetite satisfying. The weight of the crew members stabilized and remained quite constant while they were on this metabolic diet. The scientists conducting the M-7 experiment suggested that it would enhance the validity of their experiment if the medical support staff and crew would agree to their staying on the metabolic diet through the launch morning, and this suggestion was adopted. The requirement for meticulous measuring of portions was relaxed after the initial 10-day dietary control period, and the menu was liberalized to allow a broader selection of dessert items than had been allowed during the 10-day control period. Ten milligrams of bisacodyl were administered after supper on F-2 day, followed by the administration of a 10-milligram bisacodyl suppository after supper on F-1 day, with the intent to achieve evacuation of the colon of each of the flight crew members prior to launch, without producing significant bowel irritation. The crew had been pretested with this drug and had experienced no untoward effects. The medication had the desired laxative effect and left no evidence of residual bowel irritability on launch morning. In order to reduce the probability of infection developing in areas of macerated or abraded skin during the flight, the crew was advised to bathe exclusively with soap containing hexachlorophene during their period in residence at KSC. The crew was also advised to shampoo with selenium sulfide detergent suspension during the last month before flight. This measure was adopted to suppress seborrheic activity of the scalp in the hope that flaking of skin from the scalp during the mission could be minimized. During the final 3 weeks prior to the mission, the flight crew exercised caution in their contact with large numbers of people in an attempt to minimize their exposure to infectious diseases, to the extent that this was operationally feasible. There were no known exposures of either crew member to infectious disease, nor were any signs or symptoms of disease noted during the preflight period.

7.2.1.5 Preflight medical examinations.- The general plan of preflight medical evaluation, which has been followed throughout the Gemini program, was considered adequate for support of this mission. The crew underwent a general screening examination at a point in time when any developing disease or existing injuries might be found in time to carry out effective treatment prior to the flight. This was followed by a comprehensive examination using military consultants representing the clinical specialties of neuropsychiatry, ophthalmology, otorhinolaryngology, and internal medicine with special emphasis on cardiology. In conducting this examination, the physicians concentrated on assessing and recording the condition and functional status of organs, systems, and the crew members as a whole. This was done so that significant changes, which might reasonably be expected to occur during the mission, could be detected and evaluated by repetition of this examination immediately after the flight. A final physical examination was conducted on launch day by the flight surgeons who had been working closely with the flight crew throughout their mission training and preflight preparation activities. There were no medical findings during the preflight examinations which had not been well documented previously, evaluated, and accepted as posing no hindrance to full flying duty. The crew reported medically qualified for the Gemini VII mission. The program for measuring blood volume was modified for this mission to include the use of tritiated diisopropylfluorophosphate (DFP) to measure more accurately red blood cell survival time than had been possible in earlier missions. Consequently, the flight crew were administered RISA (I^{125}), Cr^{51}, along with the DFP in preflight and postflight studies of plasma volume, red cell mass, and red cell survival time. See table 7.2-I for the dates and scope of the preflight medical evaluation activities.

7.2.1.6 Bioinstrumentation.- The Gemini bioinstrumentation sensors and signal conditioners which have been described in previous reports were employed in preflight altitude chamber tests and in spacecraft system tests to obtain records that were characteristic of each crew member's electrocardiographic, respiratory, and blood pressure responses during these activities. The complexity of the bioinstrumentation employed in the flight was increased because of certain medical experiments which were incorporated in this mission. The command pilot wore two extra signal conditioners in the pockets of his undergarment and an associated wiring harness with electrical leads attached to the four scalp electrodes which were positioned to detect the signals for the electroencephalograms (EEG) needed for the M-8 experiment. The pilot wore one additional signal conditioner in a pocket in his undergarment attached to the cable and microphone for the phonocardiogram experiment, M-4. (See section 8.6). Strain gages were employed during all tilt tests, in addition to the standard Gemini bioinstrumentation, to measure changes in the circumference of the lower limbs during the tests. Amplifiers, recorders, and display equipment compatible with the flight bioinstrumentation were used for recording physiological responses from the crew during tilt-table tests and exercise tolerance tests.

7.2.1.7 Medical support activities during the crew countdown.- All planned medical activities were accomplished on schedule and with no difficulty on launch day. Flight surgeons from the MSC Center Medical Office applied the operational biomedical sensors, the M-4 phonocardiogram microphone, and the M-1 cardiovascular conditioning pneumatic cuffs to the crew members. One of the scientific investigators accomplished the necessary shaving of areas on the command pilot's scalp, skin preparation, and placement of the surface EEG electrodes as called for in the M-8 experiment. Electrical checkout of all biomedical signals in the crew ready room at launch pad 16 confirmed that clean analog tracings of appropriate voltage and contour were being received from each signal conditioner before and after suiting. The electrical polarity of the axillary lead of the electrocardiogram (ECG) from the pilot was inadvertently reversed, producing a mirror image of the usual analog trace of that lead. The resulting condition caused no actual degradation of the ability of the monitors to evaluate the ECG from the pilot.

7.2.2 Inflight

This section of the report deals with subjects of aeromedical interest from analysis of events between lift-off and spacecraft landing. The Gemini VII flight was the longest manned space flight which has been accomplished to date, with lift-off at 19:30:03 G.m.t. on December 4, 1965 and touchdown at 14:05:05 G.m.t. on December 18, 1965. The duration of the flight was 13 days, 18 hours, 35 minutes, and 2 seconds.

7.2.2.1 Physiological data monitoring.- Flight crew physiological information acquired by the Gemini bioinstrumentation system, as well as certain physiologically important environmental conditions measured in the spacecraft, were transmitted by telemetry from the spacecraft. This information was monitored in real time by physicians at the Mission Control Center, Houston (MCC-H) and by flight surgeon aeromedical flight controllers at remote network tracking sites. Additional physiological data were stored on the biomedical tape recorders located in the spacecraft. The physiological phenomena telemetered to the ground included two leads of electrocardiogram, a pneumogram (respiration), and blood pressure from each crewman. The physiological data telemetered to the remote tracking stations were transmitted by way of voice-data lines to MCC-H, either during a station pass (real-time transmission) or after completion of a station pass (postpass replay). The quality of the analog data recorded at MCC-H was satisfactory for analysis and assessment of the crew's physiological condition. At certain times, however, individual traces of analog data were either not transmitted or transmitted so that data were not readable. In rare instances, all channels of data were unreadable simultaneously. This occurred usually during early morning hours when radio transmission noise altered the analog trace. Under these conditions, heart-rate information was usually obtainable by careful evaluation of the ECG tracings even though waveform analysis was not possible. Of course, no data were transmitted or recorded on board the spacecraft when the crew disconnected the bioinstrumentation cable while doffing and donning the pressure suits.

7.2.2.1.1 Electrocardiograms and heart rate: Electrocardiographic patterns and heart rates remained within normal limits during the entire flight. A detailed analysis of the electrocardiogram from each crew member was made for each station pass by the physicians at the site and at MCC-H, or both. At MCC-H, heart-rate information was displayed graphically as time histories prepared manually in the Life Systems Staff Support Room. Information plotted included: mean heart rate, highest heart rate, and lowest heart rate observed for each station pass, maximum heart rate recorded during the programmed exercise period over a station, 4 hours of station average heart rates, and 4-hour means of station high and low heart rates. Figure 7.2.4 shows, for each crew member, the 4-hour mean heart rates and average heart rate range for each 4-hour period plotted simultaneously with sampled respiration rate and oral temperature readings. Blood-pressure readings and peak heart rate values for each significant event and special period are displayed at the approximate ground elapsed time of their occurrence. Certain important time intervals are included, such as the approximate sleep periods compared with the day-night cycle at Cape Kennedy, Florida, the time of the Gemini VI-A mission, and the times when the pressure suits were removed. Electrocardiograms from each crewman were also recorded on the onboard biomedical tape recorder for significant periods of the flight. These periods were from 1 hour prior to lift-off through 96 hours of flight; 10 hours each day after the first 4 days, including each sleep period; and the last 5 hours of flight.

Selected portions of these records will be available in analog form for review at a later date. A detailed computer-assisted analysis of inflight ECG data, collected by all physician monitors during the mission, is planned when all data log books are available. Preliminary evaluation of these data has not revealed significant changes in ECG intervals.

7.2.2.1.2 Respiration: Respiration rates, as determined from telemetered impedance pneumograms, were well within expected normal ranges. The pneumogram on the command pilot was unreadable for certain portions of the flight. Postflight evaluation revealed that the output lead from the impedance pneumograph signal conditioner had come loose at the connector. The command pilot re-established this connection in flight, and, on the final mission day, the signal quality returned to normal.

7.2.2.1.3 Blood pressure: Blood-pressure measurements were obtained on each crew member during the flight. Blood-pressure values are plotted in figure 7.2-4. Blood-pressure determinations were associated with inflight exercise periods which were part of the M-3 experiment described in section 8.5. There were no major equipment problems with the Gemini blood-pressure measuring system on this flight. All blood pressures obtained were considered within normal limits. No trends were noted when comparing pre-exercise and post-exercise blood-pressure determinations. Greatest consistent differences between pre-exercise and post-exercise pressures (the post-exercise blood pressure being greater) occurred during approximately the same time interval: 255th hour through the 288th hour for the command pilot (a 33-hour period); 282nd hour through the 304th hour for the pilot (a 22-hour period). A possible significant factor is that Gemini VI-A lifted off early in the 258th hour of Gemini VII ground elapsed time and remained in orbit for approximately 24 hours. The Gemini VII crew were both suited during this period after having flown without suits for some time prior to rendezvous with spacecraft 6. During the latter part of the mission, low amplitude pulses, corresponding in time, duration, and frequency to the Korotkoff sound pulses on the blood-pressure trace, began to appear at or near full-scale cuff inflation. These pulses greatly increased the chance for observer variation in the determination of the systolic pressure. No cause has yet been established for the appearance of this Korotkoff sound trace anomaly. It is of interest that the command pilot stated that the blood-pressure cuff, when fully inflated, felt much tighter and more uncomfortable, while in orbit, than similar determinations made during the ground simulations in the spacecraft on the launch pad. The pilot, however, did not notice a difference.

7.2.2.1.4 Body temperature: Body temperature, measured by oral thermistor and telemetered to the ground, was sampled regularly from each crew member during the crew status reports. All valid temperature readings were within the normal range. Command pilot temperatures ranged from 96.8° to 98.6° F, with the most frequent reading being 97.8° F. Pilot temperatures ranged from 97.1° to 99.1° F with 98.6° F being recorded most frequently. The oral temperature probe, used in conjunction with the light-weight communications head set, tended to drift about the cabin when the pressure suit or the helmet was removed. Both crew members considered this to be a hazard, expecially to the eyes. Occasionally during the flight, subnormal body temperature readings were noted on the ground from the pilot when no oral temperature sampling was programmed. The pilot reported that when he was wearing the pressure suit without the helmet, the probe occasionally slipped down inside the suit against his chest, giving a spurious reading.

7.2.2.1.5 Other physiological data measurements: The EEG and phonocardiogram records were recorded on the inflight biomedical recorder only. The EEG was to be recorded continuously for 96 hours (4 days). During the first day of flight, one lead was detached inadvertently, despite the fact that the command pilot wore his helmet continuously to protect the sensor and leads. During the second day of flight, the remaining three leads became snagged on the ejection seat back and were detached. An attempt by the crew to replace the sensors was unsuccessful.

7.2.2.2 <u>Medical observations</u>.-

7.2.2.2.1 <u>Lift-off and powered flight</u>: The crew members independently stressed the consistent observation of all who have made Gemini flights that the physical sensations of lift-off are unmistakable, and that the visual cues inside the cabin, such as the clock starting, are of much less significance than the sensation of the build-up in thrust coming from the sound and vibration of the launch vehicle and the definite acceleration of the vehicle as it leaves the launch pad. The crew experienced no difficulty reading their instruments or talking during powered flight. The command pilot sensed a slight POGO effect, which he stated he might not have perceived if he had not participated in an earlier centrifuge simulation program at NASA Ames Research Center to evaluate this problem. None of the vibrations during powered flight caused the crew any difficulty. No vertigo or disorientation was experienced, and the only unusual sensation reported by the crew during build-up was a slight restriction in breathing near the time of maximum acceleration (approximately 7g).

7.2.2.2.2 Weightlessness and spatial orientation: The crew members graphically described the transition from powered flight to weightless orbital flight as having the combination of sensations which told them that they were in an ever-accelerating vehicle, then all sensations of movement abruptly ceased! The command pilot reported a brief rising against his restraining straps, but both the command pilot and the pilot experienced no perceptible change in position sense or sense of balance during this transition. Both crew members were very busy immediately after spacecraft separation and had little opportunity for introspective reflection. They carried out highly coordinated eye and hand movements without being aware of any clumsiness or loss of dexterity due to the abrupt occurrence of weightlessness. After about 20 minutes in orbit, both crew members became aware of a sensation of "fullness" in their heads. They described this as being exactly like the sensation produced by lying in a head-down position or hanging upside down from a trapeze bar. They took the time to investigate this sensation and cound not find anything remarkable about it, other than a steady, mildly uncomfortable sensation. Their mirror reflections did not appear flushed, nor were their eyes noticeably blood shot. There was no appreciable pulsation or audible pounding of arterial pulse accompanying the feeling. The condition persisted for an estimated 8 hours, gradually subsiding to the point where neither crew member was disturbed by the sensation at the beginning of the first sleep period. By the beginning of the second day, both crew members had lost the sensation completely and it did not recur during the remainder of the mission. They stressed that there were no sensations such as spatial disorientation, vertigo, nausea, or dizziness associated with this transient feeling. They reasoned that the condition was probably the result of a disproportionate flow of blood into the head due to the lack of a gravity vector influencing distribution of the circulating blood volume. This explanation was also considered most probably correct by the physicians who examined and debriefed the crew immediately after the mission. Except for this interesting observation, the crew found their weightless state scarcely remarkable throughout the entire flight. Their principal awareness that they were in a weightless environment stemmed from the movement of free-floating objects inside the cabin. The debriefing reports substantiate the statement that both crew members retained a high degree of psychomotor coordination and experienced no disorientation throughout weightless flight. They tested themselves with rapid and slow head movements with the spacecraft stabilized and with the spacecraft tumbling. Neither condition produced any sensory illusions.

Both crew members affirmed that orientation during weightlessness was accomplished readily by visual reference and that no conflicting sensory clues occur.

7.2.2.2.3 Food: The Gemini flight diet has been described in previous reports. Sufficient rations were stored in the spacecraft to provide each crew member three meals a day for 14 1/3 days. The crew found the meals generally acceptable and manageable. Each consumed an average of about 2,200 calories per day (table 7.2-II). A detailed analysis of their nutritional intake and metabolic balance will be reported with the final results of the M-7 experiment. During this extended flight, the crew discovered several minor operational difficulties relating to the food packaging and stowage. One noteworthy observation was that food with a texture that would be cohesive, soft, and slightly sticky, such as corn beef hash or mashed potatoes, could probably be eaten safely and most conveniently by opening the container and eating the food with a fork or a spoon. Despite elaborate packaging and preparation techniques, dry foods crumble and particles can be dispersed around the cabin, which is undesirable.

7.2.2.2.4 Water: About 180 pounds of potable water were available to the crew from the drinking-water system in the spacecraft. A modification of the water dispenser was installed in spacecraft 7 so that a measured amount of water was delivered each time the release lever was actuated, and the total number of water discharges was displayed on a cumulative digital counter attached to the device. Each depression of the trigger on the dispenser measured out 14 ml or approximately 1/2 fluid ounce of water. (See fig. 3.1-13.) Thus, it was possible for each crew member to record his fluid intake by logging the reading on the counter before and after withdrawing any water from the system for consumption, subtracting the two values to determine the number of counts used, and dividing this result by two to record the volume in ounces. Because the two crew members used a common system with only one counter, it was necessary for each crew member to log the number of counts used each time he withdrew water. The system worked throughout the flight and made it possible to keep a close record of daily water intake for the first time in the Gemini program. The required inflight bookkeeping was obviously very time consuming and the crew strongly recommended major simplification of the process for future Gemini flights. The command pilot reported that he had occasionally caught his lip in the water cut-off mechanism which operates at the delivery end of the nozzle in order to avoid the formation of free drops of water at the end of the nozzle. The small wounds healed normally without complication. Figure 7.2-5 and table 7.2-II show the computed daily water intake for each crewman and the cumulative water intake over the duration of the mission.

7.2.2.2.5 Waste management: The crew were able to utilize the waste-disposal systems provided for this flight, but they experienced considerable difficulty with the urine system and found urination to be an uncomfortable and unpleasant experience throughout the flight. There was a medical requirement on this flight for each crew member to collect a sample of each urination and stow it for postflight analysis. The details of the urine volume measuring and collection system were presented in section 8.7 of this report. The sample collection arrangement worked well, although one bag leaked when it was distended with urine. The crew carried a supply of 10 extra latex receivers in the expectation that each would be usable for several days. Under conditions of actual use, they rapidly became gummy with urine deposits after two or three voidings. This gummy condition made leakage more likely to occur. The crew members soon developed techniques to minimize spillage by voluntarily retarding the flow, and by packing absorbent tissue around the mouth of the receiver. The crew members estimated that they may have lost a significant portion of the volume voided during the first day or two of the flight while they were learning to cope with the system, but both felt that the volume spilled after that period of initial accomodation was insignificant in terms of measurable output, although very meaningful from an esthetic and comfort standpoint. The urge to urinate, frequency of urination, volume at each voiding, and sensations during micturition were subjectively normal for both crew members. Inflight defecation was not a problem for this crew. They reported that they found the defecation bags adequate for the purpose. Both reported that using the defecation bag was vastly easier when out of the pressure suit than when wearing the suit. The crew used 15 bags during the flight. Their stools were of normal consistency on every occasion, which they felt was a major factor in their ability to utilize the defecation bags without difficulty.

7.2.2.2.6 Personal hygiene: Flying without the pressure suit enabled the crew to maintain a greater degree of cleanliness than was possible on previous missions. The crew practiced area bathing and washed the face and neck, the armpits, and the groin, when indicated or desired. Cleansing tissue was found to be extremely useful, especially for the perineal area. Tissues were used dry or wet with water from the water gun. The wet wipe, a pre-moistened cleansing tissue, was used to cleanse the hands when necessary. Both crew members used their toothbrush with water at least daily. The command pilot brushed his teeth as much as three times a day. He also massaged his gums. Both crew members used the chewing gum provided for oral hygiene. Neither crew member experienced any oral hygiene problems during the flight. The command pilot was bothered by deposits of grime beneath his fingernails.

7.2.2.2.7 Sleep, fatigue, and day-night cycles: The flight crew reported that they found the work-rest schedule very satisfactory as a basic plan for the conduct of the mission. The flight plan was designed to allow the crew to sleep during hours which generally corresponded to their normal schedule. The beginning of the scheduled rest and sleep period was planned to occur about 1/2 hour earlier each night during the mission in order to allow the crew to be up and active throughout the daily series of consecutive passes across the southern United States. As was expected, neither crew member slept as long or as soundly in orbit as he was in the habit of doing at home. Ground measurements and crew reports agree that the pilot generally fell asleep more readily and slept more restfully than the command pilot throughout the mission. The command pilot reported that he found it unnatural to sleep in a seated posture, and believes that he would have slept better if it had been possible to stretch out full length on a bunk. For several days, the command pilot found that he awakened spontaneously during his sleep period, and that he became increasingly fatigued for several days; then reached a point where he slept soundly and restfully, after which he felt quite refreshed, only to begin another cycle of light and intermittent sleep until he became fatigued to the point where the distractions of the environment no longer interfered with relatively sound sleep. The crew placed sheets of metal foil obtained from food packages over the windows in addition to the polarized light shields to prevent the glare of sunlight from awakening them and to reduce the radiant heat load in the cabin from the sun shining through the windows. Estimated sleep records are included in figure ~~7.2-4~~ 7.2.1 and table 7.2-II. The crew found that the pneumatic pressure control device for the M-1 experiment constantly interfered with sleep throughout the mission. Each time it cycled to pressurize or depressurize the thigh cuffs worn by the pilot, it made a clicking sound which the crew reported was similar to a sharp cough. The crew elected not to interrupt the experiment and endured this annoyance throughout the flight.

The subjective impression of the crew was that their fatigue was not increasing due to lack of sleep toward the end of the mission, and that it did not interfere with their performance capability. They did feel, in retrospect, that they were both noticeably less patient and more irritable than normal during the last day or two of the mission. Medical observers on the ground unanimously reported that the crew was alert, sharp, and constantly on top of the situation throughout the mission. No objective evidence of performance decrement was noted.

7.2.2.2.8 Physical status and comfort: Both crew members believed that their overall physical sense of well being and level of comfort was directly related to the question of whether they were in or out of the pressure suit. While both were partially suited, they found the cabin atmosphere uncomfortably warm and dry. Nasal stuffiness, eye irritation, and dryness in the mouth were noticed by both while they were partially suited. During this portion of the mission the command pilot reported that he awakened with a dull, frontal headache, which he had experienced in the past upon traveling from Houston, Texas, or Cape Kennedy, Florida, with high relative humidity to Edwards Air Force Base, California, where the humidity is very low. Because of the limited circulation of cabin air in the partially suited condition, small particles floated randomly throughout the cabin creating an additional source of irritation when they got in the eyes, nose, or mouth. As soon as one crew member took his suit off, this condition improved. The cabin atmosphere flowing into the open suit-exhaust hose tended to entrain small particles which were collected on a filtered screen placed over the end of the hose. The overall humidity of the cabin atmosphere also rose, alleviating the irritating dryness of the cabin atmosphere. Each crew member stated that when he was out of his suit, he found living in the confines of the Gemini cabin vastly easier than when he was suited. Moving about required much less effort, and the cumbersome bulk of the suit did not bump into things. Personal hygiene was much easier to maintain, and because movement was so much less of an effort, each crew member found he was much more motivated to carry out his inflight exercise program while unsuited than while he was wearing his pressure suit.

The command pilot developed muscular pain while using the inflight exercise bungee device on the third day of the mission. This pain was high on the lateral aspect of his left thigh, and was fairly severe, then gradually subsided and disappeared completely after a day or two. Both crew members used the methylcellulose eyedrops from the inflight medical kit on occasion to relieve eye irritation. The command pilot employed the eyedrops more liberally than the pilot. They applied the skin lotion, which was furnished in an accessory kit, primarily to relieve dryness of the lips and nostrils. No other symptoms were reported and no other medications were used throughout the mission. The medical supplies that were on board are listed in table 7.2-III. Unpleasant odors developed intermittently from passage of flatus or when the waste stowage container was opened, but with circulation of the cabin atmosphere through the charcoal filtration bed the odor rapidly cleared. The crew were able to detect odors of food, urine, perspiration, and the like, throughout the mission, indicating that none of these odors persisted in the atmosphere at high levels for prolonged periods of time. If they had, the ability to detect them would have quickly become fatigued. Odor was not a serious problem to either crew member throughout the orbital phase of the mission.

7.2.2.2.9 Retrofire and reentry: The sensation of acceleration during retrofire was strong and somewhat surprising to both crew members. Each crew member felt that the subjective sensation of acceleration forces during reentry was proportionately greater than it had been during powered flight at the beginning of the mission or during centrifuge familiarization runs. A maximum of about 4g was reached during the lifting reentry trajectory and the crew had no problem controlling the spacecraft as required throughout this period of acceleration. The landing sequence was uneventful and no symptoms referrable to postural hypotension were experienced by either crew member during the descent. The major physical impression which the return to a 1g environment made on both crew members was a sensation of heaviness in their legs.

7.2.3 Postflight

These postflight data were obtained during clinical and special examinations, medical debriefing, and by laboratory examinations of blood, urine, and feces. During the postflight period deviations from normal were limited to the following: (a) A transient reduction in pulse pressure and an elevation of heart rate during the postflight tilt procedures which were greater than the preflight controls, (b) crew fatigue, and (c) body fluid changes.

7.2.3.1 Recovery activities.- Medical recovery activities were planned in advance of the mission and were modified as dictated by the observed medical responses of the crew.

7.2.3.1.1 Planned recovery procedures: After recovery, and after the crew had removed the pressure suits, a detailed examination by the medical evaluation team, which had examined the crew preflight, was planned. Tilt procedures were planned twice on the day of recovery and daily thereafter until the crew's responses had returned to preflight control values.

7.2.3.1.2 Narrative: Significant postflight medical events are listed in table 7.2-IV. After landing, the crew reported that they were comfortable in the spacecraft. They chose to egress from the spacecraft as soon as possible and come aboard the recovery carrier in the rescue helicopter. The crew felt no seasickness and no drugs were ingested at any time during the recovery phase. The crew egressed without difficulty, although they reported that their legs felt "a bit heavy," and they were immediately taken aboard the rescue helicopter, where both crew members were first seen by a NASA physician. This physician performed a brief examination and found no gross medical abnormalities in the crew, even though they were observed to be fatigued which was scarcely remarkable. Following landing, after a very short helicopter flight, the crew walked unassisted across the carrier flight deck, below decks, and to the ship's sick bay where the initial postflight medical examinations were performed. At no time during the recovery or postflight phase of the mission did the crew report any subjective symptoms of low blood pressure.

7.2.3.2 Examinations.- A detailed medical examination was conducted by the medical evaluation team, the NASA physicians, and experimenters aboard the ship as soon as the crew arrived in sick bay. The examination protocol with times planned and times realized is shown in table 7.2-V. With the exception of body fluid changes and tilt responses, no significant abnormalities were noted during this examination. The findings are summarized in tables 7.2-VI to 7.2-IX. It should be noted that additional urine findings will be reported later in relation to experiment M-7. Radiation film badges were attached to the crew's undergarments for measuring radiation exposure. The results obtained are shown in table 7.2-X.

Both crew members exhibited a relatively mild skin reaction to the tape used to fasten the body sensors in place. In contrast to the Gemini V crew, there was little if any dead skin that peeled off at the time of underwear doffing and the skin generally appeared to be in excellent condition. The 14-day beard growth was not matted and, following shaving, the facial skin appeared to be normal. The underwear was nearly saturated with perspiration, but appeared to be quite clean. Body odor was minimal. There was no skin reaction at any site, including the perineum, other than where the biosensors had been attached. Specifically, there were no maceration, no change in the skin turgor, and no evidence of pressure points. There was a very minimal scaling of both crew members' scalps. Following a sound sleep on the night of recovery, the crew appeared rested, and reported that they were well rested.

7.2.3.3 Tilt-table studies.- The tilt-table procedure used on the Gemini VII mission was in no manner different from the Gemini V tilt procedure. Four postflight tilt studies were performed on the command pilot and five were performed on the pilot. The additional tilt on the pilot was accomplished because his responses had not returned to normal after the fourth tilt. The first postflight tilt procedure on both crew members revealed a significant elevation of heart rate and decrease in pulse pressure. These changes were not as marked as those seen in the Gemini V crew. The command pilot completed the first and all subsequent tilts with no subjective symptoms of orthostatic hypotension. However, the pilot experienced rapidly decreasing heart rate and concomitantly decreasing pulse pressure during the first tilt. His tilt was terminated after 11 minutes in the tilted position. Electrocardiograms taken during this tilt demonstrated that a sinus rhythm was present throughout. The initial tilt responses returned to preflight normals as shown in figures 7.2.1 and 7.2-2. These cardiovascular responses, which were in this mission markedly different between crew members, are believed to have occurred because of physiologic alterations. The individual crewman's tilt responses were, however, influenced by a number of individual, operational, and environmental variables. This physiologic change did not in any manner compromise the crew's ability to function during the inflight or postflight phases of the mission. Just prior to termination of the tilt-up position on the first tilt procedure, the pilot reported that his vision was beginning to gray out. His skin became pale. He did not lose consciousness, nor did he exhibit any convulsive movements of his body. Upon return to the horizontal position, his skin became flushed in color, and he reported that "everything felt fine." At no other time did either crew member have any subjective symptoms nor difficulty in completing the standard tilt procedure (5 minutes horizontal, 15 minutes tilted, followed by 5 minutes horizontal). The strain gages gave a reliable indication of the increase in leg circumference during the 70° head-up tilt. From these readings a calculation of mean change in leg volume was derived, and these changes were significantly higher on both subjects during the postflight tilts when compared with preflight normals. This change in leg volume is considered to indicate a pooling of blood in the lower extremities when the subject is tilted to the 70° head-up tilt.

7.2.3.4 Exercise capacity test.- The first postflight exercise test was performed on the recovery carrier about 24 hours after landing. The test required the subject to pedal an electronic bicycle ergometer at a rate of 60 to 70 rpm. The load was set at 50 watts (300 mkg/min) for 3 minutes, and subsequently, the load was increased by 15 watts during the first 5 seconds of each minute. Heart rate, respiration rate, and blood pressure were recorded at rest on the bicycle and during the last 20 seconds of each minute during the test. Expired air was collected from the 15th to 60th second of the third minute and seventh minute. After heart rate reached between 160 and 170 beats per minute, expired air was collected each minute. The test was continued until heart rate reached or exceeded 180 beats per minute. Heart rate and blood pressure are followed for 5 minutes after terminating the exercise. The subject was supine during recovery from the exercise to prevent pooling of blood in the lower extremities. Expired air volume was measured with a dry gas meter and analyzed for carbon dioxide and oxygen on a Scholander apparatus. Physical competence is evaluated on the basis of oxygen uptake per kilogram of body weight during the last minute of the test.

The results of the preflight and postflight tests are presented graphically in figure 7.2-3. The postflight test on the command pilot was terminated at a heart rate of 171 beats per minute due to fatigue of his leg muscles. A second postflight test on each crewman is to be accomplished at a later date.

The procedure has demonstrated a decrease in work tolerance as reflected in a decreased time to reach the end of the test postflight: command pilot, 19 percent decrease; pilot, 26 percent decrease. There appears to have been a marked reduction in oxygen consumption during the test. The results are still under investigation.

TABLE 7.2-I.- SIGNIFICANT PREFLIGHT MEDICAL SUPPORT ACTIVITIES

Date, 1965	Activity	Nature and scope
September 22 October 14 November 4	Tilt studies	Characteristic response of crew member's heart rate, respiration, and blood pressure measured and recorded for postflight comparison.
November 4 November 24	Exercise capacity	Respiratory gas exchange, heart rate, blood pressure, and lung ventilation responses to ever-increasing workload measured to maximum attainable O_2 uptake and recorded for postflight comparison.
November 24	F-10 day examination	General physical examination by flight surgeon, routine laboratory analysis of blood and urine, initial injection of radiosotopes to measure plasma volume, red cell mass, and red cell survival time.
November 25 November 30 December 2	Blood samples drawn	Data points on red blood cells survival curve, plasma analyzed for biochemical constituents required for M-5 and M-7 experiments, blood to type and cross-match with emergency supply.
December 1	F-3 day examination	Comprehensive physical examination by medical specialists.
December 4	Launch day examination	General physical examination followed by application of biomedical sensors by flight surgeon.

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TABLE 7.2-II.- FOOD AND WATER CONSUMPTION AND SLEEP

Mission day	Reporting time for food and water intake, g.e.t., hr	Command pilot						
		Calories		Water intake				Sleep, hours
				Daily		Cumulative		
		Daily	Cumulative	Liters	Equivalent pounds	Liters	Equivalent pounds	
1	$9\frac{1}{2}$	807	807	0.59	1.29	0.59	1.29	5
2	33	2665	3 472	2.07	4.56	2.66	5.85	8
3	57	2306	5 778	2.41	5.31	5.07	11.15	7
4	81	1961	7 739	1.99	4.38	7.06	15.54	$8\frac{1}{2}$
5	105	1960	9 699	2.44	5.37	9.50	20.91	8
6	129	2571	12 270	2.30	5.06	11.80	25.97	6
7	153	2098	14 368	2.49	5.48	14.29	31.45	6
8	177	1966	16 334	2.02	4.45	16.31	35.90	$4\frac{1}{2}$
9	201	2427	18 761	2.60	5.73	18.91	41.63	$4\frac{1}{3}$
10	225	2069	20 830	2.27	5.00	21.18	46.63	6
11	249	2175	23 005	2.58	5.68	23.76	52.31	6
12	273	2226	25 231	2.18	4.80	25.94	57.11	8
13	297	2181	27 412	2.10	4.62	28.04	61.73	$7\frac{1}{4}$
14	321	2399	29 811	2.46	4.76	30.20	66.49	4
15	330	789	30 600	0.70	1.54	30.90	68.03	-

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TABLE 7.2-II.- FOOD AND WATER CONSUMPTION AND SLEEP - Concluded

Mission day	Reporting time for food and water intake, g.e.t., hr	Pilot						
		Calories		Water intake				Sleep, hours
				Daily		Cumulative		
		Daily	Cumulative	Liters	Equivalent pounds	Liters	Equivalent pounds	
1	$9\frac{1}{2}$	807	807	0.56	1.23	0.56	1.23	5
2	33	2530	3 337	1.88	4.14	2.44	5.37	7
3	57	2306	5 643	2.00	4.40	4.44	9.77	7
4	81	2184	7 827	1.90	4.18	6.34	13.96	9
5	105	1960	9 787	1.99	4.38	8.33	18.34	8
6	129	2166	11 953	2.44	5.37	10.77	23.71	6
7	153	2166	14 119	1.82	4.01	12.59	27.72	$6\frac{1}{2}$
8	177	2146	16 265	1.51	3.33	14.10	31.05	$7\frac{1}{2}$
9	201	2143	18 408	2.27	5.00	16.37	36.05	$6\frac{1}{2}$
10	225	2500	20 908	1.79	3.94	18.16	39.99	$7\frac{1}{4}$
11	249	2056	22 964	1.85	4.07	20.01	44.06	7
12	273	2226	25 190	1.93	4.25	21.94	48.31	$8\frac{3}{4}$
13	297	2404	27 594	1.60	3.52	23.54	51.83	8
14	321	2024	29 618	2.04	4.49	25.58	56.32	6
15	330	789	30 407	0.87	1.92	26.45	58.24	-

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TABLE 7.2-III.- INFLIGHT MEDICAL AND ACCESSORY KITS FOR GEMINI VII

Medical kit			
Medication	Dose and form	Label	Quantity
Cyclizine HCl	50 mg tablets	Motion sickness	8
d-Amphetamine sulfate	5 mg tablets	Stimulant	8
APC (Aspirin, phenacetin, and caffeine)	Tablets	APC	16
Meperidine HCl	100 mg tablets	Pain	4
Triprolidine HCl Pseudoephedrine HCl	2.5mg 60mg tablets	Decongestant	16
Diphenoxylate HCl Atropine sulfate	2.5mg 0.25mg tablets	Diarrhea	16
Tetracycline HCl	250mg film-coated tablet	Antibiotic	16
Methylcellulose solution	15cc in squeeze dropper bottle	Eyedrops	1
Parenteral cyclizine HCl	45mg (0.9cc in injector)	Motion sickness	2
Parenteral meperidine HCl	90mg (0.9cc in injector)	Pain	2

Accessory kit	
Item	Quantity
Skin cream (15cc squeeze bottle)	2
Electrode paste (15cc squeeze bottle)	1
Adhesive discs for sensors	12 for ECG, 3 for Phonocardiogram leads
Adhesive tape	20 in.

TABLE 7.2-IV.- POSTFLIGHT EVENTS AND MEDICAL ACTIVITIES

Date, 1965	Time, e.s.t.	Activity
December 18	9:05 a.m.	Spacecraft landing, 13 miles from U.S.S. Wasp
	9:24 a.m.	Egress from spacecraft
	9:27 a.m.	Both crewmen in helicopter
	9:37 a.m.	Arrive on flight deck, U.S.S. Wasp
	9:55 a.m.	Suits doffed
	10:00 a.m.	Begin initial medical examination
	12:15 p.m.	First postflight meal
	6:15 p.m.	Completed initial medical examination
	7:15 p.m.	Second tilt procedure and blood specimens
	10:30 p.m.	To bed, asleep shortly thereafter
December 19	7:30 a.m.	Awoke, breakfast
	8:10 a.m.	Third tilt procedure
	12:00 p.m.	Departed U.S.S. Wasp
	1:00 p.m.	Arrive Cape Kennedy
December 20	10:00 a.m.	Fourth tilt procedure; medical debriefing
December 21	10:40 a.m.	Fifth tilt procedure (pilot only; medical debriefing)

TABLE 7.2-V.- POSTFLIGHT MEDICAL EXAMINATION

(a) Command Pilot

Activity	Time, e.s.t.		Duration, min	Planned examination durations, min
	Start	Finish		
Touchdown time	9:05 a.m.			
Arrive on U.S.S. Wasp by helicopter	9:34 a.m.			
Arrive sick bay	9:40 a.m.			
Unsuiting	9:40 a.m.	9:55 a.m.	15	
Laboratory (Chest X-ray and densitometry)	9:55 a.m.	10:05 a.m.	10	0
Ophthalmology and internal medicine	10:05 a.m.	10:15 a.m.	10	35
Blood and isotopes	10:15 a.m.	11:10 a.m.	55	45
Tilt and bungee cord exercise	11:10 a.m.	12:00 p.m.	50	60
Audiogram	12:00 p.m.	12:10 p.m.	10	15
Lunch	12:10 p.m.	12:45 p.m.	35	
Electrocardiogram	12:45 p.m.	1:00 p.m.	15	0
Internal medicine	1:00 p.m.	1:20 p.m.	20	55
Neuropsychiatry	1:20 p.m.	2:05 p.m.	45	35
Ophthalmology	2:05 p.m.	2:35 p.m.	30	
Counterrolling and vision testing (including transit time)	2:35 p.m.	3:40 p.m.	65	90
Telephone	3:40 p.m.	3:50 p.m.	10	
Blood sample	3:50 p.m.	3:55 p.m.	5	
Ear, nose, and throat	3:55 p.m.	4:15 p.m.	20	30
Time in sick bay for examination			6 hr 35 min	5 hr 45 min

TABLE 7.2-V.- POSTFLIGHT MEDICAL EXAMINATION - Concluded

(b) Pilot

Activity	Time, e.s.t.		Duration, min	Planned examination durations, min
	Start	Finish		
Touchdown time	9:05 a.m.			
Arrive on U.S.S. Wasp by helicopter	9:55 a.m.			
Arrive sick bay	9:40 a.m.			
Unsuiting	9:40 a.m.	9:55 a.m.	15	
Tilt	9:55 a.m.	10:45 a.m.	50	60
Telephone	10:45 a.m.	10:45 a.m.	5	
Ophthalmology	10:50 a.m.	11:15 a.m.	25	
X-ray (chest and densitometry)	11:15 a.m.	11:25 a.m.	10	
Ophthalmology	11:25 a.m.	11:30 a.m.	5	35
Laboratory (blood and isotopes)	11:30 a.m.	12:20 p.m.	50	45
Lunch	12:20 p.m	12:50 p.m.	30	
Counterrolling and vision testing (including transit time and sensoring)	12:50 p.m.	12:00 p.m.	70	90
Audiogram	2:00 p.m.	2:15 p.m.	15	15
Ear, nose, and throat	2:15 p.m.	2:50 p.m.	35	30
Electrocardiogram	2:50 p.m.	3:00 p.m.	10	
Telephone	3:00 p.m.	3:05 p.m.	5	
Internal medicine	3:05 p.m.	3:30 p.m.	25	35
Neuropsychiatry	3:30 p.m.	4:15 p.m.	45	35
Waiting	4:15 p.m.	4:20 p.m.	5	
Blood sample	4:20 p.m.	4:25 p.m.	5	
Time in sick bay for examination			6 hr 45 min	5 hr 45 min

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TABLE 7.2-VI.- SUMMARY CLINICAL EVALUATION

(a) Command Pilot

	Preflight	Postflight		
		U.S.S. Wasp December 18, 1965 11:10 a.m. e.s.t.	U.S.S. Wasp December 18, 1965 7:15 p.m. e.s.t.	U.S.S. Wasp December 19, 1965 9:50 a.m. e.s.t.
Body weight (nude), lb	162.5	153.25	158.16	156.70
Temperature, oral, °F		98.4	99	98.4
Skin	Clear	2+ erythematous reaction to tape[1] at sensor sites. Minimal dandruff, otherwise clear.	No change; clear skin after shaving.	Minimal clearing of erythema at sensor sites.
Comments	Rested, physically and mentally fit for flight.	Moderately fatigued, sparse 2-week beard growth, alert, cooperative. Beard hairs 1.5 cm in length.	No change.	Rested.

[1]A porous, pressure-sensitive adhesive.

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TABLE 7.2-VI.- SUMMARY CLINICAL EVALUATION -Concluded

(b) Pilot

	Preflight	Postflight		
		U.S.S. Wasp December 18, 1965 10:10: a.m. e.s.t.	U.S.S. Wasp December 18, 1965 8:20 p.m. e.s.t.	U.S.S. Wasp December 19, 1965
Body weight (nude), lb	169.50	162.95	165.61	164.01
Temperature, oral, °F		98	98.9	98.4
Skin	Clear	Moderate erythematous reaction to tape(1), minimal dandruff, no desquamation.	No change; skin clear after shaving.	Minimal clearing of sensor site erythema.
Comments	Rested, physically and mentally fit for flight.	Fatigued, alert, cooperative, heavy beard. Beard hairs 1.5 cm in length.	No change.	Rested.

[1] A porous, pressure-sensitive adhesive.

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TABLE 7.2-VII.- BLOOD STUDIES

(a) Command Pilot

	Preflight			Postflight					
	Nov. 24, 1965	Nov. 30, 1965	Dec. 2, 1965	Dec. 18, 1965		Dec. 19, 1965	Dec. 20, 1965	Dec. 21, 1965	Jan. 7, 1966
Time, e.s.t.				11:30 a.m.	4:30 p.m.	3:30 p.m.	10:00 a.m.	8:00 a.m.	
White cell count/mm^3 (differential) . . .	5900	3875	4750	6400	9150	7375	3725	3800	6500
Neutrophites, percent	49	52	53	81	73	66	68	67	62
Juvenile forms, percent	0	0	0	0	0	1 band	1 band	1 myelo-cyte	0
Lymphocytes, percent	39	42	39	13	20	29	26	23	28
Monocytes, percent	11	5	6	4	6	3	3	5	9
Eosinophiles, percent	0	1	1	1	0	0	2	1	0
Basophiles, percent	1	0	1	1	1	1	0	1	1
Reticulocyte count, percent	1.0	(1.1 on Nov. 25)	1.0	1.05	1.05	1.05	1.2	1.4	3.4

	Mean	Range	Normal range	Mean (first 48 hr)	Mean (48 to 72 hr)	Mean
Red cell count, millions/mm^3	5.36	5.15 to 5.64		5.227	4.418	5.3
Hematocrit, percent	46	45 to 49		52	42	47
Hemoglobin concentrations, gram percent	16			16 50 to 53	15 41 to 43	16.4

	Mean	Range	Normal range	Dec. 18, 1965, 11:30 a.m.	Dec. 18, 1965, 4:30 p.m.	Dec. 19, 1965	Dec. 20, 1965	Dec. 21, 1965	Jan. 7, 1966
Red blood cell indices									
Mean corpuscular									
Volume, μ^3	86	83 to 89	85 to 93	101	94	100	97	88	90
Hemoglobin, γγ	30	29 to 33	27 to 31	31	30	36	34	31	30.5
Hemoglobin concentration, percent	34	33 to 35	30 to 34	30	32	35	35	35	35

Isotope volume studies	Predicted	Observed	Observed	Preflight to postflight volume change, cc	Preflight to postflight volume change, Percent
Blood volume, cc	4550	4418	4442	+24	+0.5
Plasma volume, cc	2502	2341	2760	+419	+15
Red blood cell mass volume, cc	2048	2077	1682	-398	-19
Red blood survival, days	25 days (normal 22 to 29 days)		18.5 days		
Spleen:liver	1.44		1.86 (+30 percent)		

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TABLE 7.2-VII.- BLOOD STUDIES - Concluded

(b) Pilot

	Preflight			Postflight					
	Nov. 24, 1965	Nov. 30, 1965	Dec. 2, 1965	Dec. 18, 1965		Dec. 19, 1965	Dec. 20, 1965	Dec. 21, 1965	Jan. 7, 1966
Time, e.s.t.				11:30 a.m.	4:30 p.m.	3:30 p.m.	10:00 a.m.	8:00 a.m.	
White cell count/mm^3 (differential) . . .	5900	7300	7400	13 700	10 800	5975	9975	4700	8500
Neutrophites, percent	60	63	57	84	78	67	50	62	60
Juvenile forms, percent	0	1 band	1 band	1 band	0	2 bands	0	0	0
Lymphocytes, percent	32	31	33	10	13	26	44	25	34
Monocytes, percent	6	5	8	5	9	5	3	8	5
Eosinophiles, percent	2	2	2	0	0	0	3	4	1
Basophiles, percent	0	0	0	0	0	0	1	0	0
Reticulocyte count, percent	7	(0.95 on Nov. 25)	9	0.95	-	0.85	0.85	1.05	1.30
	Mean	Range	Normal range	Mean (first 48 hr)		Mean (48 to 72 hr)			Mean
Red cell count, millions/mm^3	5.36	5.14 to 5.64		5.41		4.78			5.07
Hematocrit, percent	48	47 to 49		55		44			46
Hemoglobin concentrations, grams percent	16	15.9 to 16.5		16		15			15.1
Red blood cell indices									
Mean corpuscular									
Volume, μ^3	87	83 to 92	85 to 93	93	104	91	94	88	92
Hemoglobin, $\gamma\gamma$	29	29 to 30	27 to 31	28	30	32	34	29	29.5
Hemoglobin concentration, percent	34	33 to 35	30 to 34	35	29	35	36	33	33

Isotope volume studies	Predicted	Observed	Observed	Preflight to postflight volume change: cc	Preflight to postflight volume change: Percent
Blood volume, cc	4771	4643	4599	-44	0
Plasma volume, cc	2624	2672	2774	+101	+4
Red blood cell mass volume, cc	2147	1969	1825	-144	-7
Red blood survival, days	25 days (normal 22 to 29 days)		25 days		
Spleen:liver			1.45 (+13 percent)		

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TABLE 7.2-VIII.- BLOOD STUDIES - CHEMISTRIES

(a) Command Pilot

Determination	Preflight		Postflight			
Date, 1965	Nov. 24 and Nov. 25	Nov. 30 and Dec. 2	Dec. 18 11:30 a.m. e.s.t.	Dec. 18 18:20 a.m. e.s.t.	Dec. 19	Dec. 20 and Dec. 21
Blood urea nitrogen (BUN), mg percent	19	16	16	20	25	18
Bilirubin, total, mg percent	0.4	0.2	0.3	-	0.3	0.4
Alkaline phosphatase (B-L units)	1.7	2.0	1.7	-	-	-
17-OH corticosteroid, mg percent						
Sodium, m Eq/1	147	146	138	140	144	143
Potassium, m Eq/1	4.7	5.4	4.1	4.7	4.7	4.9
Chloride, m Eq/1	103	103	100	102	103	106
Calcium, mgms percent	9.0	9.2	8.6	9.2	9.0	9.2
Phosphate, mgm percent	3.2	3.7	4.0	3.2	3.1	3.6
Glucose, mgm/100 ml, non-fasting	71	90	98	-	-	-
Albumen, gm percent	4.6	4.73	5.16	-	4.5	4.6
Alpha 1, gm percent	0.23	0.26	0.08	-	-	-
Alpha 2, gm percent	0.40	0.39	0.40	-	-	-
Beta, gm percent	0.63	0.84	0.72	-	-	-
Gamma, gm percent	1.03	0.97	0.72	-	-	-
Total protein, gm percent	6.9	7.2	7.1	7.6	7.0	7.1
Uric acid, mgm percent	6.8	6.6	4.6	6.0	5.9	6.0

TABLE 7.2-VIII.- BLOOD STUDIES - CHEMISTRIES - Concluded

(b) Pilot

Determination	Preflight		Postflight			
Date, 1965	Nov. 24 and Nov. 25	Nov. 30 and Dec. 2	Dec. 18 12:30 a.m. e.s.t.	Dec. 18 18:00 a.m. e.s.t.	Dec. 19	Dec. 20 and Dec. 21
Blood urea nitrogen (BUN), mg percent	23	22	21	28	27	24
Bilirubin, total, mg percent	1.1	2.1	1.5	-	-	0.4
Alkaline phosphatase (B-L units)	1.4	1.5	1.2	-	-	-
Sodium, m Eq/l	149	146	139	144	143	144
Potassium, m Eq/l	4.9	5.1	4.1	5.0	5.5	5.0
Chloride, m Eq/l	104	103	97	101	100	104
Calcium, mgms percent	9.5	9.6	9.2	9.4	10.0	9.6
Phosphate, mgm percent	3.1	3.3	3.9	3.9	.34	3.4
Glucose, mgm/100 ml, non-fasting	79	94	77	-	-	-
Albumen, gm percent	4.54	5.40	3.93	-	-	4.5
Alpha 1, gm percent	0.24	0.10	0.23	-	-	-
Alpha 2, gm percent	0.49	0.37	0.54	-	-	-
Beta, gm percent	0.74	0.70	0.86	-	-	-
Gamma, gm percent	1.47	1.09	1.41	-	-	-
Total protein, gm percent	7.5	7.6	7.0	7.9	8.1	7.2
Uric acid, mgm percent	6.1	5.8	3.8	5.3	5.0	5.0

TABLE 7.2-IX.- URINALYSIS

(a) Command Pilot

	Preflight		Postflight							
	F-3 days	F-2 days	R + 2 hr	R + $6\frac{1}{2}$ hr	R + 10 hr	R + $18\frac{1}{2}$ hr	R + $24\frac{1}{2}$ hr	R + $42\frac{1}{2}$ hr	R + $65\frac{1}{2}$ hr	R + 4 days
Volume, cc	455	390	505	345	368	545	430	313	270	390
Specific gravity	1.011	1.013	1.009	1.018	1.012	1.014	1.016	1.022	1.009	1.017
pH	5.8	6.0	6.8	6.4	5.6	6.0	6.2	6.2	6.0	6.0
Color, appearance	Straw, clear	Yellow, clear	Yellow, slight turbidity	Yellow, clear	Yellow	Yellow, clear	No data	Yellow, clear	Straw, clear	Yellow, clear
Sugar, protein, acetone	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Microscopic/high yield power field	Rare white blood cell	Rare epithelial cell	Not done	Not done	Not done	Not done	Not done	Rare white blood cell	Rare epithelial cell	Rare white blood cell

(b) Pilot

	F-3 days	F-2 days	R + 2 hr	R + $6\frac{1}{2}$ hr	R + 10 hr	R + $18\frac{1}{2}$ hr	R + $24\frac{1}{2}$ hr	R + $42\frac{1}{2}$ hr	R + $65\frac{1}{2}$ hr	R + 4 days
Volume, cc	175	262	440	287	185	428	263	485	488	853
Specific gravity	1.017	1.026	1.010	1.019	1.026	1.022	1.024	1.015	1.016	1.011
pH	6.2	5.9	7.0	6.0	5.8	5.8	5.8	6.4	5.8	5.8
Color, appearance	Yellow, clear	Yellow, slight turbidity	Yellow, slight turbidity	No data	No data	Yellow, slight turbidity	No data	Yellow, clear	Yellow, clear	Yellow, turbid
Sugar, protein, acetone	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Microscopic/high yield power field	Mucus shreds, rare white blood cell	Slight mucus shreds, rare white blood cell	Not done	Not done	Not done	Not done	Not done	Mucus shreds, clump of squamous epithelial cells, 1 to 2 white blood cells; rare blood cells	Slight mucus shreds; rare calcium oxylate crystal; rare white blood cells	Slight mucus shreds; 1 to 2 white blood cells

TABLE 7.2-X.- CREW RADIATION

[The Gemini VII radiation film badges were read out using a thermoluminescent detector]

Command Pilot

Film badge location	Dose, millirem (±6 percent)
Right chest pocket	113
Left chest pocket	192
Left thigh pocket	178

Pilot

Film badge location	Dose, millirem (±6 percent)
Right chest pocket	231
Left chest pocket	105
Right thigh pocket	163

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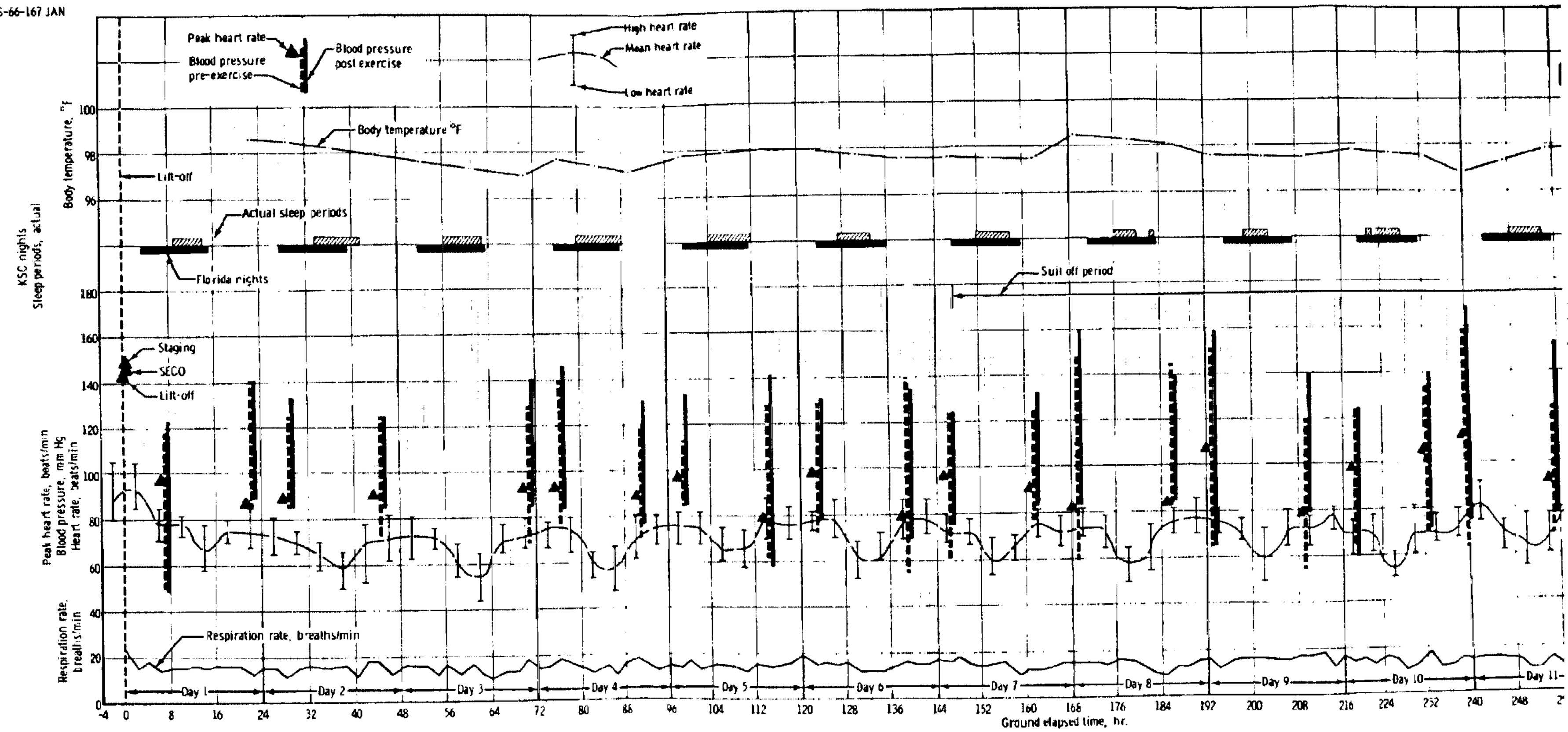
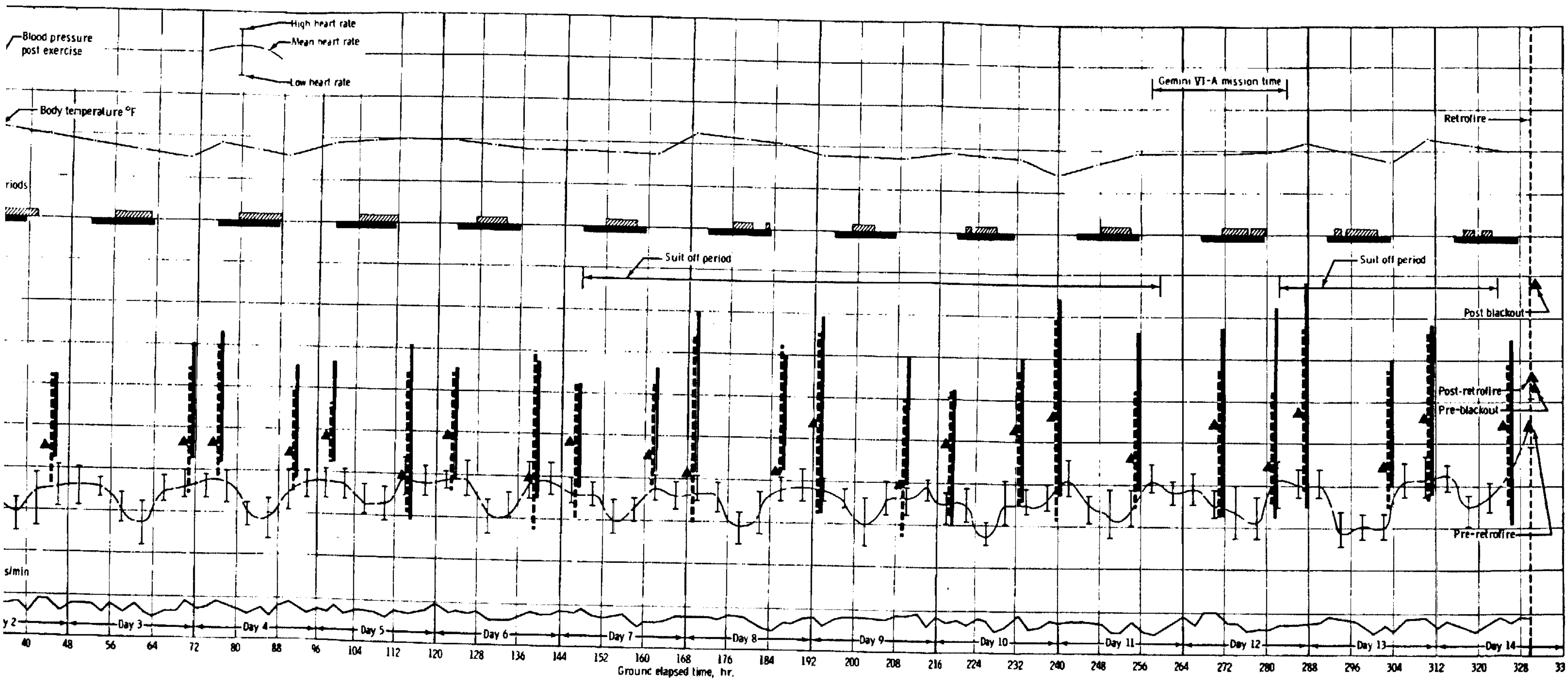


7-93-a

7-93-a

7-93 b



7-93-b

7-93-a

7-93 b

(a) Command pilot

Figure 7.2-1 -Physiological measurements.

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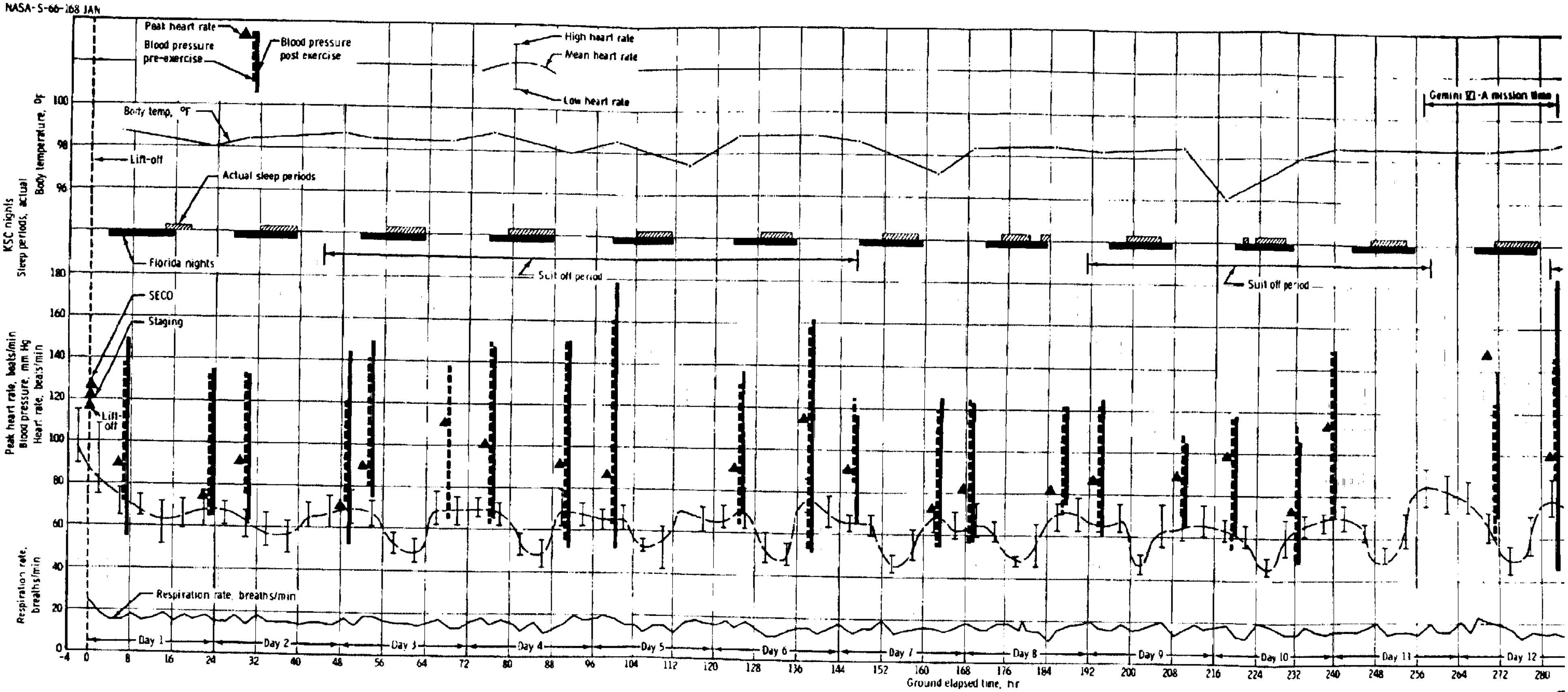

7-94-a

7-94-a

Figure 7.

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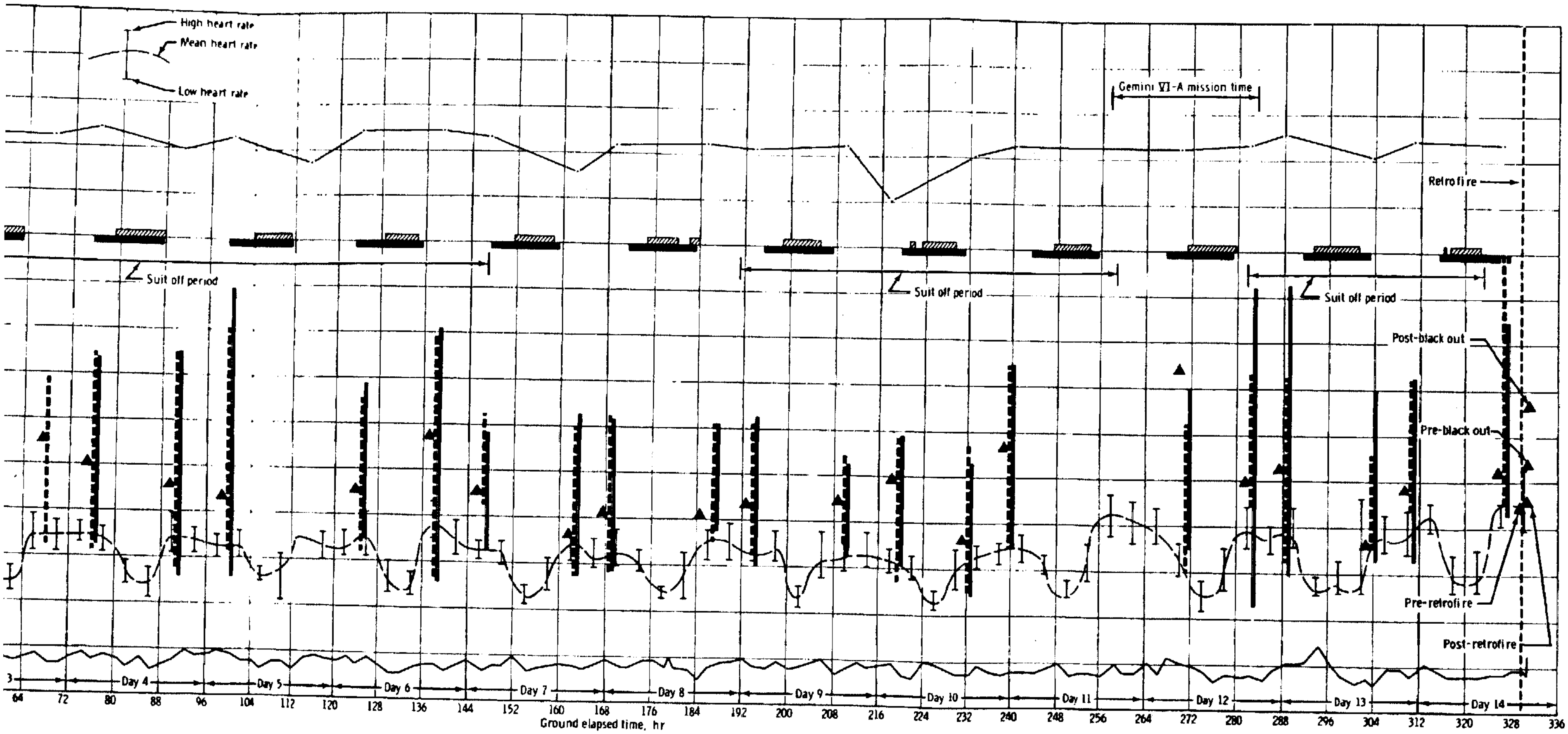

7-94-a

7-94-b

(b) Pilot

Figure 7.2-1. - Concluded.

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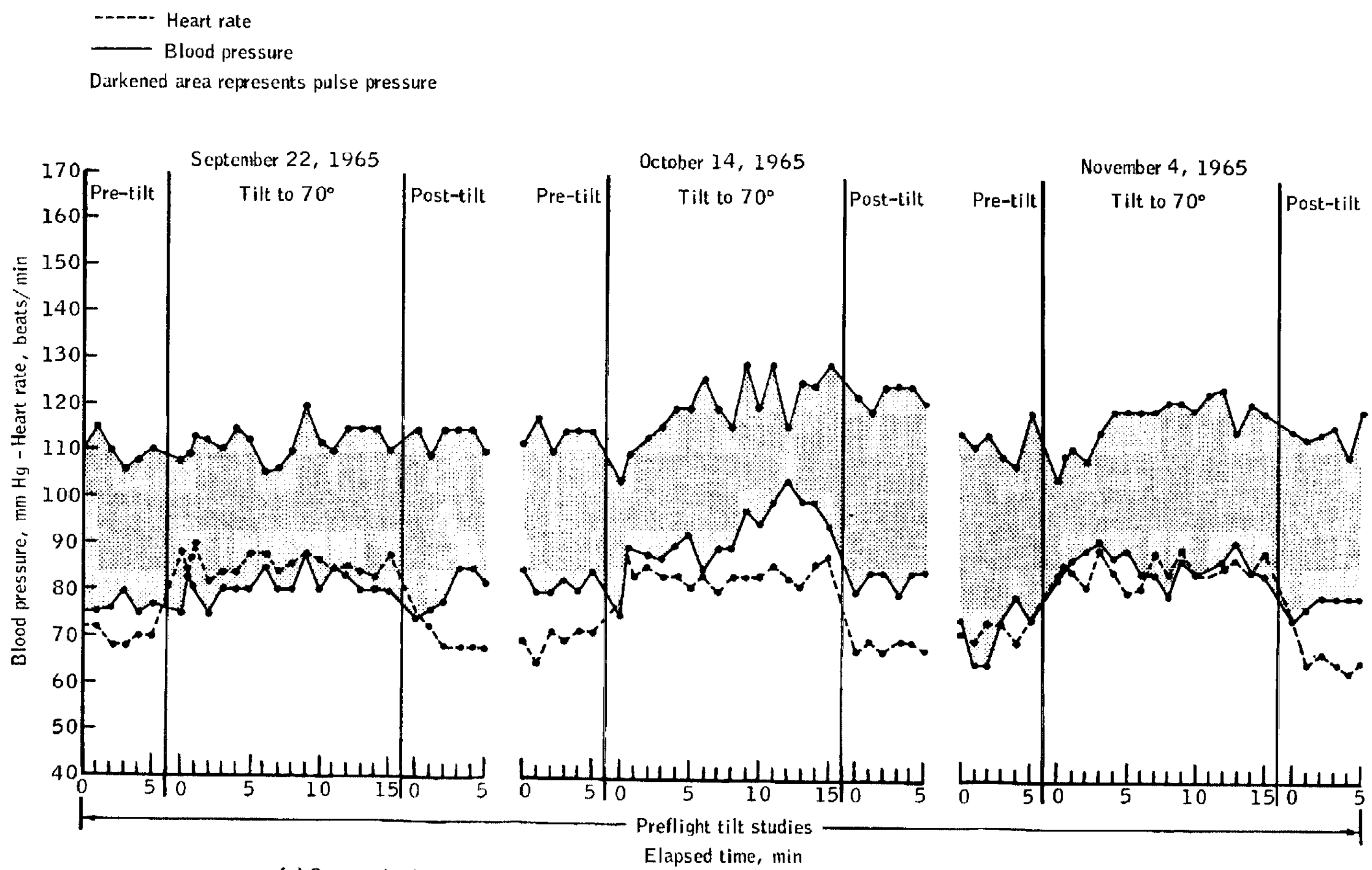

(a) Command pilot.

Figure 7.2-2. - Tilt table studies.

7-76-a

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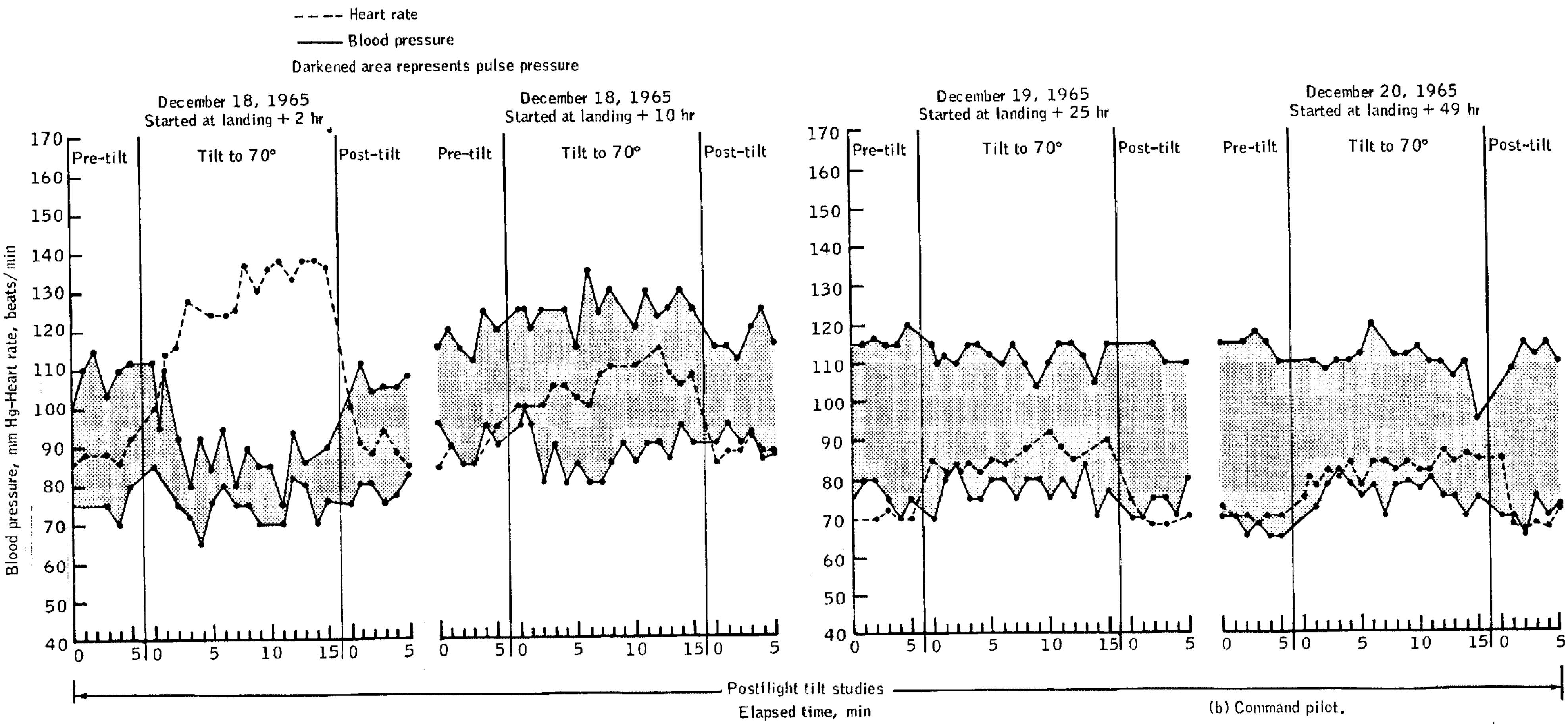

(b) Command pilot.

Figure 7.2-2. - Concluded.

7-97-a

7-97-b

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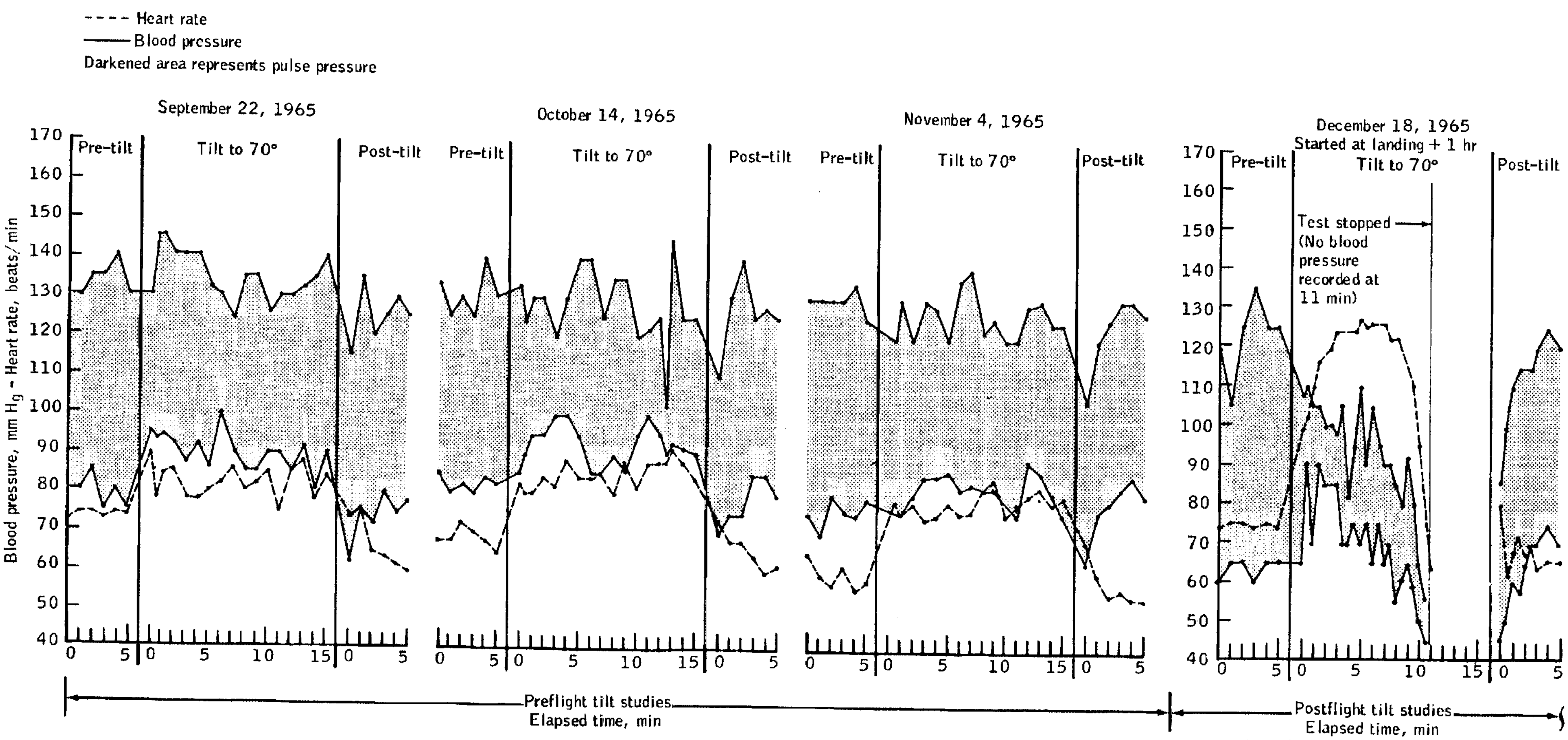

(a) Pilot.

Figure 7.2-3. - Tilt table studies.

7-98 7-98-a 7-98-b

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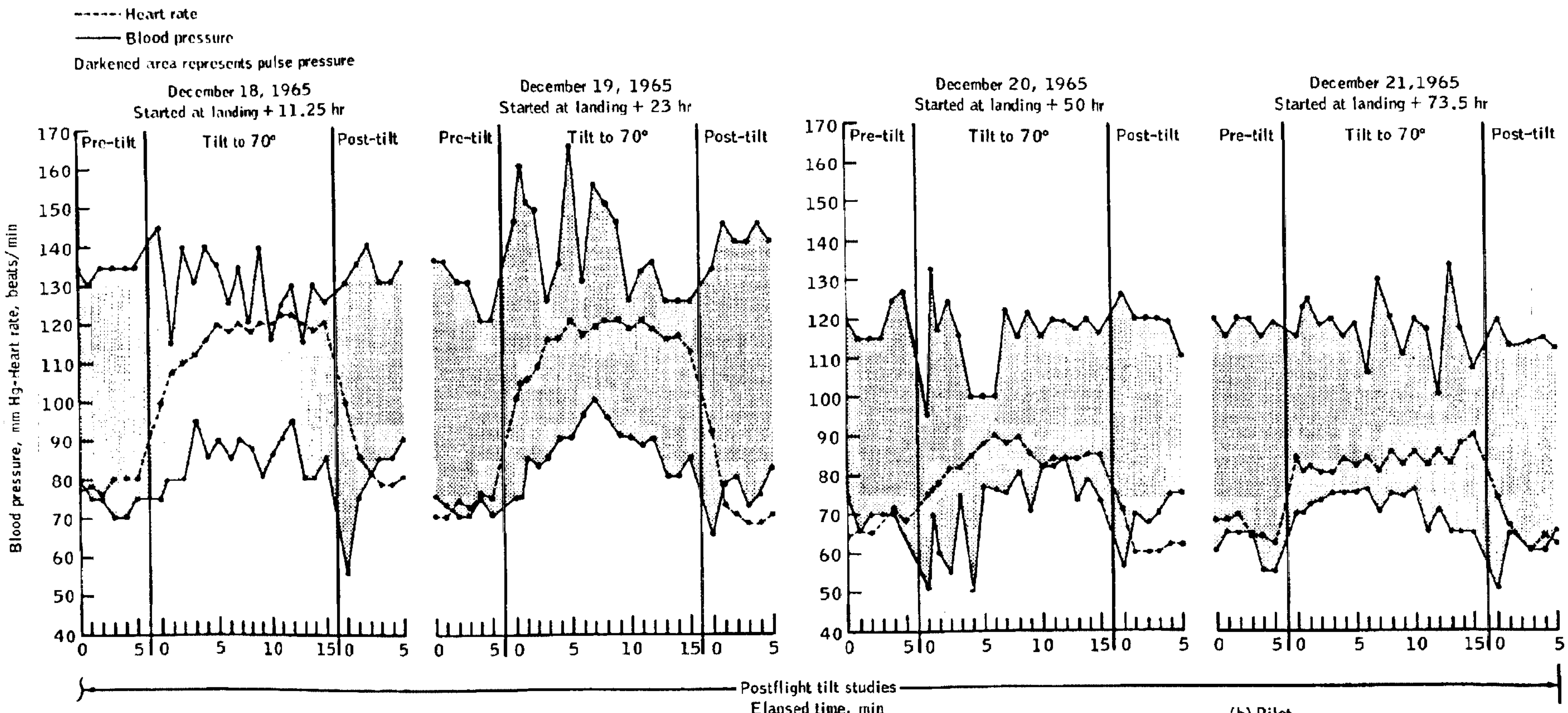

7-99-a

7-99-a

(b) Pilot.

Figure 7.2-3. - Concluded.

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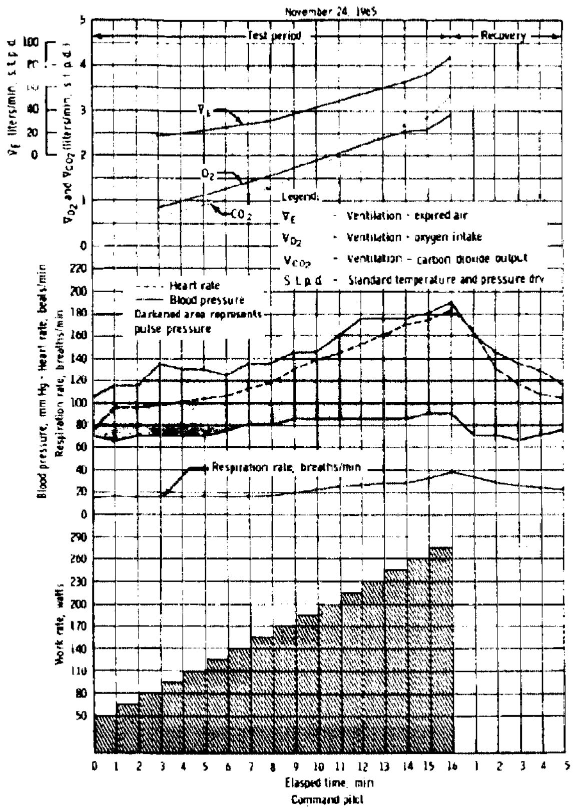
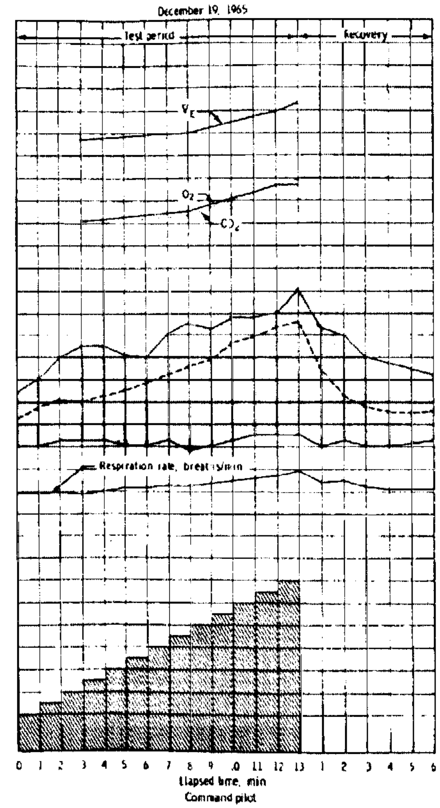
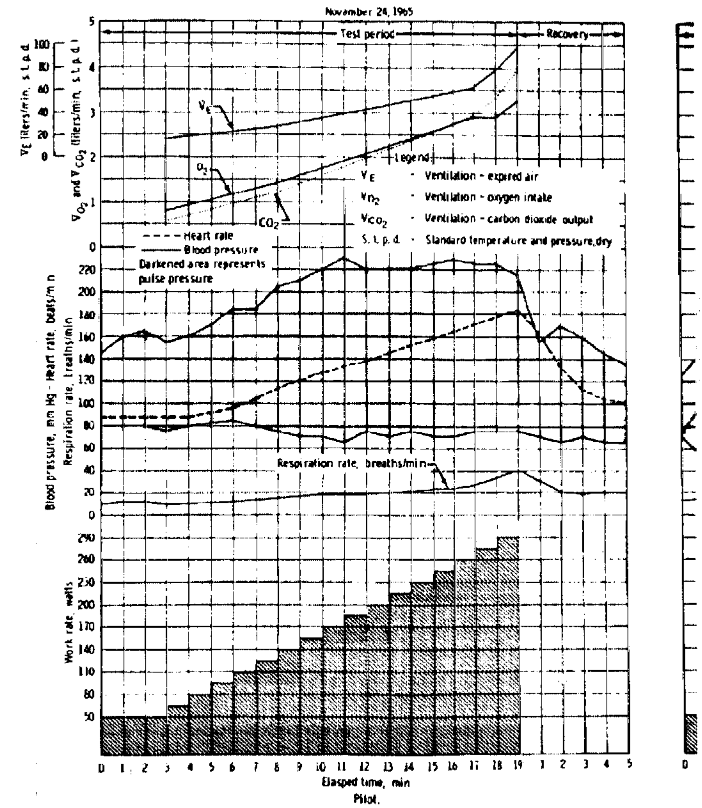
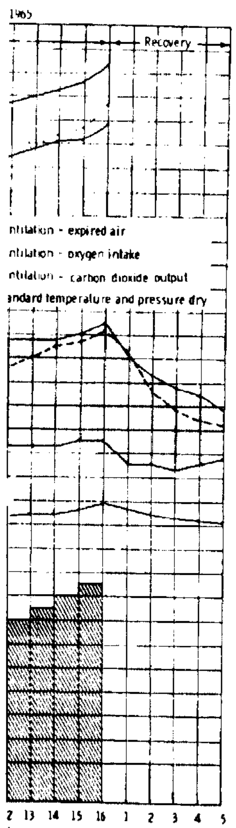




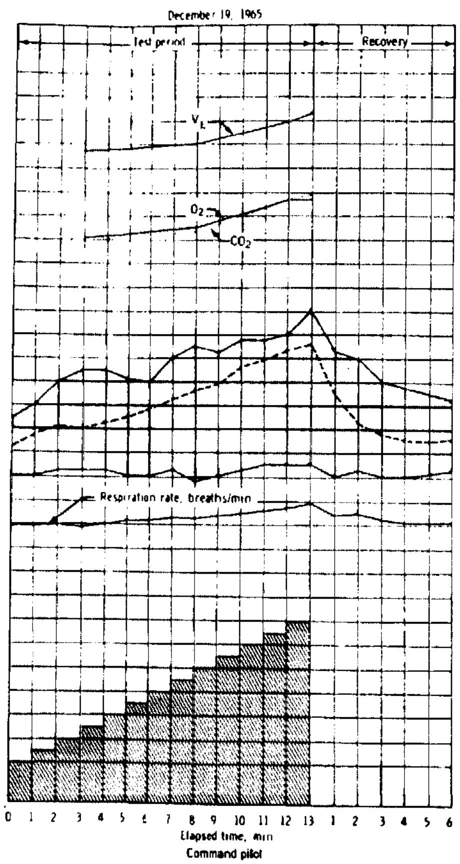


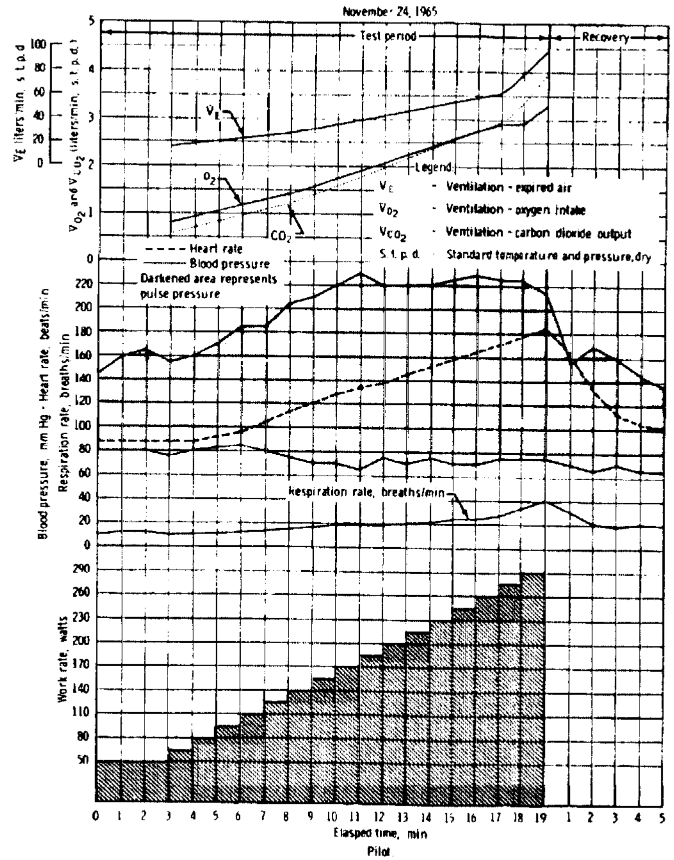
~~7-100~~ 7-101-a

7-101 b 7-101-a



7-101-a





7-101-ℓ- 7-101-a

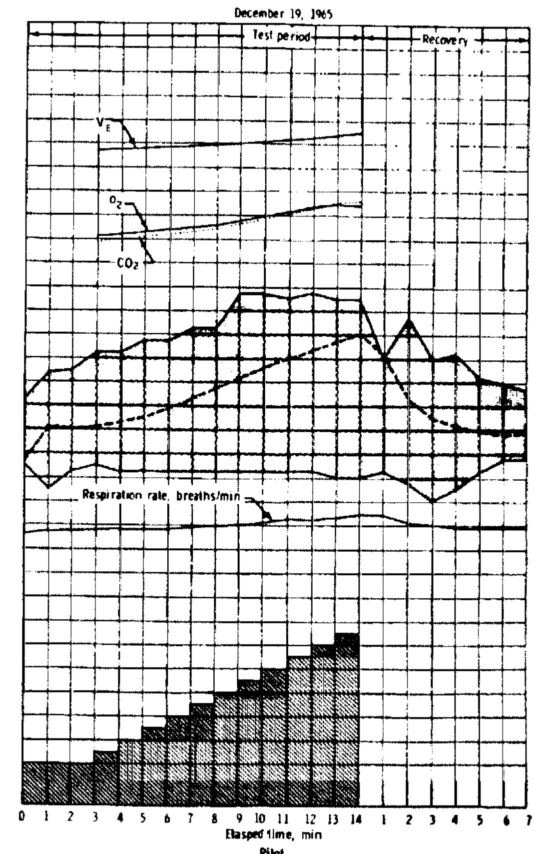


Figure 7.2-4. - Exercise capacity test results.

7-101-b.

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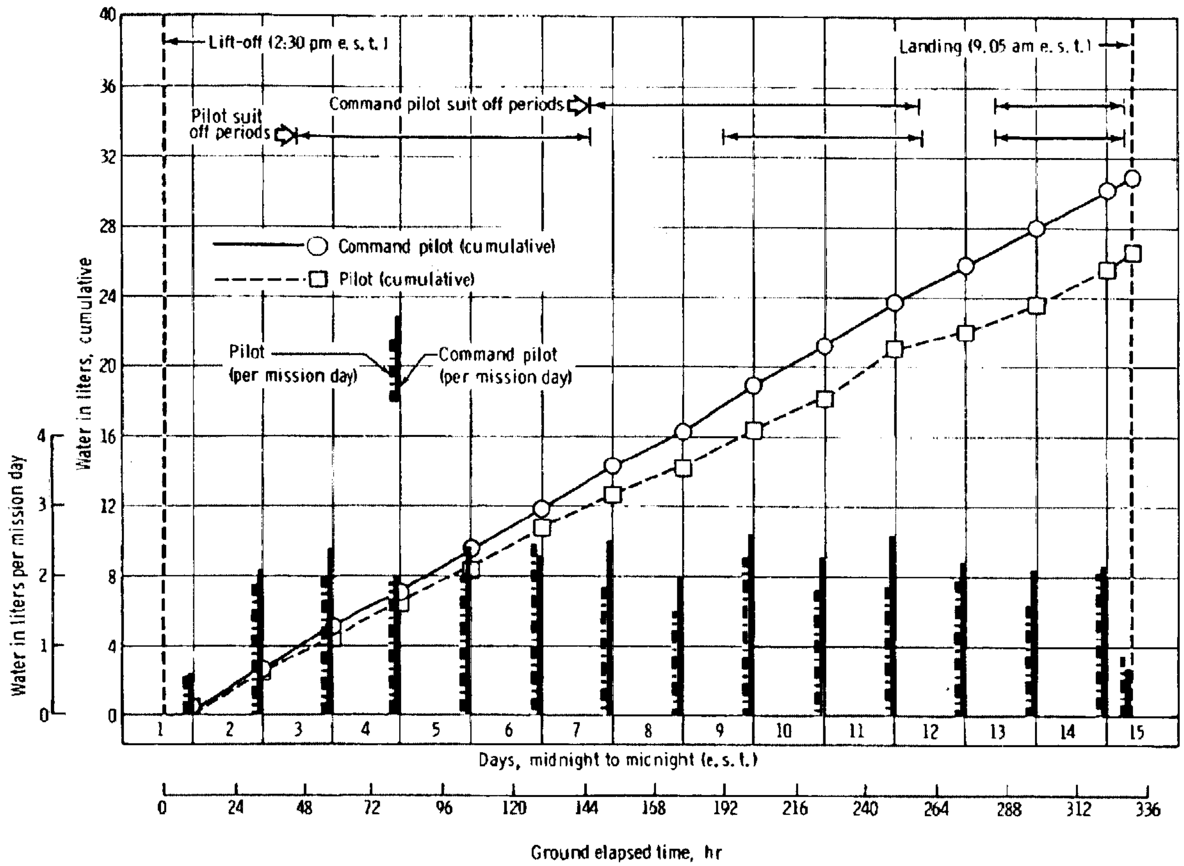

Figure 7.2-5. - Drinking water intake.

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8.0 EXPERIMENTS

Twenty scientific, medical, technological, and engineering experiments were planned for the Gemini VII mission to extend man's knowledge of space and to develop further the ability to sustain life in the space environment. These experiments are listed in table 8.0-I. Experiments S-8 and D-12 were combined for this report, as were D-4 and D-7, because of similar objectives. The D-5 and MSC-12 experiments were not conducted because of a failure in the flight experiment hardware.

Only a preliminary evaluation of the experiments results can be presented in this report because of the nature of these experiments. In most cases, detailed evaluations and conclusions will be published in separate documents after all data for each experiment have been analyzed.

TABLE 8.0-I.- EXPERIMENTS

Experiment number	Experiment title	Principal experimenter	Sponsor
D-4/D-7	Celestial Radiometry/Space Object Radiometry	Optics and Radiometry Laboratory, Air Force Cambridge Research Laboratory, Bedford, Massachusetts	Department of Defense
D-5	Star Occultation Navigation	Air Force Avionics Laboratory, Wright Patterson Air Force Base, Dayton, Ohio	Department of Defense
D-9	Simple Navigation	Air Force Avionics Laboratory, Wright Patterson Air Force Base, Dayton, Ohio	Department of Defense
M-1	Cardiovascular Conditioning	Space Medicine Branch, Crew Systems Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
M-3	Inflight Exerciser	Space Medicine Branch, Crew Systems Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
M-4	Inflight Phonocardiogram	Space Medicine Branch, Crew Systems Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
M-5	Bioassays Body Fluids	Space Medicine Branch, Crew Systems Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
M-6	Bone Demineralization	Nelda Childers Stark Laboratory for Human Nutrition Research, Texas Women's University, Denton, Texas	NASA Office of Manned Space Flight
M-7	Calcium Balance Study	National Institute of Health, Bethesda, Maryland; and Cornell University, Ithaca, New York	NASA Office of Manned Space Flight
M-8	Inflight Sleep Analysis	Baylor Medical School, Waco, Texas	NASA Office of Manned Space Flight
M-9	Human Otolith Function	U.S. Naval School of Aviation Medicine, Pensacola, Florida	NASA Office of Manned Space Flight
MSC-2	Proton-Electron Spectrometer	Radiation and Fields Branch, Advanced Spacecraft Technology Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight

TABLE 8.0-I.- EXPERIMENTS - Concluded

Experiment number	Experiment title	Principal experimenter	Sponsor
MSC-3	Tri-Axis Magnetometer	Radiation and Fields Branch, Advanced Spacecraft Technology Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
MSC-4	Optical Communications	Electromagnetic Systems Branch, Instrumentation and Electronics Systems Division, NASA-MSC, Houston, Texas	NASA Office of Manned Space Flight
MSC-12	Landmark ~~Contract~~ Contrast Measurements	Guidance Development Branch, Guidance and Control Division, NASA-MSC, Houston, Texas; MIT Instrumentation Laboratory, Cambridge, Massachusetts	NASA Office of Manned Space Flight
S-5	Synoptic Terrain Photography	Theoretical Division, NASA-Goddard Space Flight Center, Greenbelt, Maryland	NASA Office of Space Science and Applications
S-6	Synoptic Weather Photography	National Weather Satellite Center, U.S. Weather Bureau, Suitland, Maryland	NASA Office of Space Science and Applications
S-8/D-13	Visual Acuity/Astronaut Visibility	Visibility Laboratory, Scripps Institute of Oceanography, University of California, San Diego, California	NASA Office of Space Science and Applications/Department of Defense

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8.1 EXPERIMENT D-4/D-7, CELESTIAL RADIOMETRY AND SPACE OBJECT RADIOMETRY

8.1.1 Objective

The objective of the D-4/D-7 experiment on spacecraft 7 was to obtain spectral irradiance information about terrestrial features and celestial objects.

8.1.2 Equipment

The D-4/D-7 experiment differed from that flown on spacecraft 5 in that the bolometer detector and the 1P28 photomultiplier tube (PMT) had been removed from the radiometer and a new, more sensitive PMT had been installed. The radiometer filters were also different, in some cases, from those which were flown on spacecraft 5. Otherwise the equipment was the same.

8.1.3 Procedure

The experiment began during the first revolution with equipment erection. Measurements were then made on the launch vehicle second stage using the radiometer and the D-4/D-7 cryogenic spectrometer. Additional 8-12 μ measurements were made with the cryogenic spectrometer on the stars Rigel and Sirius, void space, and the dark earth horizon. After depletion of the cryogenic supply, measurements were accomplished using the radiometer and infrared spectrometer on the moon, selected stars, the milky way, earth backgrounds in day and night, a Polaris missile launch, a Minuteman missile reentry, lightning, a rocket-sled run, clouds, spacecraft 6 during station keeping and separation of the two spacecraft, a large fire in Africa, and, finally, the sun.

8.1.4 Results

A total of 37 separate measurements was made. Of the 32 possible subjects to be radiometrically measured, 29 were measured. Two of the remaining three were target-of-opportunity measurements dependent upon weather; the third was not considered of primary importance, and was deleted in real time. A total of 3 hours 6 minutes 19 seconds was used for these measurements. This information has been updated since the Gemini VII Interim Mission Report, and is based on additional information presented at the D-4/D-7 experiment debriefing.

8.1.5 Conclusions

All D-4/D-7 equipment is believed to have functioned perfectly during the flight. Quick-look information concerning several of the measurements has been reviewed and the quality appears excellent. Both of the crew members performed an outstanding job in accomplishing all possible experiment objectives. From the data seen to date, all indications are that the experiment was very successful. Final results will not be available, however, until all the raw data have been processed.

8.2 EXPERIMENT D-5, STAR OCCULTATION NAVIGATION

8.2.1 Objective

The objectives of this experiment were to determine the usefulness of star occultation measurements for space navigation, and to determine a horizon density profile to update atmospheric models for horizon-based measurement systems.

Knowledge of the time of occultation of a known star by a celestial body, as seen by an orbiting observer, determines a cylinder of position whose axis is the line through the star and the body center, and whose radius is equal to the occulting body radius. The times of six occultations provide information to uniquely determine all orbital parameters of the orbiting body. Determination of these times of occultation by the earth is difficult because of atmospheric attenuation of the star light. The star does not arbitrarily disappear but dims gradually into the horizon. Measurement of the percentage of dimming with respect to the altitude of this grazing ray from the star to the observer provides a percentage altitude for occultation. That is, the star can be assumed to be occulted when it reaches a predetermined percentage of its unattenuated value. The procedure for the D-5 experiment provides the means of measuring this attenuation with respect to time in order to determine the usefulness of the measurements for autonomous space navigation. In addition, the measurements would provide a density profile of the atmosphere which could be used to update the atmospheric model for this system and refine models used for other forms of horizon-based navigation, orbit predictions, and missile firings.

8.2.2 Equipment

The star occultation photometer is a single-unit, dual-mode, hand-held, externally powered instrument for electronically determining the extent to which the sight line to a selected star penetrates a planetary atmosphere. It also measures the contrast of a sun-illuminated ground target. Data from the instrument, when correctly calibrated and plotted against time, provide the attenuation curve of a star passing through the earth atmosphere relative to an unattenuated intensity. The general characteristics of the equipment are as follows:

Size	5 in. by 5 in. by 3 in.
Weight	2-1/2 lb
Volume	30 cu in.

Magnification . . . . × 6.0

Image . . . . Erect

The optical system of the star-occultation photometer is a dual-path-type system separated on a wavelength basis by a dichroic reflector. One path carries the short-wavelength star spectrum (0.4 to 5 micron) to the photomultiplier cathode; the remainder of the starlight continues into the operator's eye. The electronic system consists of a photomultiplier detector, preamplifier, active-band-pass-filter amplifier, and postfilter-amplifier demodulator in the carrier signal section. A unijunction oscillator and flip-flop are used to generate two-phase 100-cps power for the size-5 hysteresis-synchronous modulator motor. Input power to the motor is regulated. Additional voltage supplies provide an isolated lower voltage to the signal circuitry and a high voltage to the photomultiplier. Output of the low-pass filter is conducted to the input of the Schmitt trigger-level detector which is biased at approximately 1 volt. Depressing the CALIBRATE button inserts a nominal 5 to 1 attenuator in both day and night signal paths, lowering the full signal amplitude from 5 volts to 1 volt for calibration. The photometer is made ready for use by plugging in one cable for power and one cable for high-level telemetry, and by placing the mode switch to NIGHT.

8.2.3 Procedure

Star occultation measurements are made by identifying, acquiring, and tracking selected stars in the 1/2° reticle of the 10° field of view of the photometer. The light intensity of the star is normalized to the 5-volt telemetry output by depressing a CALIBRATE button and adjusting the gain to drive the reticle light to an alternating red-green condition. Thus normalized, the button is released and the star is tracked as it disappears into the horizon. The star intensity is measured, recorded, and time-correlated on the onboard high-level telemetry tape for postflight analysis. On any night pass, four to six stars are acquired, calibrated, and tracked to occultation; and the star and approximate time of occultation recorded in the flight log for postflight correlation with tape data and ground-track information. Timing marks are recorded on the telemetry (using the CALIBRATE button) on some runs in order to time special selected observations such as the time a star passes through the top of the airglow. Postflight data reduction and analysis would be accomplished to furnish information for the following uses.

(a) Occultation measurements would be incorporated in navigation equations to determine orbital parameters. The results would be compared with ephemeris data to determine the accuracy of the calibration.

(b) Ground-track position data would be used to determine the altitude of the grazing rays with respect to atmospheric attenuation to provide an atmospheric density profile.

(c) The newly determined atmospheric model would be used to re-compute navigation parameters from the star occultation measurements. These would be compared with ephemeris data and the previous navigation measurements to evaluate the degree of improvement.

8.2.4 Results

The photometer gathered no useful data because of an instrument malfunction. Subsequent to the initial failure report from Gemini VII, a photometer check was run by the crew members keeping all light out of the instrument. The results were inconclusive. A second test on two bright stars indicated that the instrument was operating in a degraded mode. However, tests using Venus and Jupiter showed that no data could be obtained from the night mode of operation even with all spacecraft radio equipment turned off to eliminate possible radio frequency interference. When a day test showed the same result, all operations with the photometer were suspended.

During the flight, the backup photometer was obtained from Cape Kennedy, and tests were run in an attempt to determine the nature of the flight problem and duplicate the failure modes. These tests were generally inconclusive, but they provided some possibilities which were forwarded to the crewmen. Some damage to the photometer could have occurred if passed through direct sunlight; however, corrections for this had no effect on the Gemini VII photometer. The possibility of radio-frequency interference from a frequency not carried aboard the spacecraft (possibly due to harmonics) was investigated on the ground and a correction was attempted in space by shutting down all radio equipment for one test. No effect was noted on the Gemini VII instrument. Ground testing of the backup photometer during the flight did not isolate the failure mode, nor did it provide proper corrective action. When this was determined, the backup instrument tests were abandoned. Postflight analysis of the Gemini VII photometer was carried on initially at the Manned Spacecraft Center (MSC), Houston. The problems were isolated in the phototube where it was found that a direct short existed between a 900-volt line and the signal line. This explained the total saturation indication of all successive stages of signal amplification and accounted for the inflight malfunction indication. Because facilities were not available for the complete analysis of the phototube at MSC, the equipment was flown to contractor test facilities for a detailed analysis of the cause of the phototube failure. X-rays and photographs were taken at each stage of the examination.

Microscopic analysis revealed a piece of metal between the cathode shield and the no. 9 dynode (at -900v) which provided the short to the signal line, (fig. 8.2-1). Photographs were taken of the metal particle in position (fig. 8.2-2), and then current was run through the short. When the metal was removed from between the cathode shield and the no. 9 dynode, the shorted condition no longer existed. In attempting to discover the source of the metal particles, analysis of the tube showed that similar material existed in the welded lead connections. Vibration or normal usage could dislodge a small piece of the weld spatterings, which would normally fall harmlessly to the bottom of the tube; however, in a zero-g environment, they would float and be drawn into an area of high potential. If the element spacing were approximately the same size as the particle, a short would develop. If dislodged, it would probably float back into the same high potential area. Following the determination of the exact cause of the phototube malfunction, an examination was made to establish a means for eliminating problems of this type. The following procedures were outlined:

(a) Manufacturer quality control – Additional specifications and procedures will be developed to minimize the possibility of having foreign particles in the tubes.

(b) Factory examination – The tube will be microscopically examined to find evidence of small particles and the possible source of particles.

(c) Special environmental testing – A special operating vibration test, while turning the tube in three axes, will be conducted on each tube to dislodge any loose particles and to drop any such particles through the tube elements. Voltage variation across the elements during the test, or discovery of particles after the tests, would disqualify a tube.

8.2.5 Conclusions

The D-5 experiment failed to provide any photometer star occultation data because of an instrument malfunction. The failure analysis identified the exact source of the problem and established a means for correction. The solution does not require design changes or extensive rework, but consists mainly of establishing adequate quality control procedures during manufacturing and in careful tube selection, examination, and testing by the contractor.

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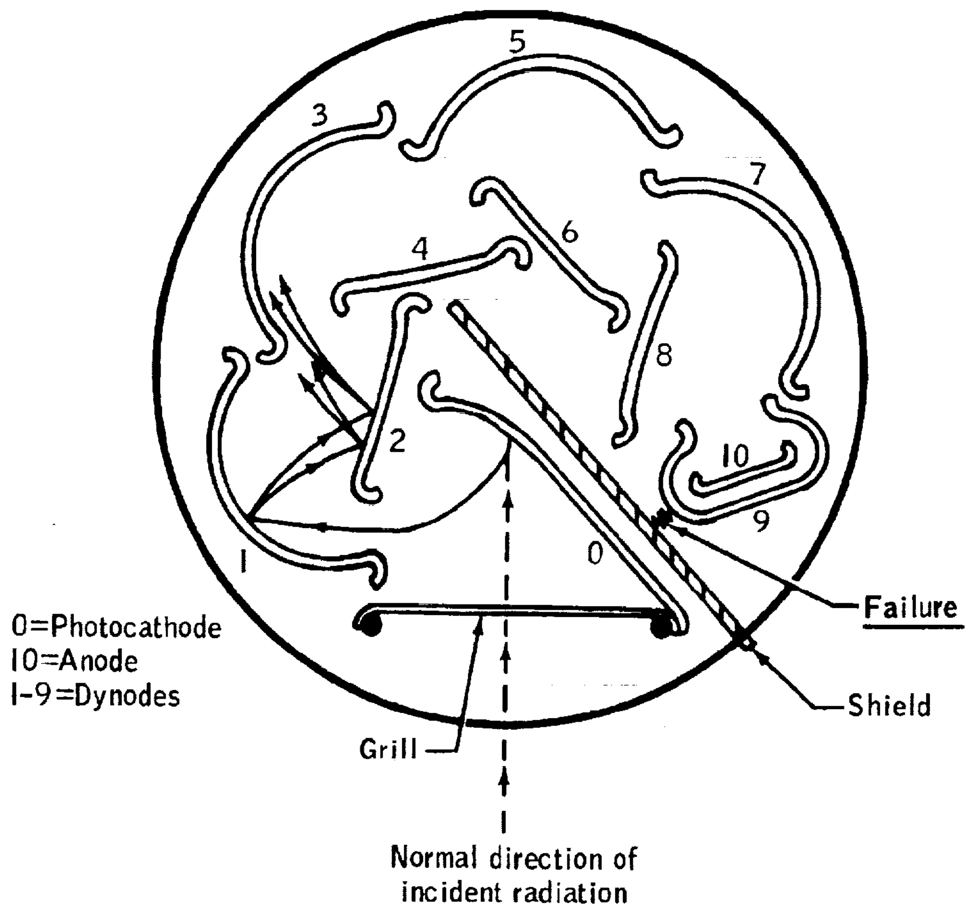

Figure 8.2-1. - Experiment D-5, sketch showing location of photomultiplier tube failure.

Changed October 12, 1966.

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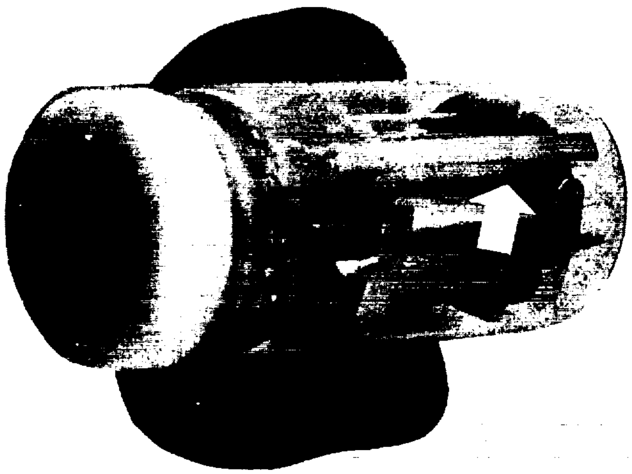
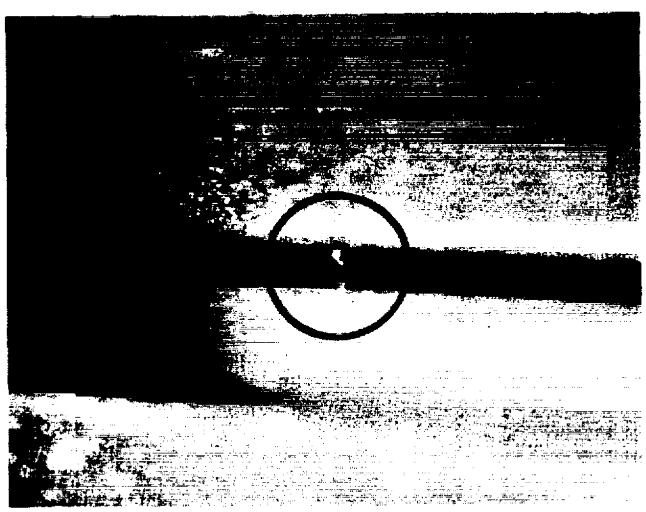


Point of malfunction



Enlargement of malfunction area

Figure 8.2-2. - Experiment D-5, photomultiplier tube malfunction.

8.3 EXPERIMENT D-9, SIMPLE NAVIGATION

8.3.1 Objective

The objective of experiment D-9 was to provide data on the observable phenomena of space flight which could be used to solve the problem of autonomous navigation by using optical data to calculate an actual space position by manual techniques. After completion of the development and test phases, the end product of the experiment would be a manual-optical technique of orbital space navigation which could be used as a backup to onboard and ground-based spacecraft navigation systems.

The first portion of experiment D-9 (which was run on Gemini IV) produced good qualitative data, but no data usable for position determination. The Gemini VII experiment was planned to produce small repetitive bits of data most useful for position calculations.

8.3.2 Equipment

The experiment flight equipment consisted of a sextant with the following general characteristics:

Size . . . . 6 11/16 in. by 6 27/32 in. by 5 9/16 in.

Weight . . . . 5 lb 13 oz

Magnification . . . . . × 4.5

Field of view . . . . . 14°

Exit pupil . . . . 7 mm

Eye relief . . . . 20 mm

Diopter adjustment . . . -2 to +2

Resolution . . . . 10 sec arc

Image . . . . Erect

Range . . . . 74°

A photograph of the sextant is shown in figure 8.3-1.

8.3.3 Procedure

The spacecraft was stabilized small end forward (SEF), stars were acquired and identified, and two star-to-horizon angles were measured. A left yaw was then established, and upon alignment of the spacecraft 90° to the orbital path, two additional measurements were made on the same pair of stars. The final measurements on the two stars were made with the spacecraft positioned blunt end forward (BEF). Each run consisted of a selected set of two stars (called a sequence) and the use of a particular filter (called a mode). A total of 5 runs was planned for the flight. In order to adapt the work schedule for ease of real-time flight planning, all selected stars were time-phased with the launch time as a base.

During the flight, sequences and modes were called up as desired. The time allotted for each sextant measurement (based on Gemini IV experience) proved to be in excess of that required. As a result, the crew was provided time for additional measurements and gathered a large amount of additional data.

8.3.4 Results

The D-9 experiment was completely successful from a procedural standpoint. The sextant operated flawlessly, and measurements of angles up to 51.155° were obtained with ease. Eight to ten measurements were taken per pass, whereas only six measurements per pass had been requested. The total number of measurements obtained is as follows: 37 star-to-horizon, 5 planet-to-moon limb (or star-to-moon limb), 6 star-to-star, and 8 zero measurements on star. The performance of the crew was excellent in all respects.

Interesting variations in the observations were recorded. The bright moon caused problems with star acquisition and identification when the stars were near the moon. The 5577Å airglow horizon was not as distinct as recorded on Gemini IV and neither crew member was able to see a 5577Å horizon with the green filter. This reflects a first look at seasonal variations in the 5577Å horizon. Most horizon measurements were made to the moon-lighted natural earth horizon which presented a more distinct line than the airglow. Determination of the degree of success of the D-9 experiment navigational theory must await detailed examination of the data acquired.

8.3.5 Conclusions

The procedures used, the operation of the sextant, and performance by the crew under orbital conditions were successful.

Examination of the raw data indicates that a sufficient number of navigation measurements can be made with the sextant; however, horizon determination still appears to be a problem. On the Gemini IV mission, a definite 5577Å horizon was found and used. No such horizon appeared in the Gemini VII observations. The stability of the observables which establish system accuracy needs further investigation.

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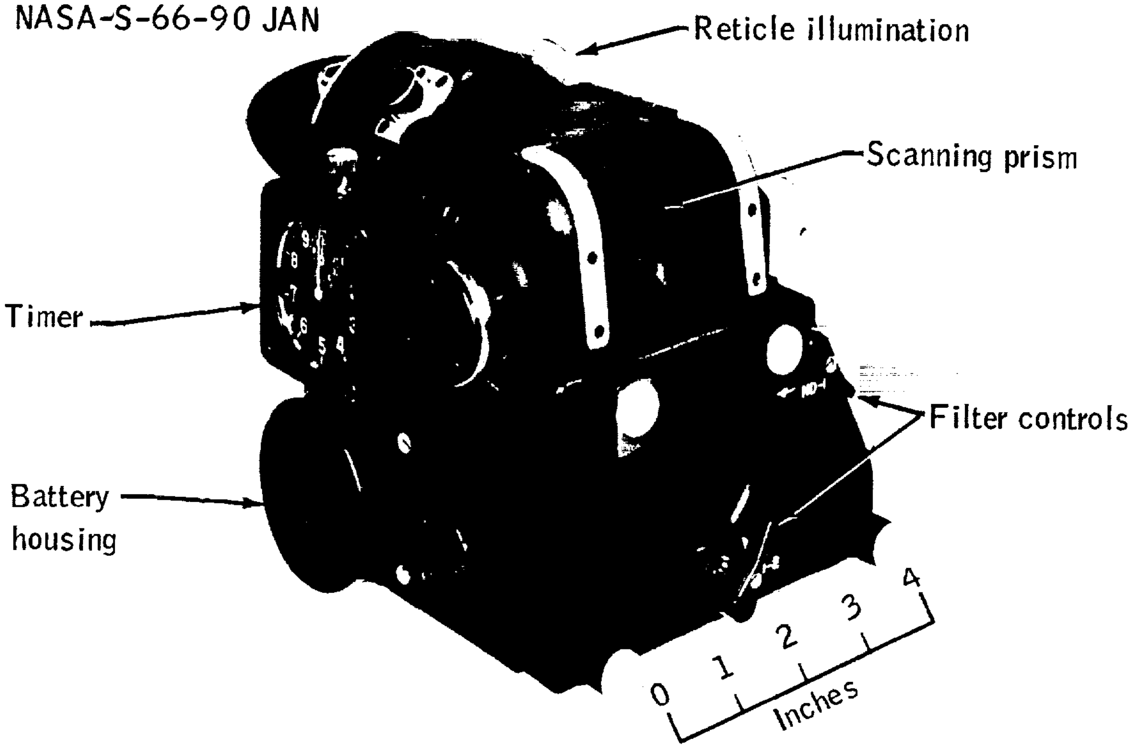

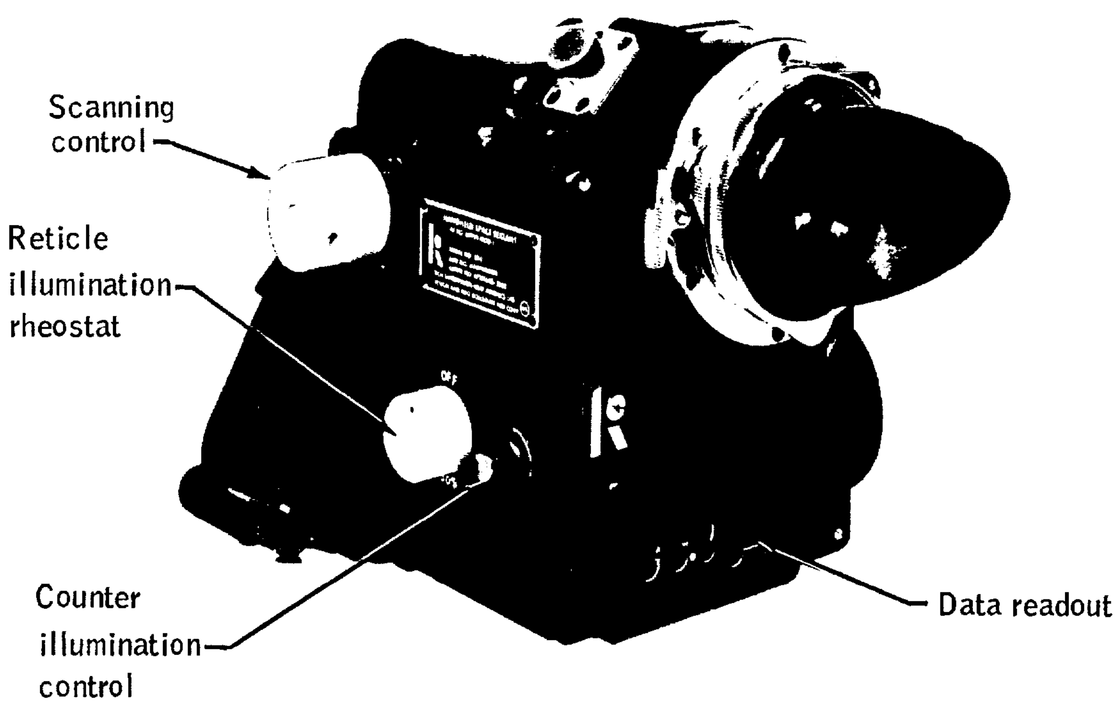

Figure 8.3-1. - Experiment D-9, sextant operating controls.

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8.4 EXPERIMENT M-1, CARDIOVASCULAR CONDITIONING

8.4.1 Objective

The objective of experiment M-1 was to determine the effectiveness of pneumatic venous pressure cuffs applied to the upper thighs during flight in preventing or mitigating the low blood pressure and high heart rate of a flight crewman when in the standing position that have been observed following previous space flights. The experiment was based on two premises: First, cyclic inflation of pneumatic cuffs was expected to prevent the loss of plasma volume by decreasing thoracic fluid volume. This reduction of the thoracic blood volume, theoretically, should prevent zero gravity excessive urine output, thus maintaining effective circulating blood volume. Second, cyclic inflation of pneumatic cuffs would produce an artificial hydrostatic gradient across the walls of the leg veins. This action would mimic the normal gradient existing in a 1g environment with the subject in the upright position, thus providing the stimuli which may be required to maintain active vessel constrictor properties or "tone". It would also theoretically decrease the pooling of blood in the lower extremities and thereby increase the effective circulating blood volume while standing in a 1g environment.

8.4.2 Equipment

The equipment for the cardiovascular conditioning experiment consisted of a pneumatic control system and a pair of pneumatic venous pressure cuffs. The cardiovascular conditioner was an automatic mechanical system (fig. 8.4-1) which alternately inflated and deflated the pneumatic venous pressure cuffs around the upper attachment of the pilot's thighs. The conditioner consisted of two basic components:

(a) A pneumatic control system to regulate pressure

(b) A pneumatic oscillator system to provide for the periodic inflation and deflation of the pneumatic cuffs

The system was supplied with aviator breathing oxygen at 110 $\pm$ 10 psia from the spacecraft environmental control system (ECS).

The pneumatic venous pressure cuffs were form-fitted to the upper thigh area of the pilot. They consisted essentially of a 3-by 6-inch rubber bladder, enclosed within a soft, non-stretchable fabric. The bladder surface of the cuffs was provided with places for snug adjustment during flight if required. The cuffs were connected to the suit inlet-outlet fitting on the right thigh through tubing having a 1/8-inch inside diameter. The suit inlet-outlet was a quick-disconnect fitting which allowed the conditioning system to be connected to the leg cuffs when the suit was removed.

8.4.3 Procedure

The pilot wore the pulsatile cuff around the proximal attachment of each thigh during the flight. Upon activation of the manual shutoff valve, the cuffs were automatically pressurized to 80 mm Hg for 2 minutes and deactivated to zero pressure for 4 minutes during each 6-minute interval. The system was capable of continuous operation during flight; however, it was designed with an ON-OFF manual-switching capability. The experiment imposed no operational requirements other than initial activation following launch and final deactivation by the pilot prior to reentry. The experiment functioned for 311 hours of the 14-day mission and was terminated 3 hours prior to reentry when the space suits were donned.

8.4.4 Results

Both Gemini VII crew members were given three (control) passive tilt-table tests at appropriate intervals prior to the flight. Mean values for heart rate, blood pressure, and leg volume changes are summarized in the following table:

	Pre-tilt		Tilt		
Subject	Heart rate, beats/min	Blood pressure, mm Hg	Heart rate, beats/min	Blood pressure, mm Hg	Leg volume change, cc/100 cc tissue/min
Command pilot	73	110/72	87	114/81	4.5
Pilot	72	131/75	84	126/84	4.4

It can be seen that the heart rate increased slightly during tilting, the diastolic blood pressure increased slightly, and the leg volume increased. The values returned to the pre-tilt levels after the subject was returned to the supine position.

Postflight tilt-table results for each crew member are presented as deviations from mean values between preflight and postflight tests.

Both crew members exhibited increases in heart rate following the mission during the postflight pre-tilt and tilt tests. The resting heart rate (pre-tilt) increases, however, were not significant in comparison with preflight and previous mission values. Differences between preflight and postflight mean values are shown in the following table and in figure 8.4-2.

Change in mean value heart rate, beats/min (a)								
	2 to 4 hr		8 to 12 hr		24 to 30 hr		46 to 50 hr	
Subject	Pre-tilt	Tilt	Pre-tilt	Tilt	Pre-tilt	Tilt	Pre-tilt	Tilt
Command pilot	+10	+40	+8	+19	-2	+2	-1	-4
Pilot	+4	[b]+26	+9	+33	+5	+34	-5	+2

[a]+ = Value above preflight mean
 - = Value below preflight mean

[b]12-minute average; subject returned to supine position after exhibiting a tendency toward fainting.

The command pilot exhibited a slight decrease in pre-tilt (resting) systolic blood pressure during the first postflight test period and an increase during the remaining pre-tilt tests. The pilot exhibited a decrease in pre-tilt systolic pressure during every postflight test period. Both crew members exhibited a slight decrease in pre-tilt diastolic blood pressure (2 to 5 mm Hg) prior to every postflight tilt except during the command pilot's second test. The command pilot's systolic pressure decreased during every postflight tilt except the second, while the pilot's decreased during the first and fourth and increased slightly during the second and third postflight tilts. A decreased diastolic pressure relative to preflight values was exhibited by the command pilot during every postflight tilt except the second. The pilot exhibited a decreased diastolic pressure during every postflight tilt except the third. These differences between preflight and postflight mean values are shown in the following table and in figure 8.4-2.

Change in mean blood pressure (systolic/diastolic), mm Hg (a)								
	2 to 4 hr		8 to 12 hr		24 to 30 hr		46 to 50 hr	
Subject	Pre-tilt	Tilt	Pre-tilt	Tilt	Pre-tilt	Tilt	Pre-tilt	Tilt
Command pilot	-3/-3	-27/-8	+11/+9	+5/+4	+2/-3	-3/-6	+5/-5	-4/-5
Pilot	-8/-4	[b]-33/-11	-7/-2	+2/-2	-4/-4	+6/+1	-14/-5	-12/-11

[a]+ = Value above preflight mean
- = Value below preflight mean

[b]12-minute average; subject returned to supine position after exhibiting a tendency toward fainting.

During the post-tilt phase (tilt-table tests) all physiological parameters measured returned to or near pre-tilt levels as indicated in figure 8.4-2.

During the postflight tilts, both crew members exhibited an increase in leg blood volume. This measurement reflects the degree of venous pooling in the lower extremities. These values are presented as percent above the preflight mean in the following table and in figure 8.4-3.

Change in leg volume, cc/100 cc tissue/minute (a)				
Subject	2 to 4 hr	8 to 12 hr	24 to 30 hr	48 to 50 hr
Command pilot	+71	+31	+47	+33
Pilot	[b]+2	+36	+9	+15

[a]+ = Value above preflight mean

[b]12-minute average; subject returned to supine position after exhibiting a tendency toward fainting.

8.4.5 Conclusions

The cardiovascular conditioning experiment (M-1) was operative for 311 hours of the 14-day mission. Postflight tilt-table data revealed responses similar to those seen after previous Gemini missions.

The pilot exhibited a tendency toward fainting during the first postflight test and had to be returned to the supine position at the end of 12 minutes. This response was accompanied by a decreased heart rate during the seventh minute of tilt with the inability to maintain adequate blood pressure; however, leg blood volume pooling measurements indicate very little blood pooling in the lower extremities. The command pilot exhibited the characteristic increased heart rate, narrowed pulse pressure, and increased leg blood volume during the first postflight tilt. The narrowed pulse pressure was also accompanied by a decrease in both systolic and diastolic blood pressure. During the remaining postflight tilt-table tests, both crew members exhibited a greater tolerance to the passive tilt test, and all physiological parameters measured returned to near preflight values after 12 to 24 hours.

In comparing the results of the M-1 experiment on the Gemini VII mission with the Gemini V mission it is evident that the pilots on both flights pooled less blood in their legs during postflight tilt-table tests. Although the pilot for Gemini VII showed fainting symptoms during the first postflight tilt, he maintained cardiovascular stability during the following tilt. Because the pilot did not exhibit excessive blood pooling in his legs nor a loss of total blood volume, the fainting symptoms cannot be attributed to these effects. The tendency toward fainting may have been involved with other physical stresses such as inactivity, fatigue, and/or possible psychological responses to the postflight test.

Thus on the basis of the preflight and postflight tilt-table data from Gemini V and VII, it cannot be concluded that the pulsatile cuffs were effective in mitigating the postflight increased heart rate and narrowed pulse pressure when in the upright position. There was significantly less pooling of blood in the pilot's lower extremities however, and this finding may be a result of the cuff technique.

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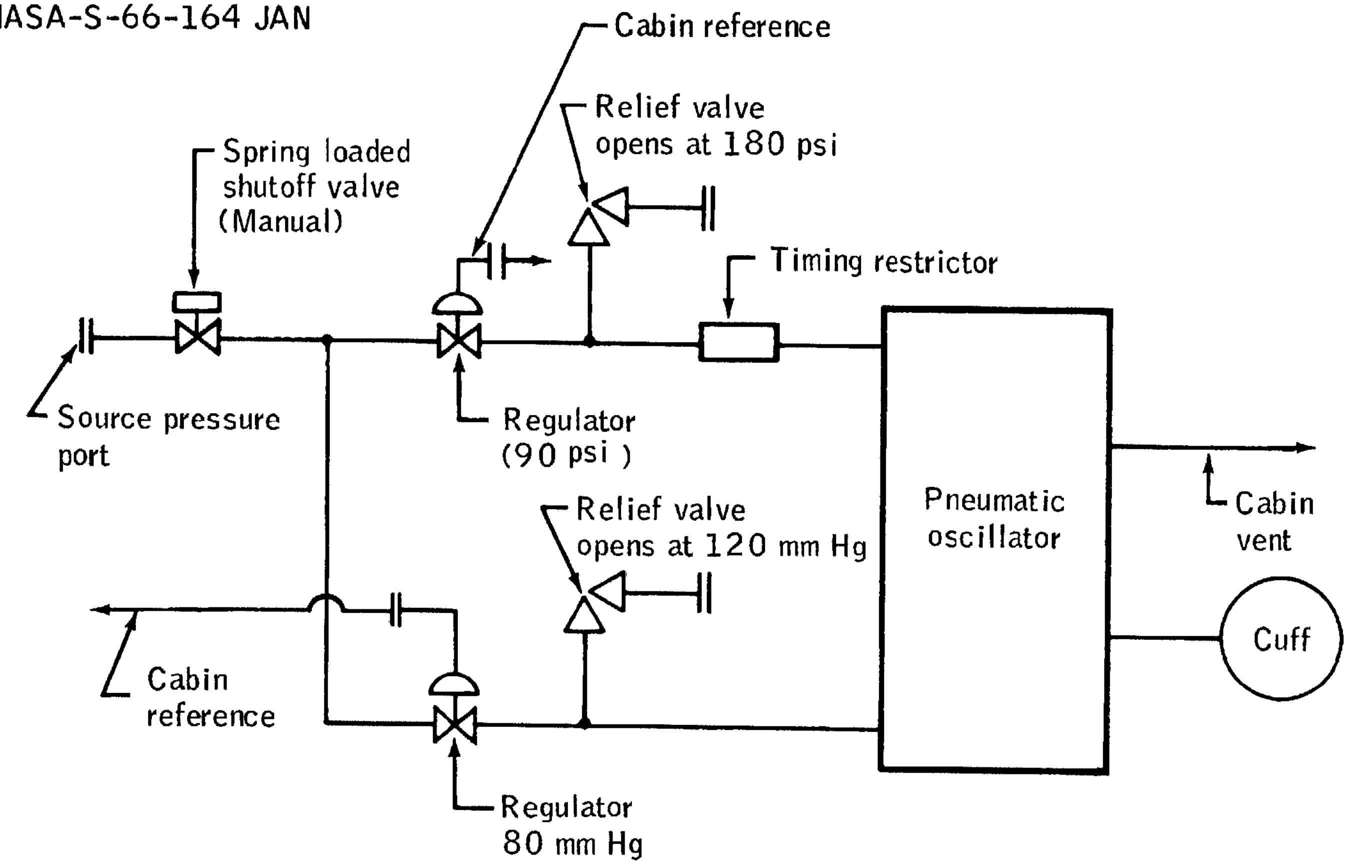

Figure 8.4-1. - Experiment M-1, schematic diagram of cardiovascular reflex conditioner.

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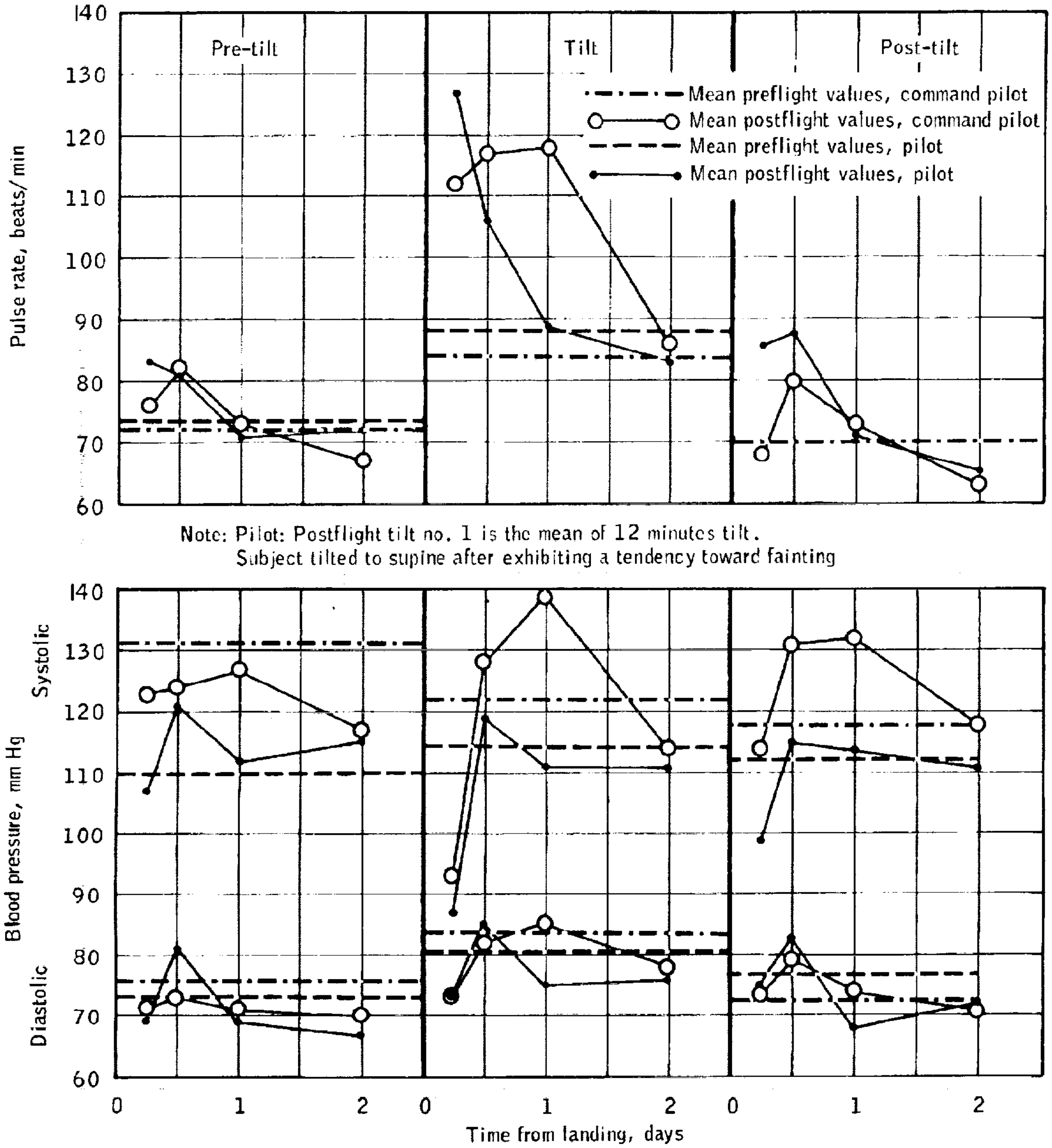

Figure 8.4-2. - Experiment M-1 Gemini VII tilt table summary.

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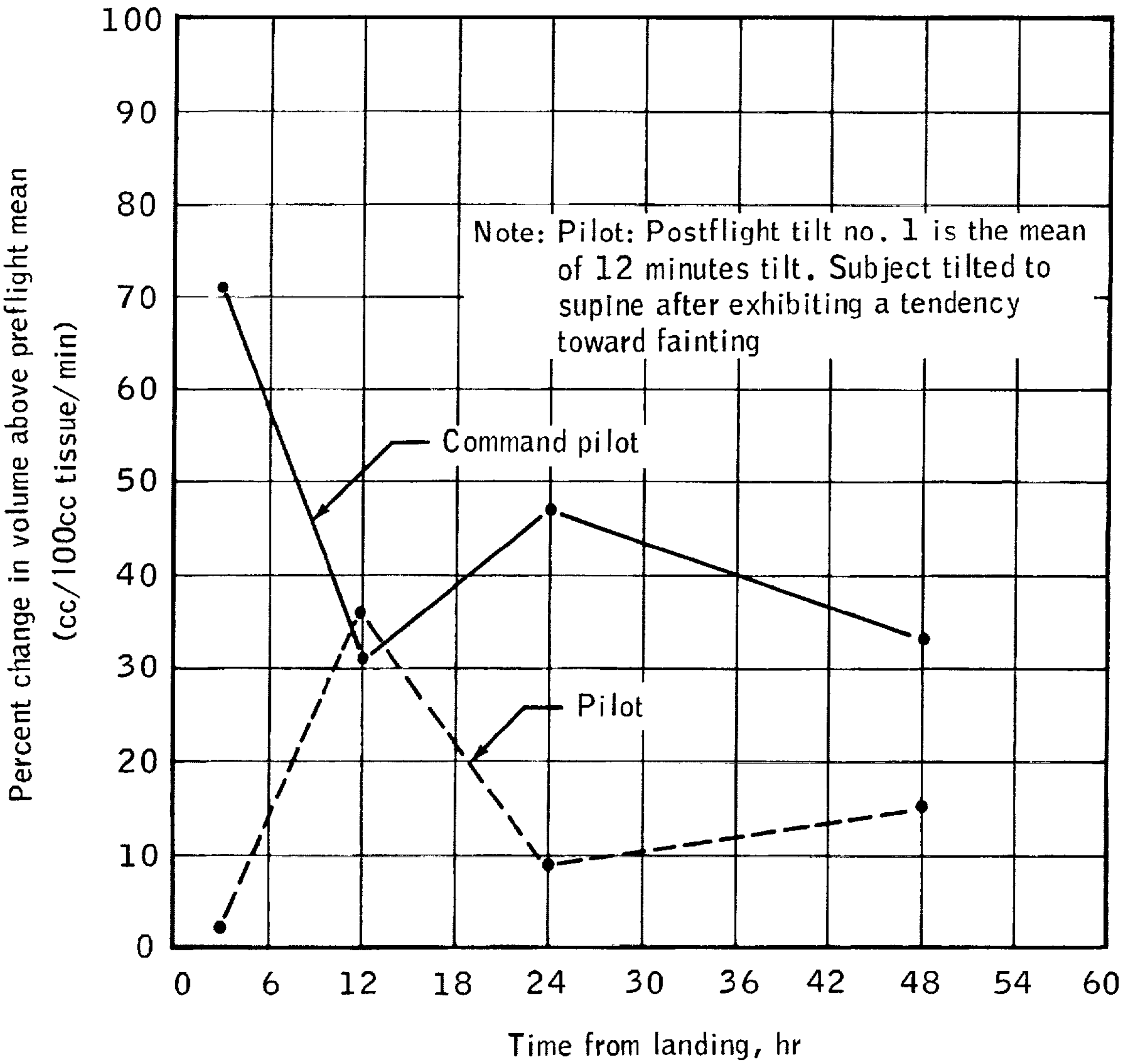

Figure 8.4-3. - Experiment M-1, Gemini VII leg plethysmograph summary.

8.5 EXPERIMENT M-3, INFLIGHT EXERCISER

8.5.1 Objective

The objective of this experiment was to assess cardiovascular reflex activity in response to a given physical workload (exercise) and to ascertain the general capacity to perform physical work under prolonged space-flight conditions. It should be noted that this experiment was not programmed to be exercise as such, but was a mild cardiovascular stimulus used to monitor reflex activity.

8.5.2 Equipment

The inflight exerciser consisted of a pair of rubber elastic cords attached to a handle at one end and to a nylon foot strap on the other end. A stop-cable limited the length of extension and fixed the workload. Seventy pounds were required to pull the exerciser to a full extension of 12 inches. The standard flight bioinstrumentation system provided the necessary data for support of this experiment.

8.5.3 Procedure

Exercise periods for this experiment were incorporated as part of the crew status report. The exercise periods, scheduled twice per day per crewman, consisted of pulling the handle one pull per second for 30 pulls. Blood-pressure measurements were made before and after each exercise period.

8.5.4 Results

The flight crew performed the exercise periods as scheduled. Heart rates were determined by counting 15-second periods for 2 minutes before and after exercise, and the first and last 15-second periods during exercise. Comparison of 1g preflight exercise periods with those obtained during flight indicates little difference in heart-rate response. Comparison of the inflight exercise periods for the first to the fourteenth day also indicates little difference in heart-rate response. Inflight heart-rate responses are illustrated in figure 8.5-1. Blood pressures are reported in section 7.2.

Throughout the flight, both crew members used M-3 hardware for performing additional exercise consisting of a series of isometric and isotonic exercises. Both crewmen performed an equal amount of exercise, and believe that exercise is essential and beneficial on long-duration flights.

8.5.5 Conclusions

The M-3 experiment on Gemini VII can be classified as a success. The crew demonstrated their ability to perform physical work through 14 days of flight. The biomedical data obtained in response to this given workload offered no evidence of cardiovascular reflex decrement during 14 days of flight. Exercise periods for exercising upper and lower extremities should be routinely scheduled into the flight plan for long-duration missions.

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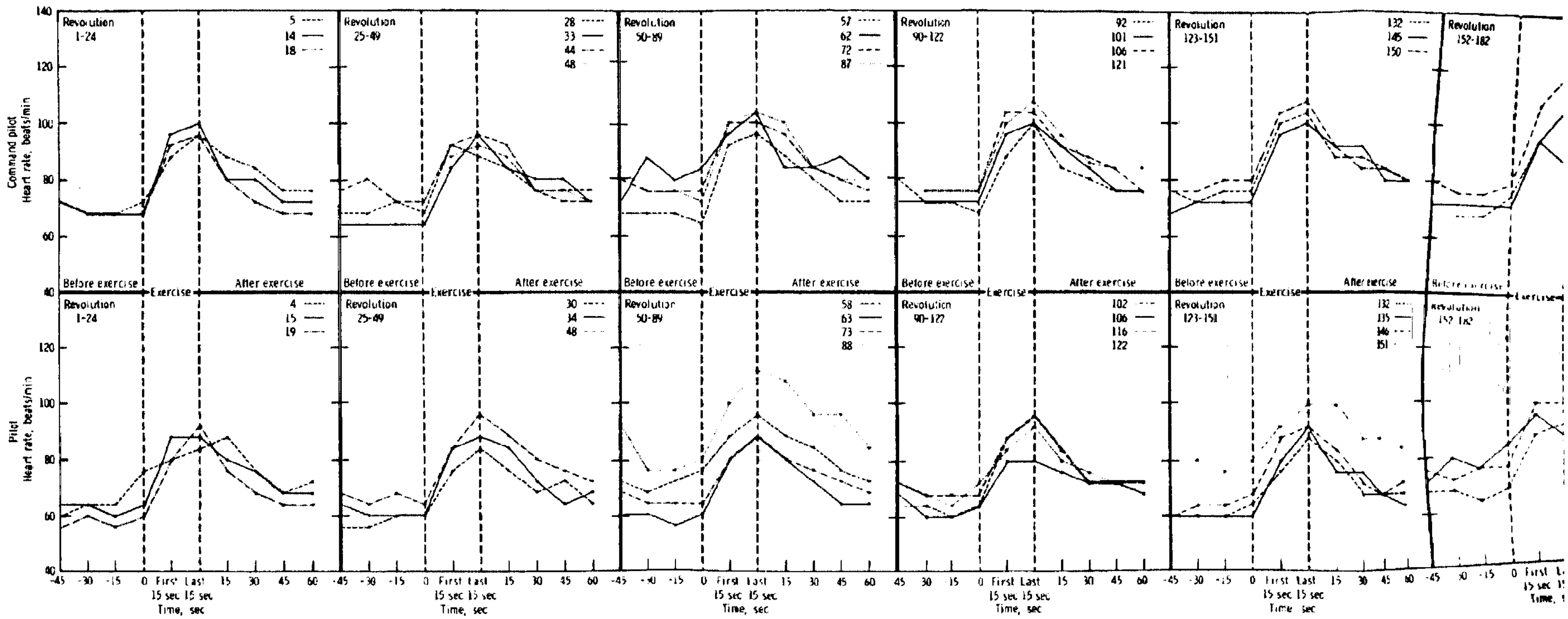

Figure 8.5-1. - Exp

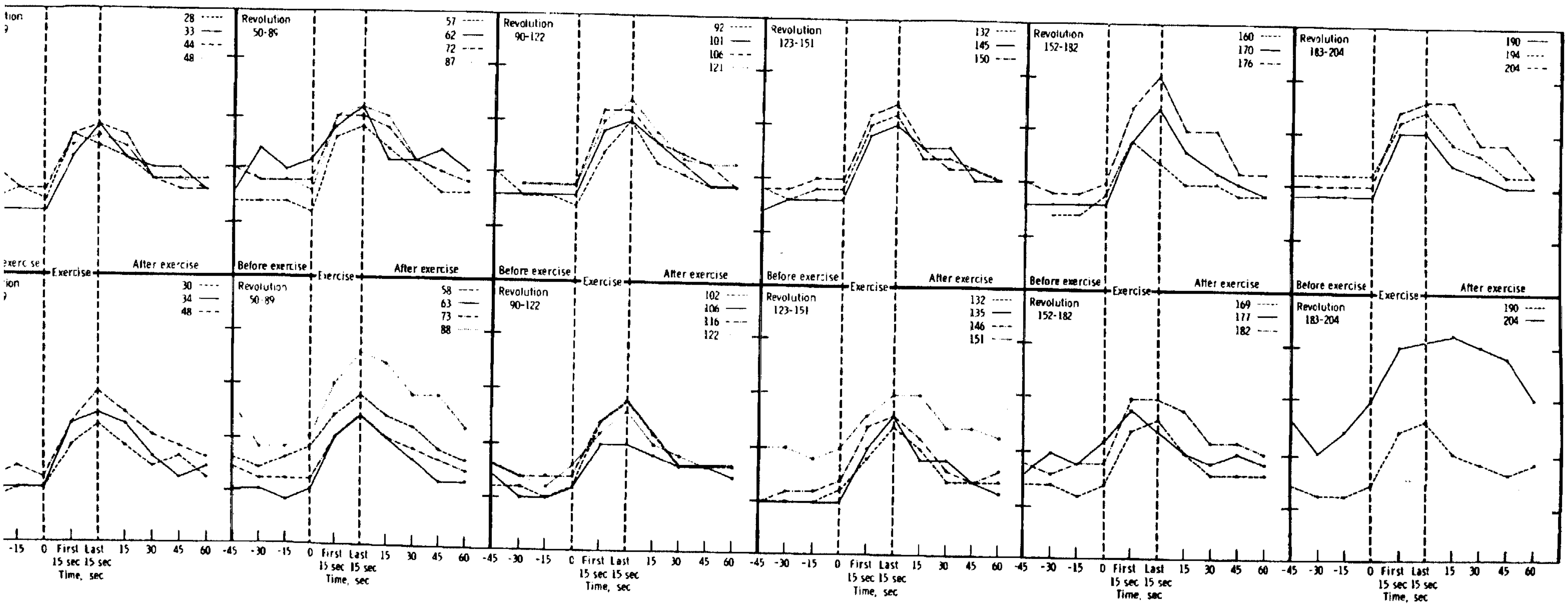

Figure 8.5-1. - Experiment M-3, response to inflight exercise. (Minute heart rate plots per 15 second intervals before, during, and after exercise).

8-27-a

8-27-b

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8.6 EXPERIMENT M-4, INFLIGHT PHONOCARDIOGRAM

8.6.1 Objective

The objective of the phonocardiogram experiment is to investigate the functional cardiac status of the flight crew during prolonged space flights. The magnitude of the time delay between various identifiable portions of the electrocardiogram signal and corresponding portions of the phonocardiogram signal is presented in digital form for analysis. The flight data are compared with data obtained during bed-rest (immobilization) studies.

8.6.2 Equipment

The phonocardiogram system as flown on Gemini VII consisted of a phonocardiogram transducer, an electrocardiogram signal conditioner, and an onboard biomedical recorder.

The transducer and signal conditioner are worn within the Gemini pressure suit; the biomedical recorder is external to the suit.

8.6.3 Procedure

The phonocardiogram system was installed on the pilot and checked out immediately prior to the Gemini VII mission during the regularly scheduled biomedical sensor application procedure. The system was put into operation before lift-off, and operated without pilot participation except for biomedical recorder switching. The pilot's phonocardiogram and sternal electrocardiogram were recorded on biomedical recorder no. 2 during approximately the first 2 hours of the mission, and 6 to 10 hours daily after the fourth day of the flight. Biomedical recorder no. 2 was brought to the Manned Spacecraft Center, Houston, after recovery of the spacecraft for processing of the data.

8.6.4 Results

Information obtained during the experiments debriefing of the Gemini VII crew and "quick-look" examination of the taped data have shown that usable phonocardiogram data were obtained during the entire mission. Reduction and analysis of the Gemini VII phonocardiogram data are continuing.

8.6.5 Conclusions

Although usable phonocardiogram data were obtained during the mission, no conclusions can be made in this report since these data have not yet been analyzed.

8.7 EXPERIMENT M-5, BIOASSAYS BODY FLUIDS

8.7.1 Objective

The objective of this experiment was to determine the physiological effects due to the stresses of space flight. To accomplish this, body fluids obtained preflight, inflight, and postflight are analyzed for electrolytes, hormones, proteins, and other organic constituents which are indicative of the physiological status of the crew members.

8.7.2 Equipment

During flight, urine was sampled with a urine-sampling and volume-measuring system, which consisted of a valve with a tritiated water injector, mixing bag, and 110 sample bags.

8.7.3 Procedure

Prior to urination, a precise volume of tritiated water was injected into the lines of the valve by a positive displacement pump incorporated into the valve. Urine washed the tritium into the mixing bag. A sample of urine containing tritium was then transferred through the valve from the mixing bag to a sample bag. The sample bag was removed and stored. The total volume of each voiding was determined postflight by measuring the dilution of the tritium isotope.

8.7.4 Results

The preflight and postflight urine and blood samples are being analyzed. A total of 71 preflight urine samples was obtained from the command pilot and 49 from the pilot. Twenty-nine postflight samples were obtained from the command pilot, and 16 from the pilot.

The inflight collections were recovered, and yielded 48 samples from the command pilot and 43 from the pilot. These samples are currently at Cornell University for analyses pertinent to experiment M-7. Upon completion, the remaining portion will be transferred to MSC for completion of those analyses pertinent to experiment M-5.

8.7.5 Conclusions

Any conclusions must await the receipt of the samples at MSC and their subsequent analyses.

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8.8 EXPERIMENT M-6, BONE DEMINERALIZATION

8.8.1 Objective

The objective of experiment M-6 was to investigate the occurrence and degree of any bone demineralization resulting from prolonged space flights.

8.8.2 Equipment

The equipment used in this experiment was a standard clinical X-ray machine, standard 8- by 10-inch X-ray films, and calibrated densitometric wedges.

8.8.3 Procedure

X-rays were made of the flight crew at Cape Kennedy, Florida, in accordance with the following schedule:

(a) Launch minus 10 days (Nov. 24)

(b) Launch minus 3 days (Dec. 1)

(c) Launch minus 220 minutes (Dec. 4)

Precise X-ray densitometric measurements were made of the heel bone (os calsis) of the left foot and the terminal bone of the little finger (fifth digit) of the left hand.

Four similar measurements were made after completion of the mission according to the following schedule:

(a) As soon as possible after recovery (Dec. 18, onboard U.S.S. Wasp)

(b) Approximately 24 to 48 hours after completion of the mission but prior to the flight crew's departure from the prime recovery ship (Dec. 19, onboard U.S.S. Wasp)

(c) At the NASA Manned Spacecraft Center, Houston, Texas, approximately 10 days after completion of the mission (made on 11th day, Dec. 29)

(d) Again at the Manned Spacecraft Center 60 days after completion of the mission

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These data will be compared to determine if any bone demineralization occurred during the mission.

8.8.4 Results

All preflight X-rays have been developed and initially analyzed. The postflight films taken to date have been developed and ascertained to be suitable for densitometric analysis.

8.8.5 Conclusions

Available data and current analysis do not permit any conclusions to be reached at the time of the publication of this report because the postflight X-ray densitometry has not been completed.

8.9 EXPERIMENT M-7, CALCIUM AND NITROGEN BALANCE

8.9.1 Objective

The primary objective of this experiment is to obtain data on the effects of space flight of up to 14 days in duration on two of the largest metabolically active tissue masses in the human body, namely, bone and muscle; and therefore, to assess the functional integrity of the skeletal and muscular systems.

8.9.2 Equipment

This experiment consisted of measurements of calcium and nitrogen balances and related biomedical parameters made under known dietary conditions, preflight and postflight, as well as inflight. The measurements will be used to quantitatively assess the crew members' calcium and nitrogen balances exhibited during the Gemini VII mission. Normal hospital equipment was required for collection of samples during the preflight and postflight periods. For inflight collection of samples, special urine sample bags containing a tracer element (tritium) were used to provide an indication of total volume. As a backup to the sample bags, a flowmeter was added in the urine transport system and the flowmeter's output signal was recorded on the voice tape recorder.

8.9.3 Procedure

The experiment has three phases:

(a) Preflight - 10 days (15 days before launch to 5 days before launch)

(b) Inflight - 14 days

(c) Postflight - 4 days (recovery to 4 days after recovery). If significant changes occur, a second post-recovery phase (5 days) will be required about 1 month after recovery.

Experimental parameters, measured or controlled, and which interfaced with the crew are described in the paragraphs that follow.

(a) Body weight (preflight and postflight phase): Weight was checked daily upon arising (after micturition).

(b) Diet: Calcium intake was set at 800 to 1000 mgs/day and maintained within these limits. The preflight and postflight diet was a calcium-controlled diet. The inflight diet was the Gemini menu of freeze dehydrated and otherwise dried or processed foods of known composition. Each serving was weighed before flight and reweighed after flight.

(c) Fluid intake: Fluids were taken as desired, but the quantity was recorded. Water intake was measured preflight and postflight by using a personal reusable water container on which the number of times filled could be recorded, and was measured inflight by employing a water-measuring device and recording intakes in the appropriate logs.

(d) Specimen collection:

(1) Preflight and postflight: Urine and stools were collected.

(2) Inflight: For inflight stools, Gemini defecation devices served as adequate collection, preservation, and storage containers. Defecation bags were provided in the amount of one per man-day (plus 20 percent contingency). A tab was included for identifying name and time. Limited storage space did not permit all urine voided to be collected; therefore, the urine transport system provided a means for measuring total volume of each micturition by means of a tracer dilution technique. Aliquots (75cc) of each micturition were collected. The crew member's initials, and time of voiding were recorded on the sample bag and in the log.

(e) Blood:

(1) Preflight and postflight: Two samples of venous blood (approximately 30 to 40 ml) were withdrawn during preflight and postflight medical examinations.

(2) Inflight: No blood samples were collected.

(f) Sweat collection:

(1) Preflight: During two different uninterrupted 24-hour intervals, separated by at least 2 days (13 days before launch and 11 days before launch, crew preference), the crew wore garments for the collection of sweat.

(2) Postflight: The above procedure was repeated twice, one day after recovery and 3 days after recovery.

(3) Inflight: The flight undergarments worn during the entire 14-day mission were removed onboard the recovery ship and retained for sweat analysis.

8.9.4 Results

All preflight and postflight diet, sweat, urine and stool samples have been collected, divided, and processed for preservation and shipment.

Inflight used and unused food, waste containers, urine sample bags, and flight undergarments were removed from the spacecraft and processed aboard the recovery vessel. They were then transferred to Cape Kennedy and further processed for shipment.

All M-7 samples have been shipped to Cornell University and analyses have begun.

8.9.5 Conclusions

Available data and current analysis do not permit any conclusions to be reached at the time of the publication of this report. Approximately 4800 individual determinations must be completed in duplicate and statistically analyzed prior to publishing any conclusions.

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8.10 EXPERIMENT M-8, INFLIGHT SLEEP ANALYSIS

8.10.1 Objective

The inflight sleep analysis experiment was intended to accomplish the following three objectives:

(a) Assess objectively the pilot's depth of sleep during orbital flight in order to optimize work-rest cycles and to correlate sleep depth with pilot performance.

(b) Assess the effects of the weightless state (with diminished proprioceptive inputs to the central nervous system) on the wave patterns of the normal (command pilot's) electroencephalograph (EEG).

(c) Objectively assess states of diminished alertness and relate these to the general inflight command pilot performance.

8.10.2 Equipment

The following equipment comprised the Gemini VII electroencephalograph system:

EEG electrodes - Four EEG electrodes of the Ag-AgCl type were installed on the pilot's scalp.

Helmet liner - The Sierra bump hat liner was worn by the command pilot and was recessed to fit over the electrodes.

EEG electrode cable - A flexible, four-conductor EEG electrode cable served to conduct the EEG signal from the command pilot's head to the input terminals of the EEG signal conditioner.

EEG signal conditioner - Special low-noise, high-input impedance EEG signal conditioners were worn in pockets of the command pilot's underwear.

Modified Gemini biomedical harness - A modified Gemini biomedical communication harness having an extra connector was provided to accommodate an additional signal conditioner. This modification allowed two channels of EEG data to be taken from the command pilot.

Skull cap - A close-fitting nylon skull cap was designed to serve as a retainer for the electrodes and electrode leads and as a bearing

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surface between the helmet liner and the electrodes. The primary purpose of this cap was to protect the equipment when the helmet was removed. The cap was available at the time of final suiting for flight but was found to be unsatisfactory. It was agreed that the helmet provided equal or better protection and the pilot decided not to wear the skull cap and to keep the helmet on until after completion of the experiment.

8.10.3 Procedure

Preflight ground-based studies were made on both the primary and backup command pilots.

The electrodes and electrode cable were installed immediately prior to the Gemini VII lift-off during the biomedical sensor application. The system was checked out electrically during this procedure and was put into operation onboard the Gemini VII spacecraft before lift-off.

The EEG signals from the Gemini VII command pilot were recorded on biomedical recorder no. 1 during the first 55 hours of the mission. Recorder no. 1 was returned to MSC, Houston, after the flight for data reduction and analysis.

8.10.4 Results

The experiment was terminated by the command pilot at 55:10 hours ground elapsed time after the accidental removal of all of the electrodes. A "quick-look" examination of the tapes has shown that usable EEG data were obtained during the 55-hour duration of the experiment. Analysis of the data is continuing.

8.10.5 Conclusions

No conclusions concerning the experiment results could be made in time for publication in this report.

8.11 EXPERIMENT M-9, HUMAN OTOLITH FUNCTION

8.11.1 Objective

The major overall objective of experiment M-9 was to measure any change in otolith activity associated with the Gemini VII flight, and particularly to measure any change that might result from prolonged weightlessness. It was essential for this experiment to determine, prior to the flight, the basic otolith function of each crew member (primary and backup crew) by measuring his ocular counterrolling (CR) response to body tilt. These measurements were to serve also as a basis for comparison with postflight CR data in establishing whether changes in otolithic sensitivity had occurred during the 14 days of weightlessness. Evaluation of the effect of any change in otolithic input on the crew member's behavior was to be accomplished by measuring his ability to orient visually to his environment under standard and zero gravitational conditions. The perceptual task of orienting a luminous line in the absence of empirical visual cues (egocentric visual localization (EVL)), that was carried out in flight, provided the means for monitoring the otolith activity of the crewmen daily, throughout the mission.

A long history of experimentation has established EVL as a delicate, reliable, and specific indicator of otolithic input. Furthermore, studies carried out during transient periods of weightlessness demonstrated that EVL is stable and quite accurate under temporary de-efferentation of the otolith organs. EVL therefore provided a reliable baseline indicator and one ready to reflect the influence of any unusual otolith activity that might be generated during the Gemini VII flight.

8.11.2 Equipment

The apparatus for measuring EVL was incorporated into the onboard vision tester which was part of the S-8/D-13 experiment. This incorporation was made to save weight and space in the spacecraft, and it represents only a physical interface; in all other respects, the two experiments were completely separate entities.

The inflight vision tester is a binocular instrument with an adjustable interpupillary distance (IPD), but without any focusing adjustment. The instrument is held at the proper position, with the lines of sight coincident with the optic axes of the instrument, by means of a bite-board individually fitted to the subject. This assures that at each use the instrument is identically located with respect to the visual axis, providing the subject makes the proper IPD adjustment. In this position, eyecups connected to the eyepieces of the instrument exclude all extraneous light from the visual field. For Gemini VII, power was supplied by the spacecraft utility cord. In addition, a bracket (head brace) was provided to fix the position of the instrument about the roll axis with respect to the spacecraft. The head brace and bite-boards were employed during all testing sessions except the fourteenth.

A luminous line target is produced when using the vision tester, by the insertion of an astigmatizer to refract the collimated light from a small central field of this instrument (adaptive field light of S-8/D-13 experiment turned off). The line of light is rotated about its center through a helical gear system by turning a knurled ring located between two numbered cylinders. An index mark on the side of the eyepiece indicates the position of the line in the eyepiece. The cylinder nearer the eye shield is marked in 10° increments with each 30° mark numbered through 180°; the more distant cylinder indicates the location of the line to the nearest 0.5° through a range of 10°. Absolute zero is represented by a value other than zero or 180° to reduce or eliminate any possible influence that knowledge of the settings might have upon subsequent judgments.

The apparatus for measuring ocular CR is essentially a tilt device on which a camera system is mounted. The main supporting part of the CR device acts as a carrier for the stretcher-like section. This section contains velcro straps and a saddle mount to secure the subject in a standing position within the device. The stretcher section can be rotated laterally up to 90° about the optic axis of the camera system, and when the subject is properly adjusted, it can also be rotated 90° about his right or left eye.

The camera system used to photograph the natural iris landmarks includes a motor-driven 35-mm camera with bellows extension and an electronic flash unit. A console located at the base of the tilt device contains a bank of power packs which supply the electronic flash, a timer control mechanism, and controls for the flashing fixation light. A triaxial accelerometer unit which senses and relays signals of linear acceleration to a galvanometer recorder is attached to the head portion of the device.

A test cubicle 12 feet by 16 feet and 10 feet high, insulated against outside sounds, light, and temperature, was constructed onboard the carrier for carrying out the postflight tests of EVL and CR.

8.11.3 Procedure

The initial testing of the inner ear function and EVL was carried out on the Gemini VII prime and backup crews in a 1-day session at U.S. Naval Aerospace Medical Institute in Pensacola, Florida, on July 24, 1965, and in a 90-minute per man session at the Kennedy Space Center on October 24, 1965.

Immediately prior to the preflight and postflight tests of EVL, one drop of 1 percent pilocarpine hydrochloride opthalmic solution was placed in the subject's eye on the opposite side from the one to be used for making visual orientation judgments. The subject was then placed in the CR tilt device, properly adjusted, and secured. The IPD of the vision tester was adjusted and the device was brought into its proper position by inserting the bite-board into the mouth of the subject. The experimenter initially offset the line target presented to one eye only (the other eye observed a completely dark field). By means of the wheel, the subject rotated the target clockwise or counterclockwise until it appeared to be aligned parallel to the gravitational horizontal. This procedure was repeated until several settings (eight preflight and five postflight) had been made in the upright as well as in several tilt position (±10°, ±20°, ±30°, ±40°). The angles of body tilt were presented in a random order.

Inflight EVL testing was accomplished immediately after completion of the S-8/D-13 experiment, and without removing the eyes from the eyecups. The instrument was readied for EVL testing by turning off the adaptive field, occluding the left eyepiece (command pilot) or right eyepiece (pilot) by means of the ring on the eyepiece, and rotating the astigmatizer into its proper position before the opposite eye. The white line target appearing against a completely dark background was initially offset at random by the observer pilot. The subject pilot's task was to align the target parallel to the apparent position of the flight director attitude indicator (FDAI) pitch-axis zero indicator. The subject, when satisfied with his setting, closed his eyes and removed his hand from the knurled ring. This served as a signal to the observer pilot to record the setting and offset the target. This procedure was to be repeated five times. The vision tester was then handed to the other pilot and the same sequence was carried out after completion of the visual acuity test. Finally, the readings for each pilot were to be recorded by voice on the onboard tape recorder. The pilots were additionally requested to fasten their seat belts to the same degree each time during execution of the experiment.

The preflight and postflight measurements of ocular CR were accomplished according to the standard procedure used at the U.S. Naval

Aerospace Medical Institute. Following the EVL test, the subject remained in the upright position in the tilt device, the vision tester and its bite-board were removed and preparations were made for photographically recording eye position. The CR bite-board was inserted in the subject's mouth and the position of his appropriate eye was adjusted so that it centered upon the optic axis of the camera system when he fixated a flashing red ring of light. Six photographic recordings were made at this position; then the subject was slowly tilted in his lateral plane to each of four other positions ($\pm 25°$, $\pm 50°$), and the same photographic procedure was repeated.

The accelerometer system was used in the postflight measurements to record continuously, during the EVL and CR tests, motions of the recovery ship around its roll, pitch, and yaw axes.

During the EVL and CR tests, readings of blood pressure, pulse rate, and electrocardiogram were carried out by the MSC medical evaluation team. Postflight M-9 examinations were begun on the pilot 4 hours after landing, and on the command pilot 6 hours after landing.

8.11.4 Results

(a) Ocular counterrolling: Preflight measurements of ocular CR indicated that the basic otolithic function of each crew member closely approached the mean of a nonsystematically selected population of 100 normals previously tested at U.S. Naval Aerospace Medical Institute.

Postflight processing of all photographic records has been completed; analysis of ocular movements are being carried out at U.S. Naval Aerospace Medical Institute.

(b) Egocentric visual location: The judgments of each crewman as to the location of the gravitational horizontal within $\pm 40°$ of body tilt from upright were generally quite accurate during preflight EVL tests. These deviations in perceived horizontal from the physical horizontal are typical of those found for normal subjects and serve as a basis of comparison with EVL postflight data.

Daily inflight M-9 measurements were made by each crew member. Preliminary evaluation of EVL data indicates that each pilot rendered accurate and consistent visual estimations of the horizontal. An analysis of the variance is now being conducted at the U.S. Naval Aerospace Medical Institute. Postflight debriefing reports indicate that neither crewman experienced any disorientation or disturbing vestibular effects during the flight. Neither disorientation nor malaise were observed by the command pilot after a series of intentional head-shaking movements carried out with his eyes closed. Both crew members reported that they were unable to sense movement of the spacecraft when their external visual frame of reference was excluded by covering the windows.

An early inflight report of a "feeling of standing on my head" was explained in this crew debriefing as a description of sensations of increased cranial blood pressure rather than any indication of disorientation produced by vestibular phenomena.

Together with preflight and inflight data, postflight data are undergoing an analysis of variance. The preliminary evaluation indicates that no substantial differences existed between the EVL of gravitational horizontal for either crewman in the preflight, inflight, or postflight periods.

8.11.5 Conclusions

The available data indicate that the M-9 experiment successfully met its stated objectives. Further reduction and analysis of data are necessary before a detailed account of the experiment can be presented.

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8.12 EXPERIMENT MSC-2, PROTON-ELECTRON SPECTROMETER

8.12.1 Objective

The objective of experiment MSC-2 was to measure simultaneously the proton and electron intensities outside the spacecraft and the dose being received by the crew throughout the mission. The measurements were to provide data through which the dose could be calculated for the mission and subsequently compared to the measured dose. In this manner, the dose computational techniques being devised can be checked for accuracy and dependability.

8.12.2 Equipment

The spectrometer, which monitored the external environment, was mounted in the equipment adapter section of the Gemini VII spacecraft and had an essentially unobstructed view of the radiation environment. The instrument was constructed to alternately detect the flux and energy of electrons of $0.4 < E < 4.0$ Mev and protons of $5 < E < 20$ Mev. The integrated radiation dose was monitored with operational film-badge packages located in the crew underwear.

8.12.3 Procedure

The spectrometer was actuated by the pilot each day during passes through any portion of the South Atlantic anomaly region (latitudes 30° E. to 60° W. by longitudes 15° S. to 55° S.). Data were relayed via telemetry using the spacecraft delayed telemetry system.

8.12.4 Results

A check of the crew flight log indicated the experiment was operated as planned through the first 8 days of the Gemini VII mission. At the end of this period, however, a failure in the spacecraft telemetry recorder prevented obtaining any data except those which could be transmitted in real time to ground stations along the orbital track. In order to salvage as much of the experimental data as possible, the Mission Director elected to leave the spectrometer on for the remainder of the mission. This allowed real-time pickup of background information outside the anomaly region, and provided some anomaly data which could be received in real time by the Rose Knot Victor (instrumentation ship) off the eastern coast of South America.

A preliminary evaluation of quick-look data from an early revolution in the mission (revolution 5) has been made and indicates the instrument was operating properly in the electron mode. A built-in calibration check indicated the photomultiplier tube and circuit gain had not changed appreciably from the values obtained approximately 6 hours prior to lift-off. However, an erratic signal from the coincidence detector indicated an apparent malfunction in the proton mode of operation. The faulty signal was intermittent and it is believed that proton indications could be present in data from other revolutions. Unfortunately, the only data available at this time are from a pass that does not traverse the heart of the anomaly region, and the lack of proton data may be due to the absence of protons in this region. An evaluation of data from later in the mission will show whether the proton mode was operating intermittently or if it failed completely. An analysis is underway to determine the possible cause of the spurious behavior of the coincidence circuit, and it includes a study of the rendezvous photographs to determine whether the mylar window covering the entrance orifice of the instrument was ruptured during launch or later in the mission.

8.12.5 Conclusions

The MSC-2 experiment on Gemini VII was expected to provide electron data throughout the mission. However, an erratic response in the equipment indicated that an intermittent failure had occurred in the proton mode. Whether proton information will be obtained later will not be known until further analysis of the mission data is performed. Dose estimates will be calculated as soon as all data from the spectrometer are reduced.

8.13 EXPERIMENT MSC-3, TRI-AXIS MAGNETOMETER

8.13.1 Objective

The objective of experiment MSC-3 was to determine the magnitude and direction of the geomagnetic field in the South Atlantic anomaly and to support experiment MSC-2, Proton-Electron Spectrometer, with magnetic-field-line orientation with respect to the spectrometer.

8.13.2 Equipment

The tri-axis flux-gate magnetometer equipment consisted of an electronics package, a sensor unit mounted on an extendible antenna boom, and interconnecting cable between the two units.

8.13.3 Procedure

The sensor was extended on the boom after orbital insertion and remained in the extended position throughout the mission.

The experiment was activated for approximately eight revolutions during each day of the flight.

8.13.4 Results

Data obtained with the experiment hardware prior to launch revealed a loss of data from the Z axis, test parameter XF05. The effect of the failure of the Z axis cannot be determined until all data from the mission have been examined. Preliminary data from the mission have been evaluated and indicate that the X and Y axes were functioning properly.

8.13.5 Conclusions

Further analysis and comparison of data must be made before conclusions for this experiment can be determined.

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8.14 EXPERIMENT MSC-4, OPTICAL COMMUNICATIONS

8.14.1 Objective

The objectives of experiment MSC-4 were to evaluate an optical communications system, to evaluate the flight crew as a pointing element, and to probe the atmosphere using an optical coherent radiator outside the atmosphere.

8.14.2 Equipment

The experiment equipment consisted of a gallium-arsenide laser transmitter (flight hardware), and three instrumented ground sites, each equipped with a flashing beacon and capable of collecting and demodulating coded optical signals.

The flight laser transmitter was a small, self-contained unit whose dimensions were 8.5 in. by 5 in. by 3 in. It produced 16 watts of optical coherent power in short bursts that were coded in a manner similar to a home movie camera. Special infrared safety (spectral) glasses and a microphone were attached to the unit. A 6-power telescope in conjunction with a 400-angstrom filter for fine tracking of the ground beacon was integral to the unit.

The three ground sites specially instrumented for this equipment were located at the White Sands Missile Range, New Mexico; at Kauai Island, Hawaii; and at Ascension Island in the south Atlantic Ocean. Each site operated in the same way. Each employed an argon laser as an optical beacon, each used large collecting telescopes, and each slaved its telescope mount to an orbital-track radar. The sites had instrumentation adequate for voice processing and determination of high-frequency atmospheric effects.

8.14.3 Procedure

Both of the flight crew members were given preflight beacon tracking experience in the docking simulator room and experience in sighting the unit in a field situation. Data recorded on a spacecraft test were to be complemented with static and aircraft fly-by field tests in an effort to isolate all deleterious parameters affecting the data and to determine a method of eliminating them. The ultimate goal is to identify atmospheric properties affecting the equipment and to provide mathematical models for future design efforts.

8.14.4 Results

Unfavorable cloud conditions hampering this experiment throughout the Gemini VII mission forced cancellation of all but four attempts. The ground beacon was observed by the crew only twice in these four attempts and this was for short intervals. No solid track could be accomplished by the crew in these short intervals, and no data were recorded. The following paragraphs describe the four attempts.

Revolution 79 over Hawaii – Even though cloud cover in the general area was favorable, the ground beacon site was obscured by a cloud.

Revolution 105 over Hawaii – The crew saw the ground beacon for about 20 seconds. However, the beacon came in and out of view. After the pass, it was determined that a slaving data-corrector package at the ground site was not operating properly and did not allow close tracking of the spacecraft.

Revolution 104 over White Sands – An equipment failure and complications with safety procedures delayed boresighting of the beacon with the radar, and only a coarse boresight was accomplished. After the pass, it was determined that the boresight was off by 3 beam widths.

Revolution 119 over White Sands – The crew observed the beacon for 2 or 3 seconds twice during the pass. After the pass it was determined that reversed stator leads on the ground caused a poor track.

The argon lasers used as ground beacons caused severe problems at the Hawaii and Ascension stations. The same type of laser had worked well at White Sands during the Gemini V mission, and, in fact, worked well during the Gemini VII mission. The Ascension Island station was not able to get a laser to operate beyond boresighting.

The problems encountered with this experiment were corrected in the field with the exception of the laser deterioration. This problem has been relieved by equipment modifications, but it is not fully resolved.

8.14.5 Conclusions

Experiment MSC-4 did not achieve any of the stated objectives. However, the information gained does indicate the following:

(a) Beacon lasers with greater adaptability to different environments are needed.

(b) A 1-watt argon gas laser is visible at orbital altitudes.

(c) The green filter in front of the spacecraft acquisition and tracking telescope hinders acquisition of the beacon.

(d) Very close inspection of the beacon-telescope mount and tracking-radar mechanism must be maintained on a day-to-day basis to insure the necessary close track of the spacecraft.

The Gemini VII crew has recommended that a laser site be placed in an area that is more easily acquired, such as Cape Kennedy.

Although the experiment was not successful on the Gemini VII mission, the major system parts have been proven. The laser beacon was shown to be visible at orbital altitudes, static tests have shown that adequate signal-to-noise ratios can be obtained, and previous aircraft fly-bys have indicated that the system can track to within the required accuracy when the system is functioning properly.

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8.15 EXPERIMENT MSC-12, LANDMARK CONTRAST MEASUREMENT

8.15.1 Objective

The objective of experiment MSC-12 was to measure the visual contrast of landmarks against their surroundings. These data were to have been compared to calculated values of landmark contrast in order to determine the relative visibility of terrestrial landmarks as seen from outside the atmosphere. These landmarks, when visible, provide a source of data for the onboard Apollo guidance and navigation system.

8.15.2 Equipment

The experiment equipment consisted of the D-5 experiment photometer equipped with an optical filter which was positioned in front of the objective lens. This filter attenuated the light reaching the photometer sensor in the blue region of the visual spectrum. In this way, the photometer spectral response was adjusted reasonably well to that of the standard Commission Internationale de l'eclairage (C.I.E.) observer. For details of photometer operation and data readout, reference should be made to the D-5 star occultation experiment section (section 8.2) of this report.

8.15.3 Procedure

The observations were to include sightings of nine landmarks at each of three sun elevations. All landmarks were established at land and sea boundaries. The method of observation involved tracking the landmark for approximately 80 seconds of time as the landmark passed through nadir. Figure 8.15-1 shows the measurement geometry. Data were to have been taken continuously as the pitch angle to the landmark from the spacecraft ranged from 30° to 150°. The photometer was to have been aligned alternately on the land and then on the sea for periods of 4 seconds of time and then 2 seconds of time, respectively. The resulting data would have been stored in the onboard tape recorder and later telemetered to ground. A photograph was to have been taken of the landmark at nadir to aid in identification and also to provide a photographic contrast. Measurement of the photograph would afford a rough correlation with the visual contrast measured by the photometer.

8.15.4 Results

Because of a malfunction of the D-5 photometer, no photometric data were obtained. A trial sighting run was made at 163:19:40 g.e.t. in which a landmark on the western African coast was acquired, tracked through nadir, and photographed. The telemeter record of the photometer output was then examined. The telemeter record compared to predicted data typical for a similar land area and sun aspect is shown in figure 8.15-2. Because the telemeter data were inconsistent with the known conditions of measurement, no further fuel usage for the MSC-12 experiment seemed to be warranted.

The photograph of the landmark taken during the sighting run will be used for practice identification of the exact geographic area observed. If a photographic contrast can be obtained for the land area and surroundings, that value will be compared with the calculated visual contrast estimated for the landmark at nadir. This comparison will be qualitative rather than quantitative.

8.15.5 Conclusions

Postflight technical debriefing comments by the command pilot and pilot indicate that the experiment is operationally feasible. The fact that photometric data were not obtained from the sighting run that was performed appears to be due to the malfunction of the D-5 photometer sensor or associated electronic components.

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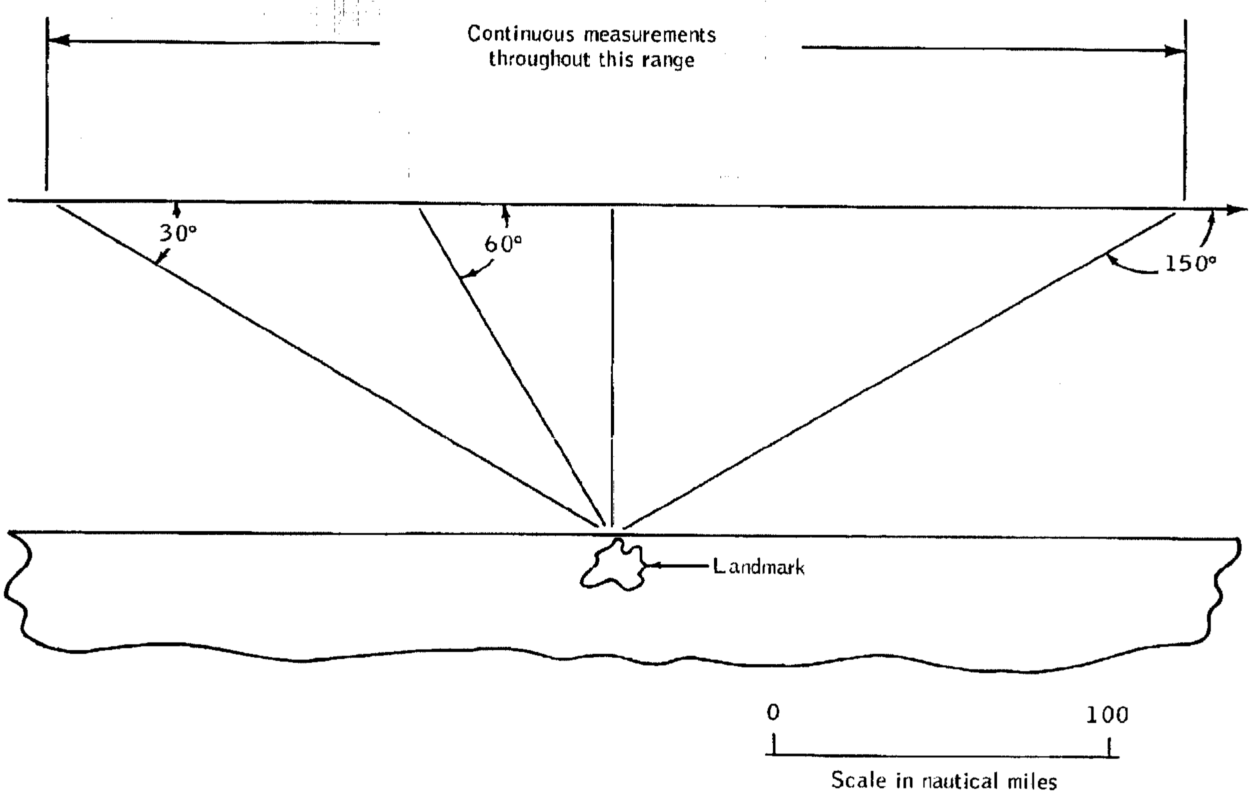

Figure 8.15-1. - Experiment MSC-12, measurement geometry.

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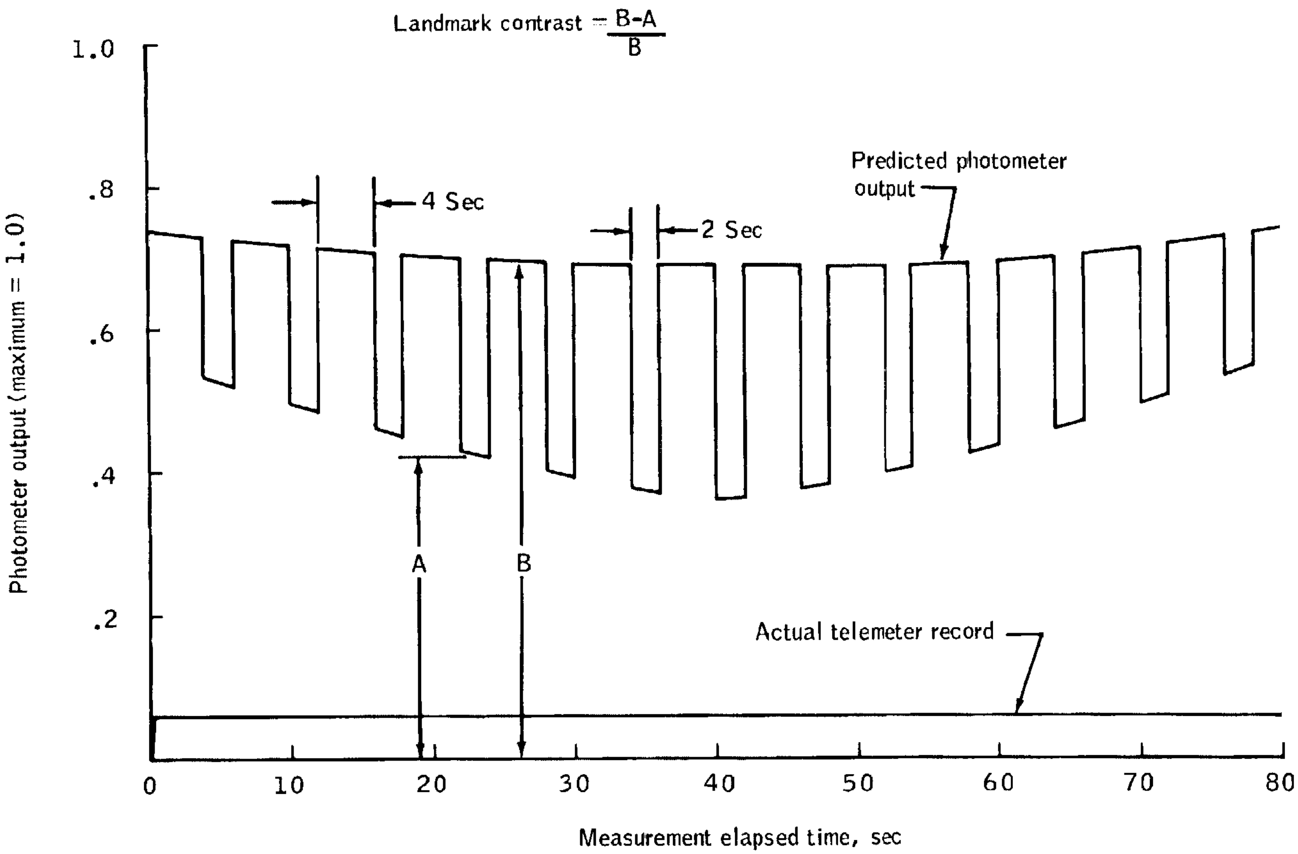

Figure 8.15-2. - Experiment MSC-12 - typical predicted photometer output compared to actual telemeter record.

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8.16 EXPERIMENT S-5, SYNOPTIC TERRAIN PHOTOGRAPHY

8.16.1 Objective

The objective of experiment S-5 was to obtain high-quality, small-scale photographs, using color film and color-shifted infrared film, of terrain and ocean areas for geological, geographical, and oceanographic research. Pictures were desired of selected areas in Mexico, Africa, Australia, South America, and certain preselected ocean areas.

8.16.2 Equipment

A modified Hasselblad 500C camera, similar to those which had been carried on the Mercury and previous Gemini flights, was used for the experiment. The camera used had a Zeiss Planar f/2.8 lens with an 80-mm focal length. A haze filter was available for the crew's use. Seven magazines loaded with Ektachrome MS (SO-217) film and one with Ektachrome infrared film were carried on this mission.

8.16.3 Procedure

The crew was instructed, subject to fuel and power restrictions and rendezvous requirements for film, to take vertically oriented, systematic, overlapping pictures across Mexico, Africa, and Australia, or any other areas showing cloud-free terrain. As in previous Gemini flights, it was stressed that almost any picture of the earth's surface was valuable, even if the planned procedure could not be followed exactly.

8.16.4 Results

A large number of photographs of the selected areas was obtained, and the quality ranged from poor to excellent. Several continuous sequences suitable for stereoscopic study were obtained covering portions of Africa and Mexico. A number of high quality oceanographic pictures showing the Bahama Islands was obtained which should be useful in studying the changes in bottom topography caused by Hurricane Betsy.

The quality of the infrared pictures appears to be excellent. They show good haze penetration as had been hoped. Most of the infrared pictures do not show the exotic colors, such as red replacing green as seen on low-altitude photographs, but instead, shades of blue dominate. The area photographed with the infrared film, the southeast coast of the United States, is especially suitable for testing the efficiency of the film because the low altitude and high humidity of the region promotes haze.

Several of the pictures taken over North Africa are badly blurred, though usable. The cause of the blurring appears to be a deposit on the command pilot's window. A similar deposit was noticed on the previous Gemini flights and even though the photographs were very good, it probably degraded the quality of the pictures to some degree. The nature of the deposit should be investigated as in previous missions, and steps should be taken to prevent a recurrence. The Gemini IV crew reported that the residue was partially wiped off during the extravehicular operation and this suggests that during future Gemini missions involving extravehicular operation, it should be possible to clean the window from the outside.

8.16.5 Conclusions

The S-5 experiment can be classified as highly successful. Despite the amount of film required for rendezvous operations, and the blurred photographs caused by the window deposit, a large number of valuable photographs was obtained. In addition, infrared color was used successfully for the first time on a manned flight.

8.17 EXPERIMENT S-6, SYNOPTIC WEATHER PHOTOGRAPHY

8.17.1 Objective

The objective of this experiment was to obtain color photographs of a variety of cloud systems for meteorological studies of the earth's weather in equatorial regions during different seasons. These high resolution pictures will supplement those taken for the S-6 experiment during the Gemini IV and V missions.

8.17.2 Equipment

Eight 70-mm film magazines containing color film, each having a 60-frame capability, were carried in the spacecraft. One of these magazines contained infrared color film. These magazines, used with a 70-mm still camera, were also available for the S-5 experiment and for general photography requirements. A haze filter was available to be used when needed.

8.17.3 Procedure

The crew was briefed prior to the flight on the types of weather systems of interest for the experiment. During the mission, meteorologists from the Environmental Science Services Administration used TIROS weather satellite pictures and worldwide weather maps to select specific areas likely to contain cloud patterns of interest. These areas were incorporated in each day's flight plan when scheduling permitted. Additional photographs were made at the crew's discretion.

8.17.4 Results

Two hundred forty exposures were made and of these, approximately 190 good photographs containing clouds were obtained. The remaining 50 pictures were not useful because of the coating that had collected on the exterior of the spacecraft windows during launch. This substance blurred the image in about one-third of all the photographs taken. Several series of photographs were taken over the Bahama and Caribbean Islands (fig. 8.17-1(a)) and over northern South America and the Amazon River basin (fig. 8.17-1(b)). These photographs show lines of trade wind cumuli and tropical zone cloudiness. Cirrus clouds and a general undercast of other clouds associated with an upper-air long-wave trough were photographed over Baja California (fig. 8.17-1(c)) and northern Mexico. Other pictures showed cloud conditions near Pacific islands and atolls such as New Guinea, the Cook Islands, and Guadalupe Island.

A variety of sand dune formations in North Africa and Saudi Arabia indicates the prevailing wind direction, and drifting smoke from fires in southern Sudan shows low-level wind direction.

8.17.5 Conclusions

Experiment S-6 can be classified as a success although some original objectives, such as photographing particular areas on successive revolutions, could not be met because of more pressing crew activities. A detailed study of the many photographs, with extensive analysis and evaluations, will be an outstanding contribution to present meteorological studies.

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(a) View taken at approximately 12:56 G.m.t. on December 8, 1965 during revolution 57 north of Venezuela over the Caribbean Sea. The three distinct holes in the cloud deck are likely caused by small islands influencing the stability and motion of the atmosphere in their vicinity.

Figure 8.17-1. - Experiment S-6, a series of three typical synoptic weather photographs.

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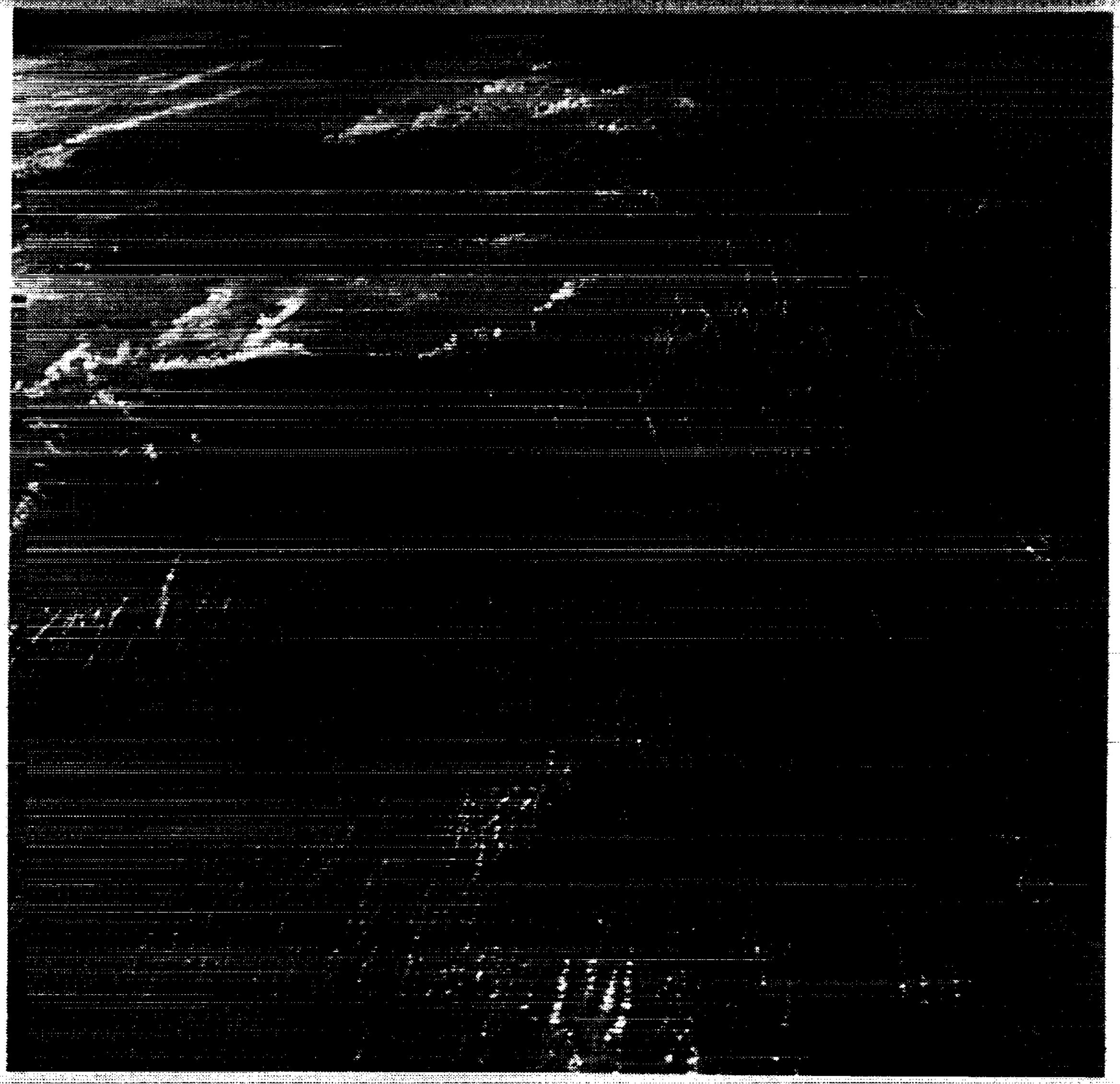

(b) View taken at approximately 19:49 G.m.t. on December 12, 1965 during revolution 121 over the mouth of the Amazon river in Brazil. The long lines of cumulus clouds oriented east-west with the wind direction have a spacing which is related to the vertical wind profile.

Figure 8.17-1. - Continued.

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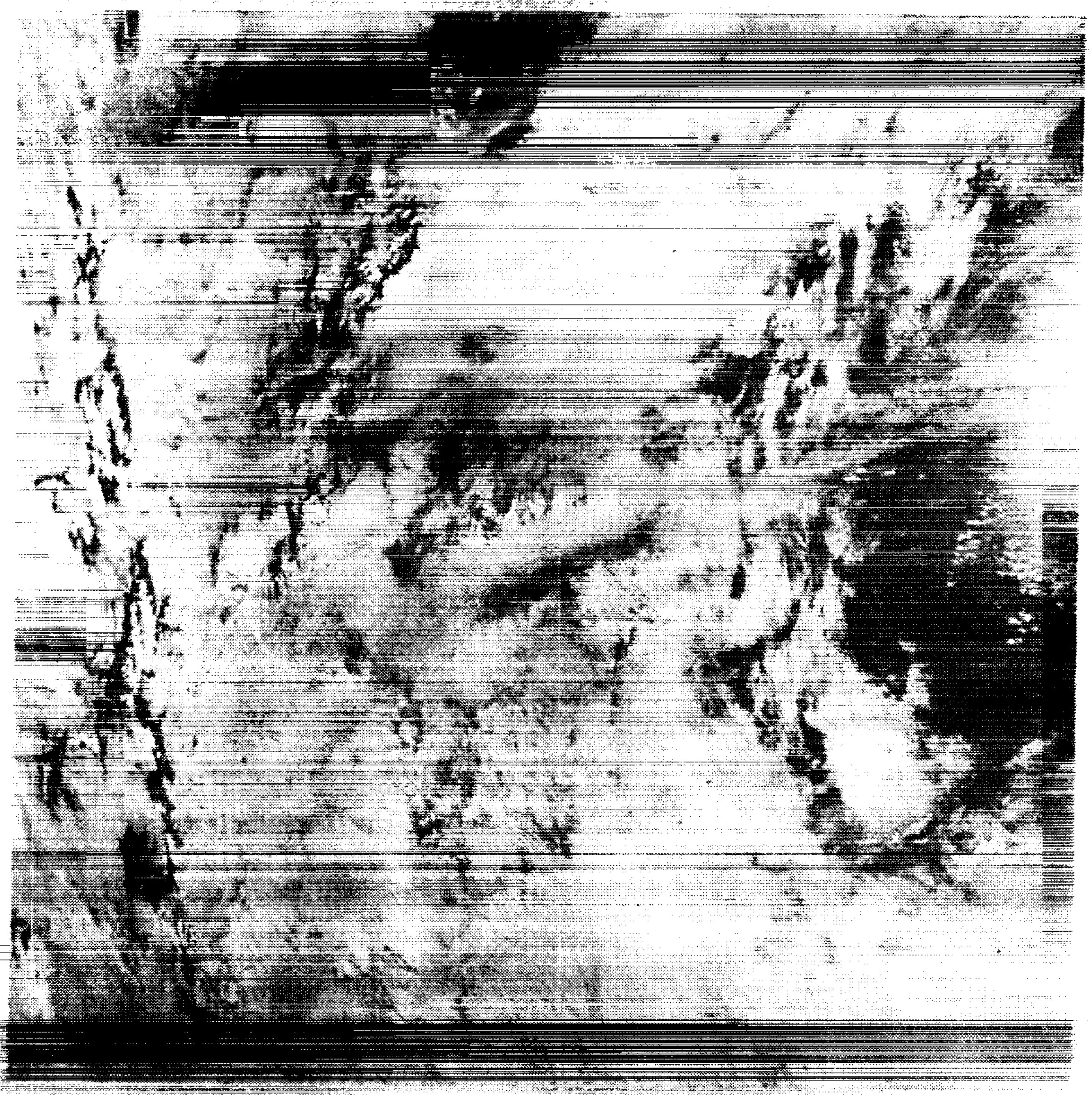

(c) View taken at approximately 20:40 G.m.t. on December 9, 1965 during revolution 76 west of Baja California. The lines of cirrus clouds over the lower clouds are associated with an upper-air long-wave trough in the atmosphere.

Figure 8.17-1. - Concluded.

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8.18 EXPERIMENT S-8/D-13, VISUAL ACUITY AND ASTRONAUT VISIBILITY

8.18.1 Objective

The objectives of experiment S-8/D-13 were to:

(a) Measure the visual acuity of the flight crew members before, during, and after long-duration space flight in order to ascertain the effects of a prolonged stay in the space environment.

(b) Test the use of basic visual-acuity data combined with the measured optical properties of ground objects and their natural lighting, the atmosphere, and the spacecraft window to predict the limits of naked-eye visual capability of the flight crew in discriminating small objects on the surface of the earth during daylight.

8.18.2 Equipment

The experiment equipment consisted of an inflight vision tester for testing visual acuity, an inflight photometer to monitor the spacecraft window, and an instrumented test pattern at a ground observation site.

The inflight vision tester was a small, self-contained, binocular, optical device containing a trans-illuminated array of 36 high-contrast and low-contrast rectangles. Half of the rectangles were oriented vertically in the field of view while the other half were oriented horizontally. Rectangle size, contrast, and orientation were randomized, the presentation was sequential, and the sequences were non-repetitive. Each rectangle was viewed singly at the center of a 30° adapting field, the apparent luminance of which was approximately 100 foot-lamberts. Both members of the flight crew made forced-choice judgments of the orientation of each rectangle and indicated their responses by punching holes in a record card. Optical alignment was accomplished by means of a bite-board provided with the flight crew member's dental impression. Electrical power for illumination within the instrument was derived from the spacecraft.

A photoelectric photometer was mounted near the lower right corner of the right hatch window to measure the amount of ambient light scattered by the window into the patch of sight at the moment when observations of the ground test patterns were to be made. The photometer had a narrow (1.2°) circular field of view into the opening of a small black cavity a few inches away from the outside of the right hatch window. The photometric scale was linear and extended from 60 to 3000 foot-lamberts. Since the apparent luminance of the black was always less than 60 foot-lamberts, any reading of the photometer was ascribable to ambient light scattered by the window. This information, combined with data about the beam transmittance of the window and about the apparent luminance of the background squares in the ground array, enabled the contrast transmittance of the window at the moment of observation to be calculated.

The ground observation site was located 40 miles north of Laredo, Texas. Eight 2000 foot by 2000 foot squares of plowed, graded, and raked soil were arranged in a 4 by 2 matrix. White rectangles of styrofoam-coated wallboard were laid out in each square. Their length decreased in a uniform logarithmic progression from 610 feet in the northwest corner (square number 1) to 152 feet in the southwest corner (square number 8) of the array. Each of the eight rectangles was oriented in one of four positions (i.e., north-south, east-west, or diagonal) and the orientations were random within the series of 8. Advance knowledge of the rectangle orientations was withheld from the flight crew since their task was to report the orientations. Provision was made for changing the rectangle orientations between passes and for adjusting their size in accordance with anticipated slant range, solar elevation, and the visual performance of the flight crew on preceding passes. Pattern contrasts and atmospheric effects in the direction of each path of sight were measured from the ground by means of a newly devised system of photoelectric photometers.

8.18.3 Procedure

Both of the flight crew members completed twelve or more preflight sessions in a laboratory training van during which they became experienced in psychophysical techniques and established physiological baselines descriptive of their individual visual performance. The statistical fluctuations in that performance were established, providing a means by which the inflight vision tests and the ground pattern observations could be interpreted.

8.18.4 Results

Inflight vision tests were performed once each day by each crew member. The results of these tests, together with preflight and postflight test results, are shown in figure 8.18-1. Ground observations were to be made by the command pilot on revolutions 17 and 31. The results of these observations are shown in figure 8.18-2. Unfavorable cloud conditions caused some scheduled observations of the ground markings to be deleted.

The solid line in figure 8.18-2 represents the preflight visual performance of the command pilot as measured in the training van, and the dashed lines represent the 1σ and 2σ limits of his visual performance. The numbered circles represent the physically measured apparent contrast and angular size of the rectangles at the Laredo site at the moment they were read by the command pilot. A double circle denotes that the orientation of the rectangle was reported correctly by the command pilot. The positions of the double-circled points indicate that his visual performance during space flight was within the statistical range of his preflight visual performance.

8.18.5 Conclusions

Experiment S-8/D-13 has successfully achieved both of its stated objectives. Data from the in-flight vision tester are complete and of high quality; preliminary evaluation indicates that the visual performance of the crew members was not degraded during the 14-day mission. Results from observation of the ground site near Laredo, Texas, confirm that the visual performance of the command pilot during space flight was within the statistical range of his preflight visual performance. The results also demonstrate that laboratory visual acuity data can be combined with environmental optical data to predict correctly the limiting visual capability of the flight crew to discriminate small objects on the surface of the earth in daylight.

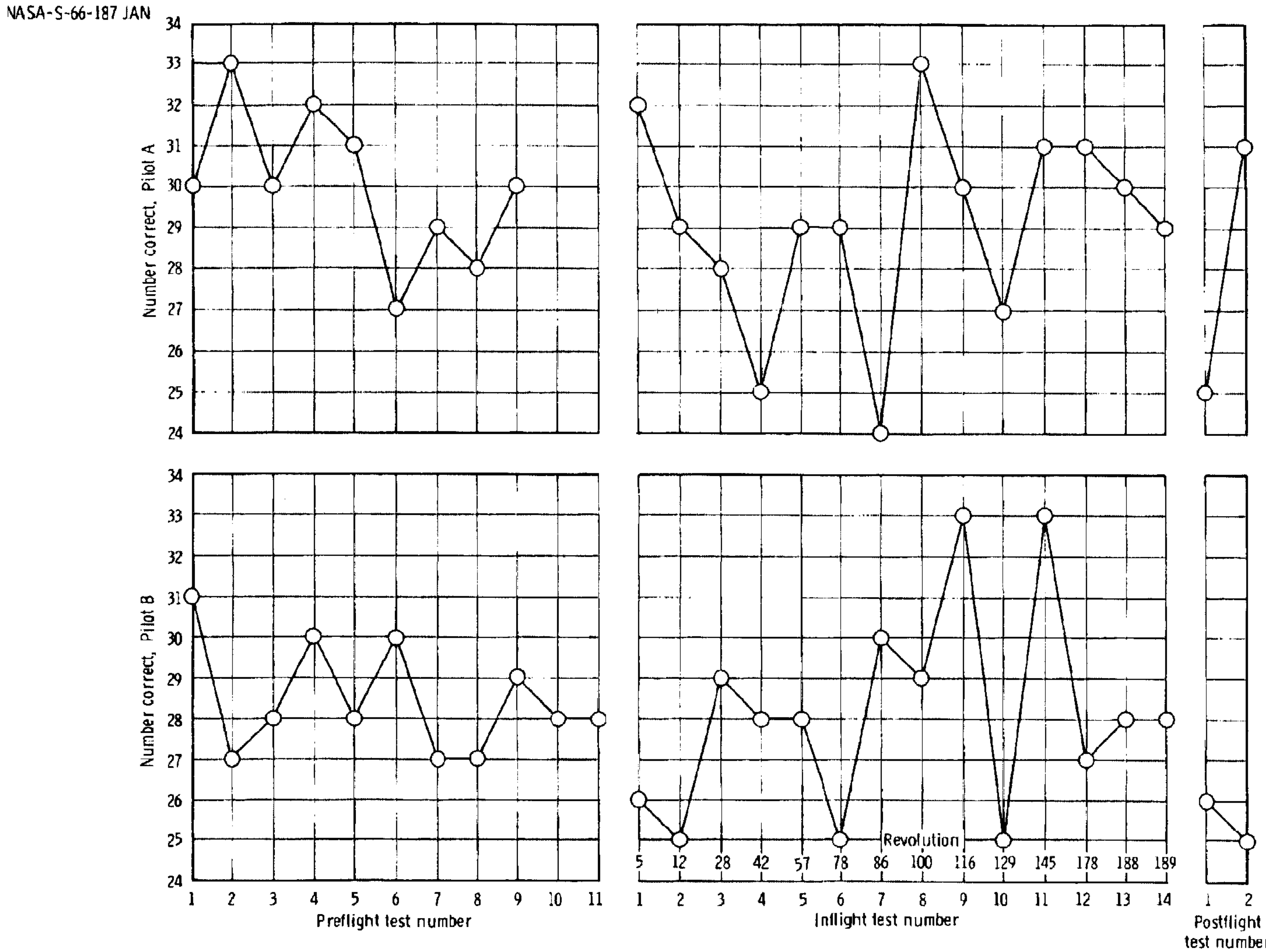

Figure 8.18-1. - Experiment S-8/D-13, vision tester results.

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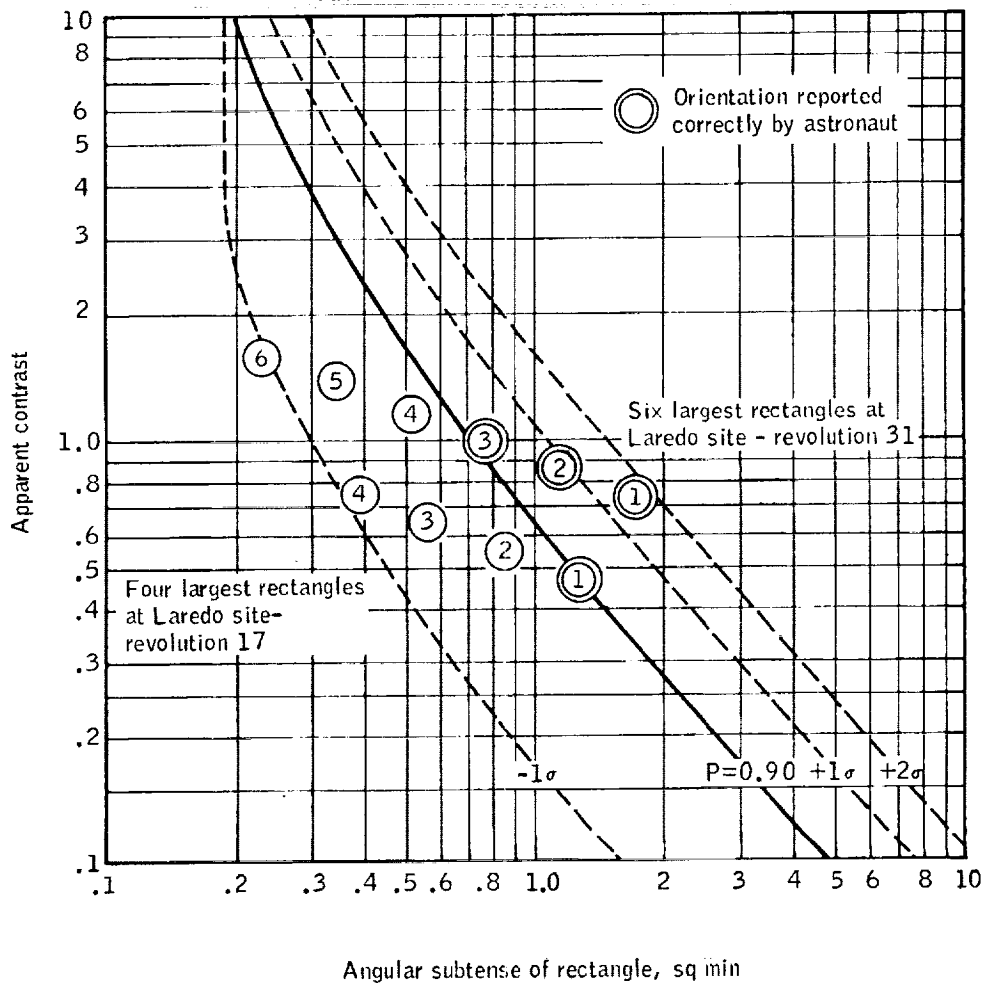

Figure 8.18-2. - Experiment S-8/D-13, preflight visual thresholds, command pilot.

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9.0 CONCLUSIONS

The performance of the spacecraft, launch vehicle, flight crew, and mission support was very satisfactory for the Gemini VII mission, and all objectives of the mission were accomplished. The flight contributed significantly to the knowledge of manned space flight, especially in the area of long-duration flight and in man's ability to operate for this extended period of time in space.

The following conclusions were obtained from the evaluation of the Gemini VII mission data.

1. The performance of the Gemini launch vehicle was very satisfactory and the spacecraft was placed into the nearest-to-nominal orbit yet achieved in the Gemini Program.

2. Station keeping was successfully performed with the second stage of the launch vehicle at distances as close as 60 feet, despite second-stage fuel venting which caused excessive tumble rates and translation. Station keeping at distances closer than 60 feet with a vehicle having excessive tumble rates is not desirable.

3. The film deposited on the spacecraft windows during the launch phase was similar to that experienced on previous flights and interfered with visibility, as well as degraded the quality of some of the photographs. However, the condition of the windows was made worse by the effects of reentry and landing.

4. Voice communications were excellent throughout the mission. The ultrahigh frequency (UHF) air-to-ground, ground-to-air, and spacecraft-to-spacecraft communications were very satisfactory except for the few minutes during the launch phase when air-to-ground communications were practically unreadable. This condition was caused by the lower acoustic attenuation of the soft helmet as opposed to the attenuation of the hard helmet used for the design of this system.

5. The tape recorder used for delayed-time telemetry transmissions failed at approximately 201 hours ground elapsed time because of a bearing seizure. It is notable that the identical failure occurred during the Gemini VI-A mission.

6. The lightweight pressure suit when unpressurized represented a significant improvement in comfort and mobility over previous suits when unpressurized. However, the crew's comfort, mobility, and efficiency were improved to even a greater extent when they were not wearing the pressure suits. The environmental control system operated in an

excellent manner and provided very comfortable conditions for the crew while operating with their suits off; however, conditions were less desirable when the crew was in the pressure suits.

7. The fuel cell electrical power system met all of its requirements during the mission despite the minor system problems associated with the removal of water from the section, although these problems did require considerable attention by the crew and by ground monitoring personnel during the latter half of the mission.

8. The opening of the snorkel valve at 26 000 feet, prior to opening the cabin air recirculation valve, permitted objectionable fumes to be ingested into the suit circuit and caused considerable irritation to the pilot who had his hood closed. However, this condition lasted for only a few seconds and would have been prevented had the cabin air recirculation valve been opened prior to the opening of the snorkel valve.

9. An analysis of the photographs of the spacecraft 7 launch vehicle-spacecraft separation plane, taken after rendezvous and during station keeping by the spacecraft 6 crew, identified several loose strands of material hanging from the spacecraft as the silicone rubber holders and blast absorber for the flexible linear shaped charge. These materials do not present a hazardous condition for future flights because they can be readily removed and discarded during extravehicular activities.

10. Thrust chambers 3 and 4 (yaw-right attitude thrusters) of the orbital attitude and maneuver system were seriously degraded for approximately the last 47 hours of the flight. Yaw-right control was obtained by using thrust chamber 12 (right-hand forward maneuver thruster) with supplemental vernier corrections from degraded thrust chambers 3 and 4. It was determined that the spacecraft could be rolled 90° right and pitch-up thrusters used to take out excessive "yaw", if time permitted.

11. The reentry control system propellant was depleted at approximately the initiation of drogue parachute deployment. Tight control of spacecraft attitude by the crew, using the orbit rate command mode, expended fuel at a higher rate than planned. Without fuel, there would have been no way to stabilize the spacecraft during the critical aerodynamic phase of the flight below 50 000 feet if the drogue parachute had failed to deploy properly.

12. The crew performed all activities associated with stowage, equipment handling, housekeeping, and waste management with no apparent difficulty, although these activities constituted a heavy mission task. The lack of apparent difficulty in performing these operations was the result of adequate preflight planning and training.

13. It was not possible to see stars in the daytime during the Gemini VII mission.

14. The equipment for the food, water, personal hygiene, and waste management systems was satisfactory for use during the Gemini VII mission, except for the urine receiver which needs improvement.

15. The Gemini VII flight proved that man can stay in earth orbit for up to 14 days with no inflight or no significant postflight medical effects which might affect his ability to perform normal tasks. It must be noted, however, that after 14 days there was a noticeable level of fatigue which did lower the stamina of both crew members for a short period immediately after landing.

The conclusions from each experiment are included in section 8.0, EXPERIMENTS.

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10.0 RECOMMENDATIONS

The following recommendations are made as a result of data evaluation and crew observations of the Gemini VII mission.

1. Corrective action should be taken to insure that visibility through the spacecraft windows is not obscured during the mission. The corrective action should not require extravehicular activity as a backup means to remove any protective covering from the windows, but should not preclude this means of cleaning the window.

2. The centerline crew station stowage structure should be modified to insure that there are no opening or closing problems when the cabin is pressurized.

3. The spacecraft 7 instrumentation configuration for the guidance and control system and the propulsion system should be retained on all future spacecraft.

4. The snorkel inflow valve should be opened in a sequence to prevent the entry of toxic gases into the pressure suits as occurred on the Gemini VII mission.

5. In view of the fuel-cell problems encountered during the mission, additional instrumentation should be provided on subsequent spacecraft, and an analysis should be made to resolve these problems.

6. Necessary spacecraft modifications should be made to minimize the possibility of ice formation at fuel-cell purge outlets.

7. Inflight tests of suspected malfunctioning thrust chamber assemblies should be performed with the rate gyros operating to provide data for real-time and postflight evaluations. The tests should be performed only on the malfunctioning thrust chamber assembly and over a continuous 3-second thrust period.

8. The presently utilized reentry control procedures should be modified to insure that adequate reentry control system propellants remain for spacecraft stabilization below 50 000 feet in case the drogue parachute should not function properly.

9. Future long-duration missions should be planned to allow the crew to operate without wearing pressure suits during non-critical mission phases.

10. Ground elapsed time should be used as the universal time reference for all flight plans.

11. The quick-disconnect fittings used at several points in the spacecraft cabin area should be modified or replaced to correct the difficulties encountered by the crews of both Gemini VII and Gemini VI-A.

12. The urine measuring and disposal system should be improved to prevent the leakage and spillage experienced on the Gemini VII mission, if the system is to be flown in the future.

13. Consideration should be given to provisioning and stowing meals such that appropriate menus are offered for each normal meal of the day (such as eggs and bacon, rather than shrimp and bacon for breakfast). Also, the packaging of reconstitutable foods should be improved to allow chunks of food, such as shrimp, to be extracted from the package without breaking it; and the bite size food, such as beef bites, must be prepared so that it does not crumble.

14. At the present time, optical rendezvous procedures relying on the use of star backgrounds should be limited to night-side operations until daylight rendezvous procedures using stars have been developed and proven for day-side flight.

15. Future missions should be flown with a work-eat-sleep schedule to which the crew has been accustomed prior to the mission.

16. Current operating procedures should be modified to require the use of the cabin repressurization valve for cooling when postlanding egress and pickup are near at hand.

17. Flight plans should require only those activities during the retrofire, reentry, and landing phases which are essential to reentry and landing and should not include experiments, operational tests, or medical tests such as blood-pressure measurements or other medical procedures.

18. Typical air-to-ground communications procedures should be used for training in the Gemini mission simulator.

11.0 REFERENCES

1. Gemini Mission Evaluation Team: Gemini Program Mission Report for Gemini-Titan I (GT-1). MSC-R-G-64-1, NASA Manned Spacecraft Center, May 1964.

2. Gemini Mission Evaluation Team: Gemini Program Mission Report GT-2, Gemini 2. MSC-G-R-65-1, NASA Manned Spacecraft Center, Feb. 1965.

3. Gemini Mission Evaluation Team: Gemini Program Mission Report GT-3, Gemini 3. MSC-G-R-65-2, NASA Manned Spacecraft Center, April 1965.

4. Gemini Mission Evaluation Team: Gemini Program Mission Report, Gemini IV. MSC-G-R-65-3, NASA Manned Spacecraft Center, June 1965.

5. Gemini Mission Evaluation Team: Gemini Program Mission Report, Gemini V. MSC-G-R-65-4, NASA Manned Spacecraft Center, August 1965.

6. Gemini Mission Evaluation Team: Gemini Program Mission Report, Gemini VI. MSC-G-R-65-5, NASA Manned Spacecraft Center, Oct. 1965.

7. Gemini Mission Evaluation Team: Gemini Program Mission Report, Gemini VI-A. MSC-G-R-66-2, NASA Manned Spacecraft Center, Feb. 1966.

8. Aerospace Corp.: Systems Test Objectives for Gemini Launch Vehicle NASA Mission Gemini VII. TOR-669 (6126-80)-3. Nov. 1965.

9. NASA Manned Spacecraft Center: Project Gemini Trajectory Data for the Gemini VII Mission Plan prior to October 25. MSC Internal Note 65-FM-156, Nov. 1965.

10. International Business Machines Corp.: Gemini Reentry Math Flow 6 Description. IBM No. 64-528-00021.

11. NASA Manned Spacecraft Center: Gemini Spacecraft/Launch Vehicle Interface Specification and Control Document. Report ISCD-1, Nov. 1963. (as revised)

12. McDonnell Aircraft Corp.: Recovery Operations Manual. SEDR 303.

13. McDonnell Aircraft Corp.: Gemini Spacecraft Postflight RCS Deactivation. SEDR F-399.

14. McDonnell Aircraft Corp.: Postflight Inspection and Cleanup. SEDR F-498.

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, concurrent problem areas.

12.1.2 Gemini Launch Vehicle Histories

The GLV history and significant manufacturing activities at the contractor's facilities in Denver, Colorado, and Baltimore, Maryland, are presented in figure 12.1-5. The GLV history at Cape Kennedy, Florida, is presented in figure 12.1-6. This figure also includes problem areas which were concurrent with GLV prelaunch preparation activities.

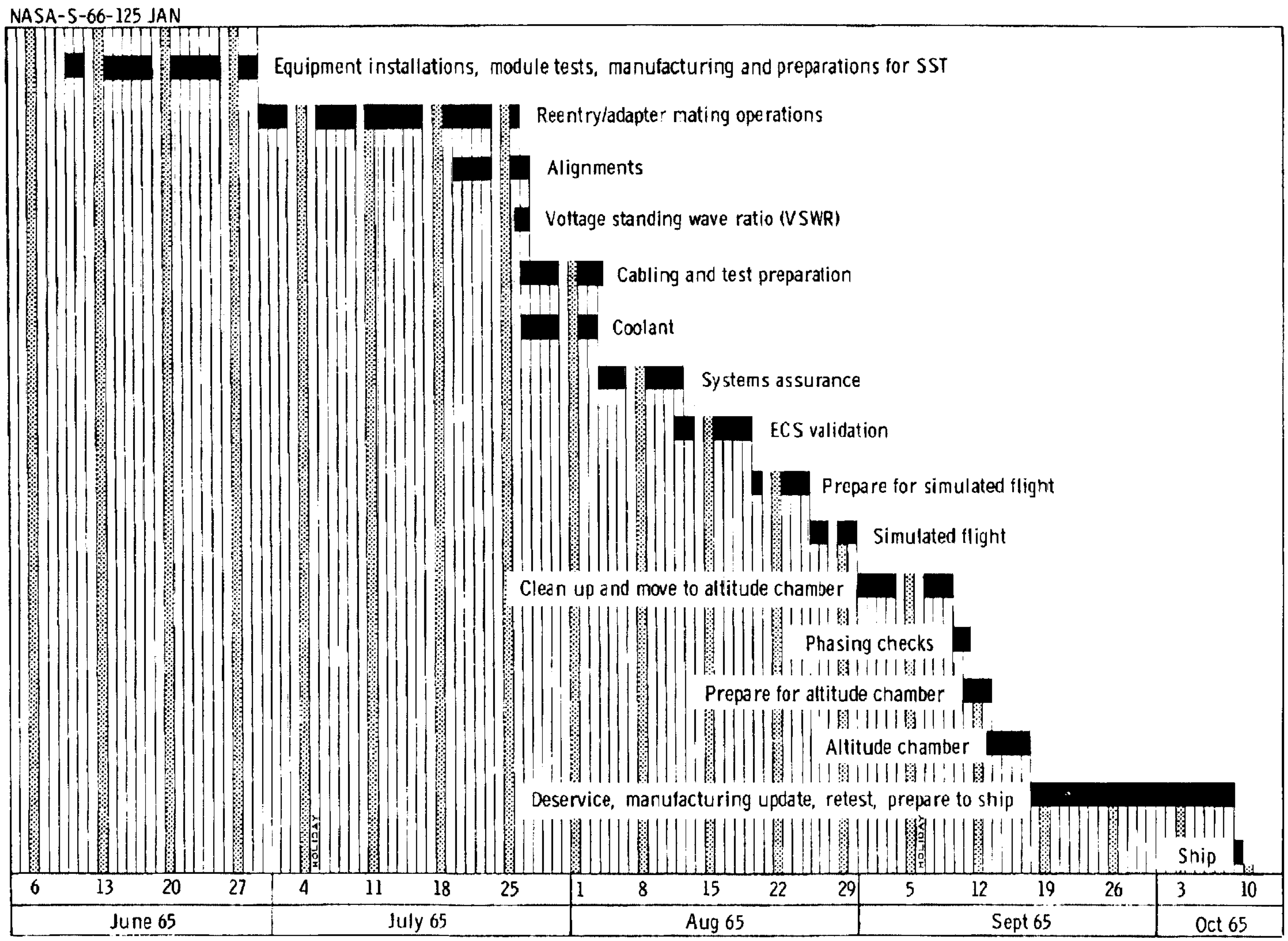

Figure 12. 1-1. - Spacecraft 7 test history at contractor facility.

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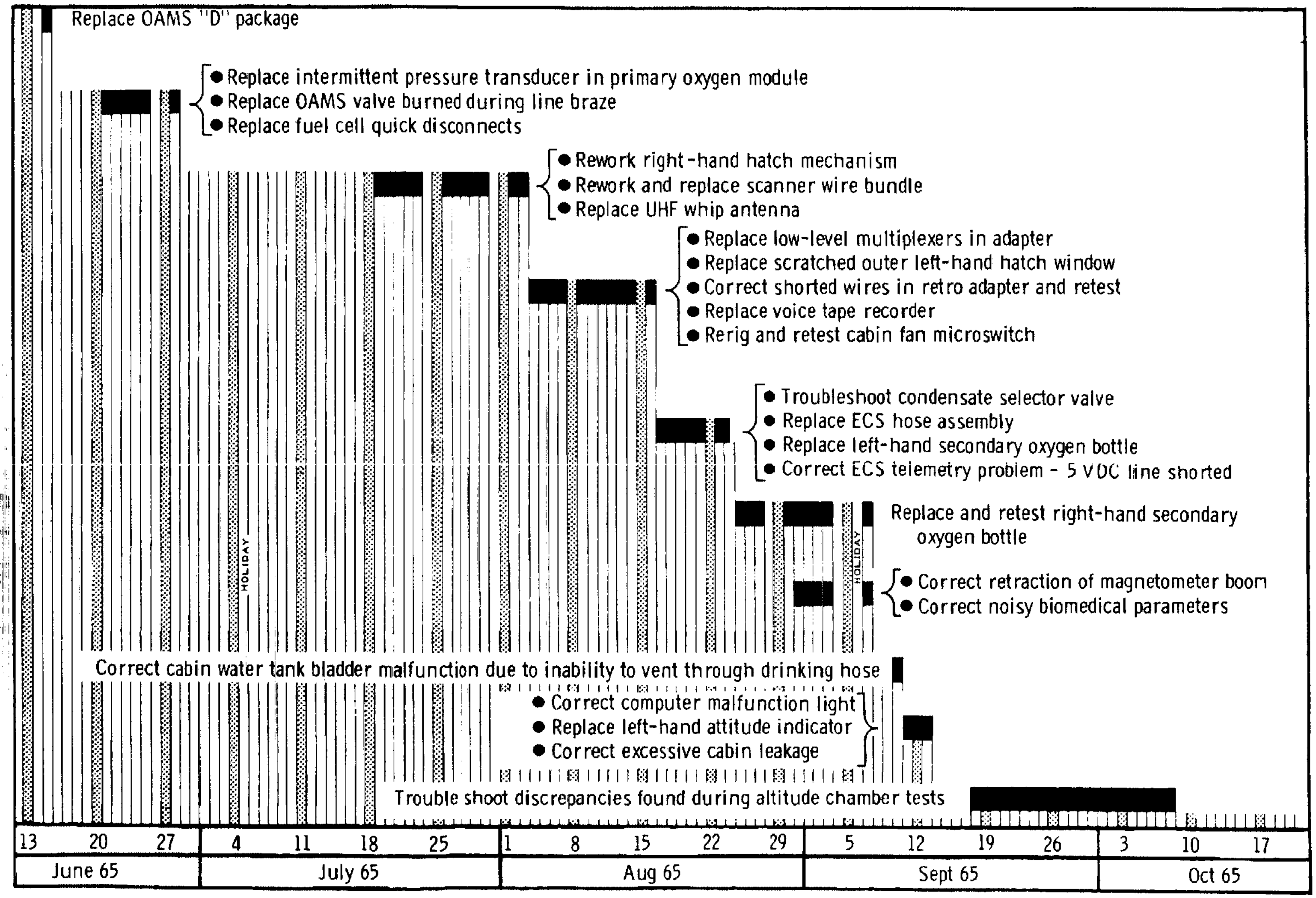

Figure 12.1-2. - Spacecraft 7 significant problem areas at contractor facility.

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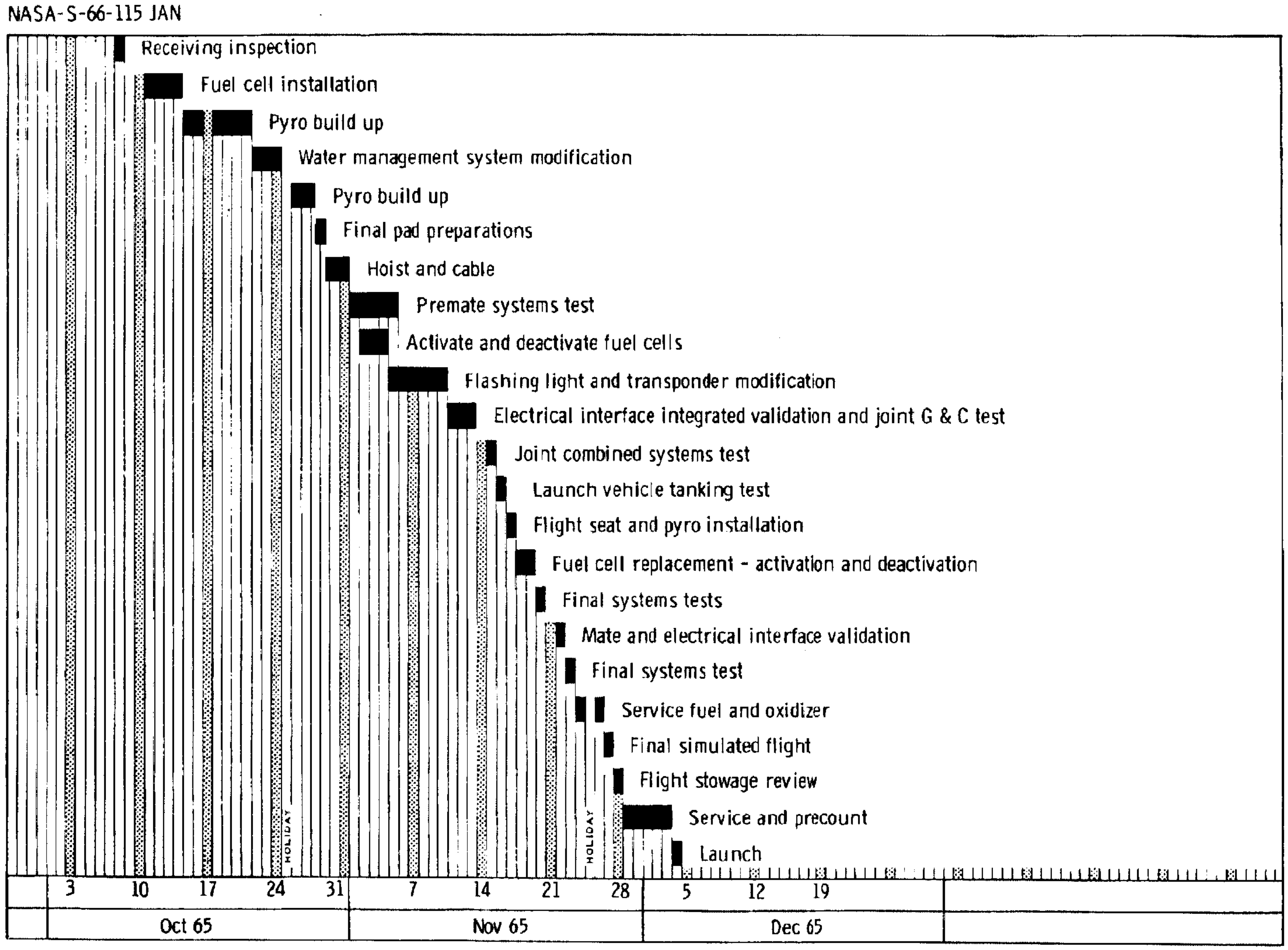

Figure 12. 1-3. - Spacecraft 7 test history at Cape Kennedy.

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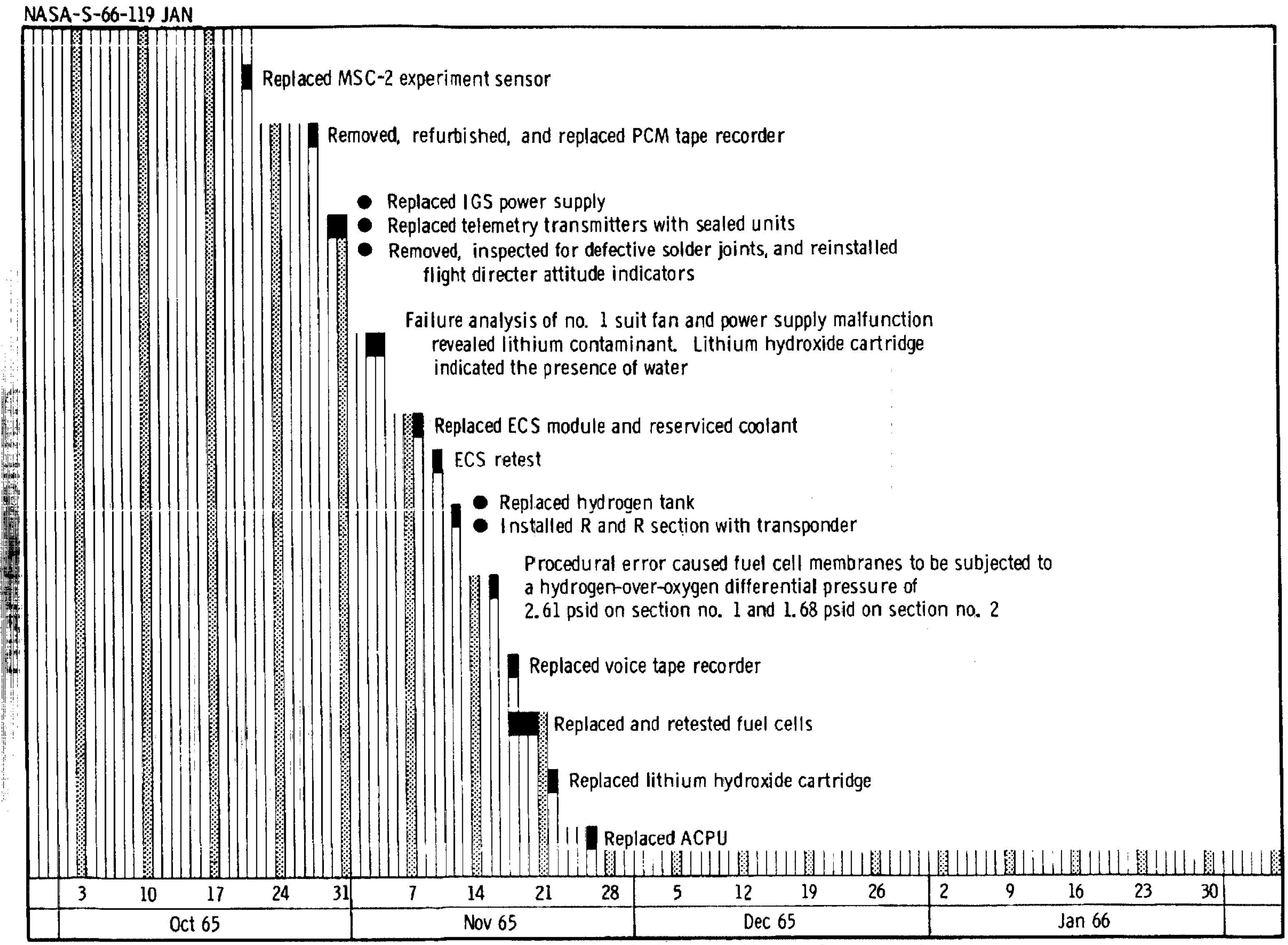

Figure 12.1-4. - Spacecraft 7 significant problems at Cape Kennedy.

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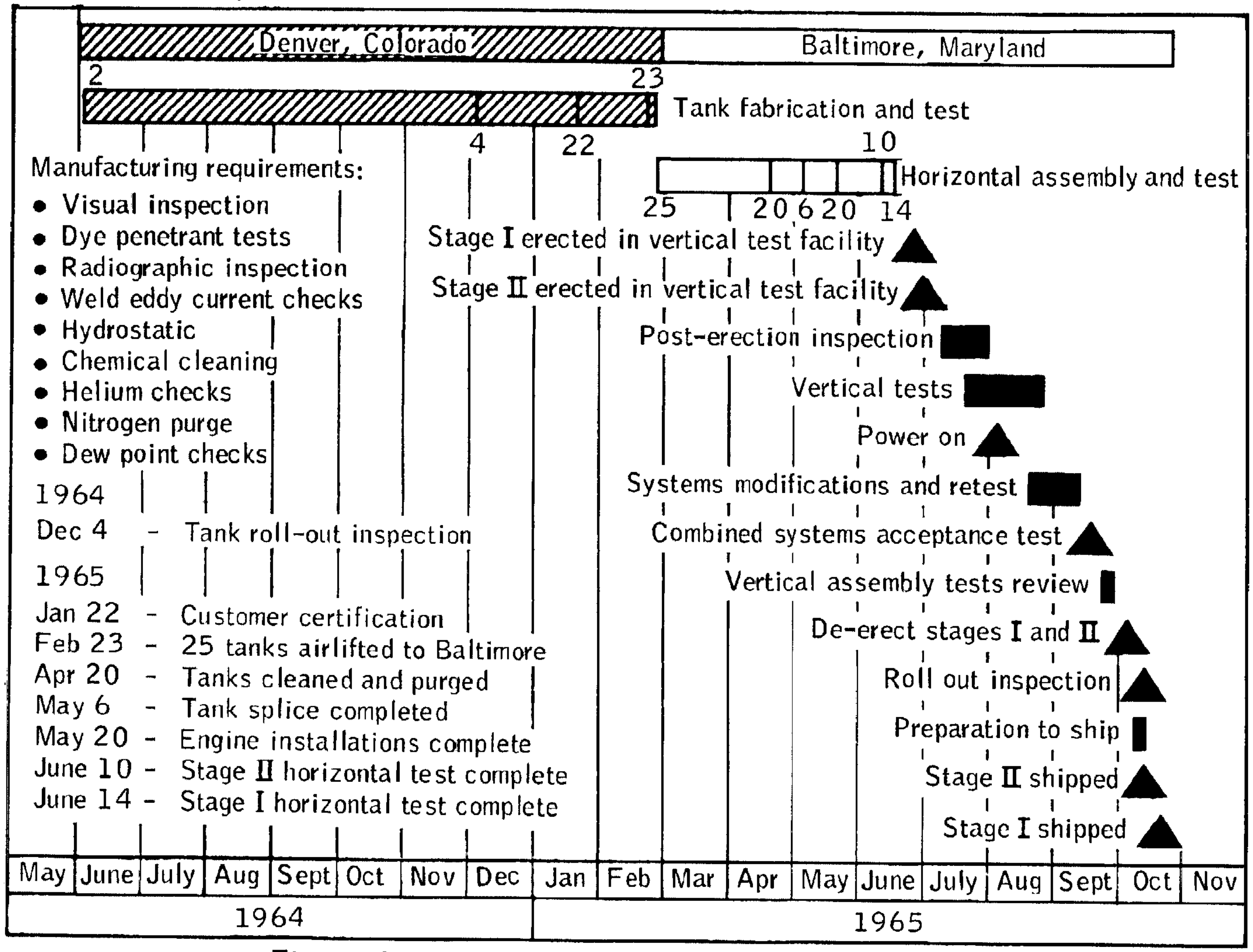

Figure 12.1-5. - GLV-7 history at Denver and Baltimore.

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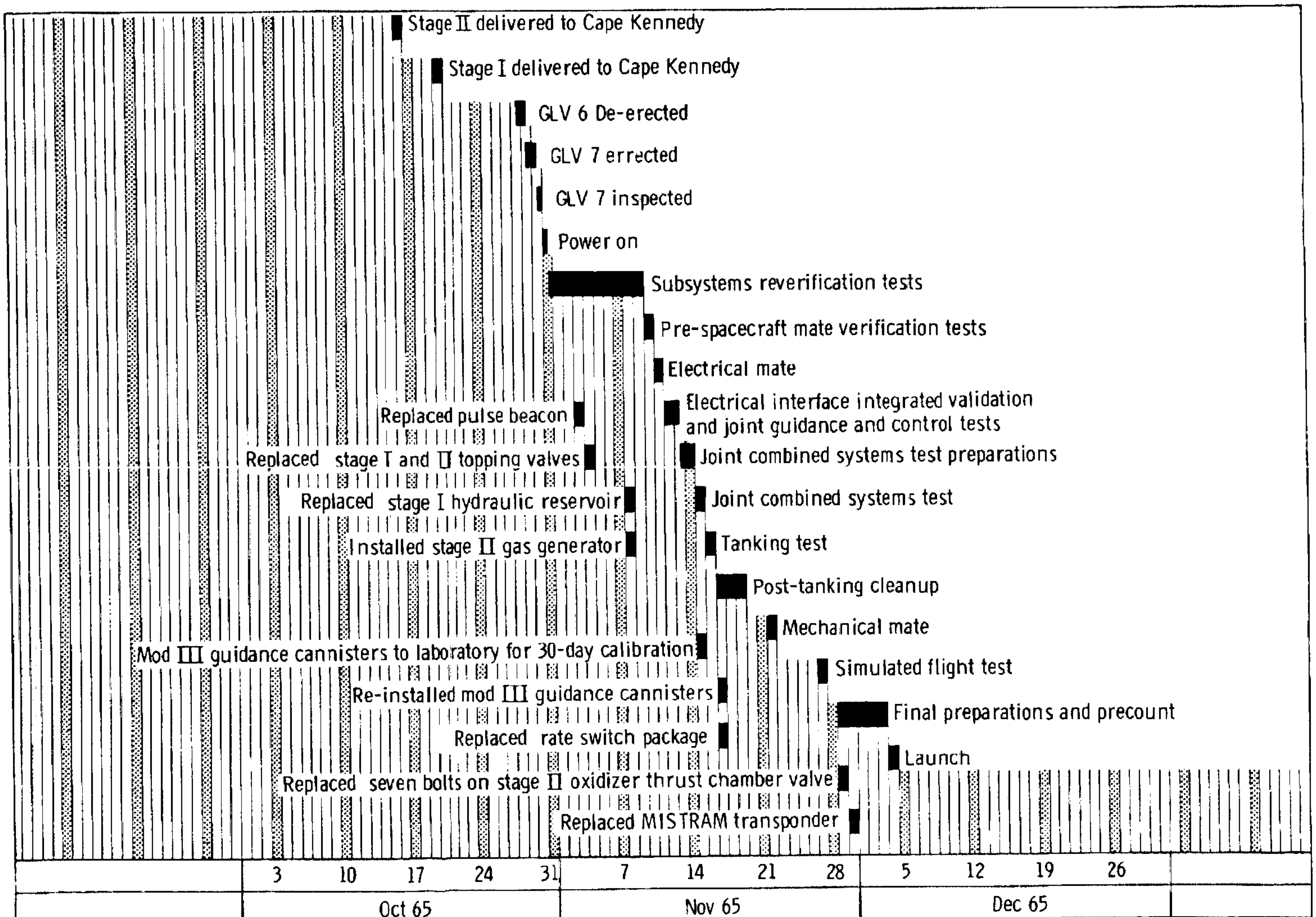

Figure 12. 1-6. - GLV-7 history at Cape Kennedy.

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12.2 WEATHER CONDITIONS

The weather conditions in the launch area at Cape Kennedy were satisfactory for all operations on the day of the launch, December 4, 1965. Surface weather observations in the launch area taken at 2:30 p.m. e.s.t. (19:30 G.m.t.) were as follows:

Cloud coverage	5/10 altocumulus at 16 000 ft
Wind direction, deg	340
Wind velocity, knots	10
Visibility, miles	8
Pressure, in. Hg	29.98
Temperature, °F	70
Dew point, °F	61
Relative humidity, percent	73

The weather observations in the recovery area taken at 14:05 G.m.t., December 18, 1965, onboard the U.S.S. Wasp located at latitude 25°22' N., longitude 70°09' W. were as follows:

Cloud coverage	2/10 cumulus at 2000 feet, 1/10 altocumulus at 7000 feet
Wind direction, deg	270
Wind velocity, knots	17
Visibility, miles	10
Temperature, °F	75
Dew point, °F	71
Relative humidity, percent	82
Sea temperature, °F	76
Sea state	2 ft waves with 3 ft swells

Table 12.2-I presents the launch area atmospheric conditions at approximately 1 hour prior to lift-off (18:30 G.m.t.). Table 12.2-II provides weather data in the vicinity of Cape Kennedy at the approximate time of reentry. Figures 12.2-1 and 12.2-2 present the launch area and reentry area wind direction and velocity plotted against altitude.

TABLE 12.2-I.- LAUNCH AREA ATMOSPHERIC CONDITIONS

AT 18:30 G.m.t., DECEMBER 4, 1965

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/sq ft (a)	Density, slugs/cu ft (a)
0×10^3	68.4	2121.7	2325.6×10^{-6}
5	47.3	1772.7	2028.6
10	41.0	1472.6	1709.8
15	26.2	1218.2	1459.7
20	10.8	1002.3	1240.0
25	-8.9	818.3	1057.3
30	-29.7	662.1	897.0
35	-51.9	530.1	757.3
40	-76.9	418.5	637.2
45	-89.3	326.2	513.2
50	-93.3	253.5	403.2
55	-97.2	195.9	315.1
60	-90.4	152.0	239.6
65	-81.8	118.4	182.4
70	-76.2	92.7	140.9
75	-69.5	72.9	108.9
80	-69.3	57.4	79.9
85	-69.5	45.3	67.7
90	-61.8	35.7	52.4
95	-57.5	28.4	41.1
100	-54.6	22.6	32.6
105	-39.4	18.0	25.0
110	-32.5	13.8	18.9
115	-22.0	11.7	15.6
120	-5.1	9.5	12.2

[a] The accuracy of the readings is indicated at the end of the table.

TABLE 12.2-I.- LAUNCH AREA ATMOSPHERIC CONDITIONS
AT 18:30 G.m.t., DECEMBER 4, 1965 - Concluded

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/sq ft (a)	Density, slugs/cu ft (a)
125×10^3	0.5	7.7	9.8×10^{-6}
130	2.3	6.3	8.0
135	9.7	5.2	6.5
140	12.3	4.3	5.3
145	16.3	3.5	4.3
150	17.4	2.9	3.5
155	16.2	2.4	2.9
160	20.6	2.0	2.4
165	25.8	1.6	1.9
170	27.6	1.4	1.6
175	20.9	1.1	1.4
180	21.0	.92	1.1

[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 120	1	1	.8
120 to 165	4	1.5	1.0
165 to 180	6	1.5	1.5

TABLE 12.2-II.- REENTRY AREA ATMOSPHERIC CONDITIONS

AT 14:20 G.m.t., DECEMBER 18, 1965

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/sq ft (a)	Density, slugs/cu ft (a)
0×10^3	66.4	2124.7	2337.5×10^{-6}
5	55.0	1776.9	2005.9
10	42.4	1479.3	1711.9
15	27.9	1225.3	1462.4
20	11.8	1008.3	1244.7
25	0.3	825.8	1045.4
30	-21.8	670.8	892.5
35	-45.6	539.0	758.5
40	-68.8	427.5	660.5
45	-89.1	334.5	526.2
50	-97.2	259.6	417.4
55	-99.8	200.1	323.8
60	-98.0	154.8	249.1
65	-96.2	119.7	191.7
70	-85.7	93.2	144.9
75	-80.7	72.9	112.0
80	-74.2	57.23	86.3
85	-68.1	45.11	66.9
90	-62.1	35.5	52.0
95	-53.7	28.2	40.6
100	-48.3	22.6	31.82
105	-43.4	18.2	25.0
110	-26.5	14.6	19.8

[a]The accuracy of the readings is indicated at the end of the table.

TABLE 12.2-II.- REENTRY AREA ATMOSPHERIC CONDITIONS

AT 14:20 G.m.t., DECEMBER 18, 1965 - Concluded

Altitude, ft (a)	Temperature, °F (a)	Pressure, lb/sq ft (a)	Density, slugs/cu ft (a)
115×10^3	-19.3	11.9	15.7×10^{-6}
120	8.2	9.6	12.4
125	-0.4	7.9	9.9
130	4.2	6.4	8.1
135	-0.8	5.3	6.7
140	-7.5	4.3	5.5
145	-3.6	3.5	4.5
150	15.2	2.9	3.5
155	32.6	2.4	2.8
160	47.9	2.0	2.3
165	43.4	1.7	1.9
170	36.0	1.4	1.6
175	34.6	1.14	1.35
180	29.6	0.95	1.13

[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	1	1	0.8
120 to 165	4	1.5	1.0
165 to 180	6	1.5	1.5

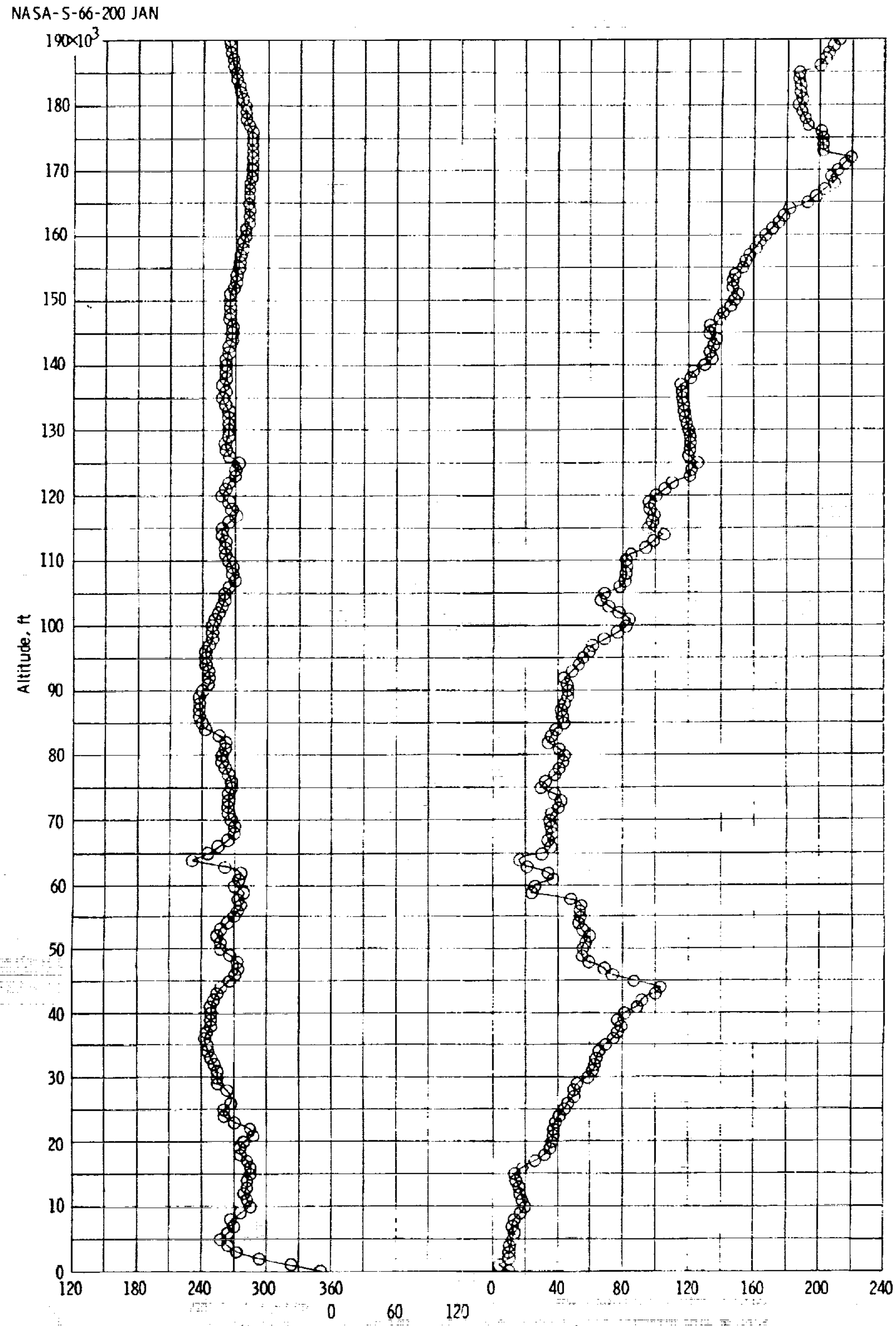

Figure 12.2-1. - Variation of wind direction and velocity with altitude for the launch area at 18:30 G.m.t., December 4, 1965.

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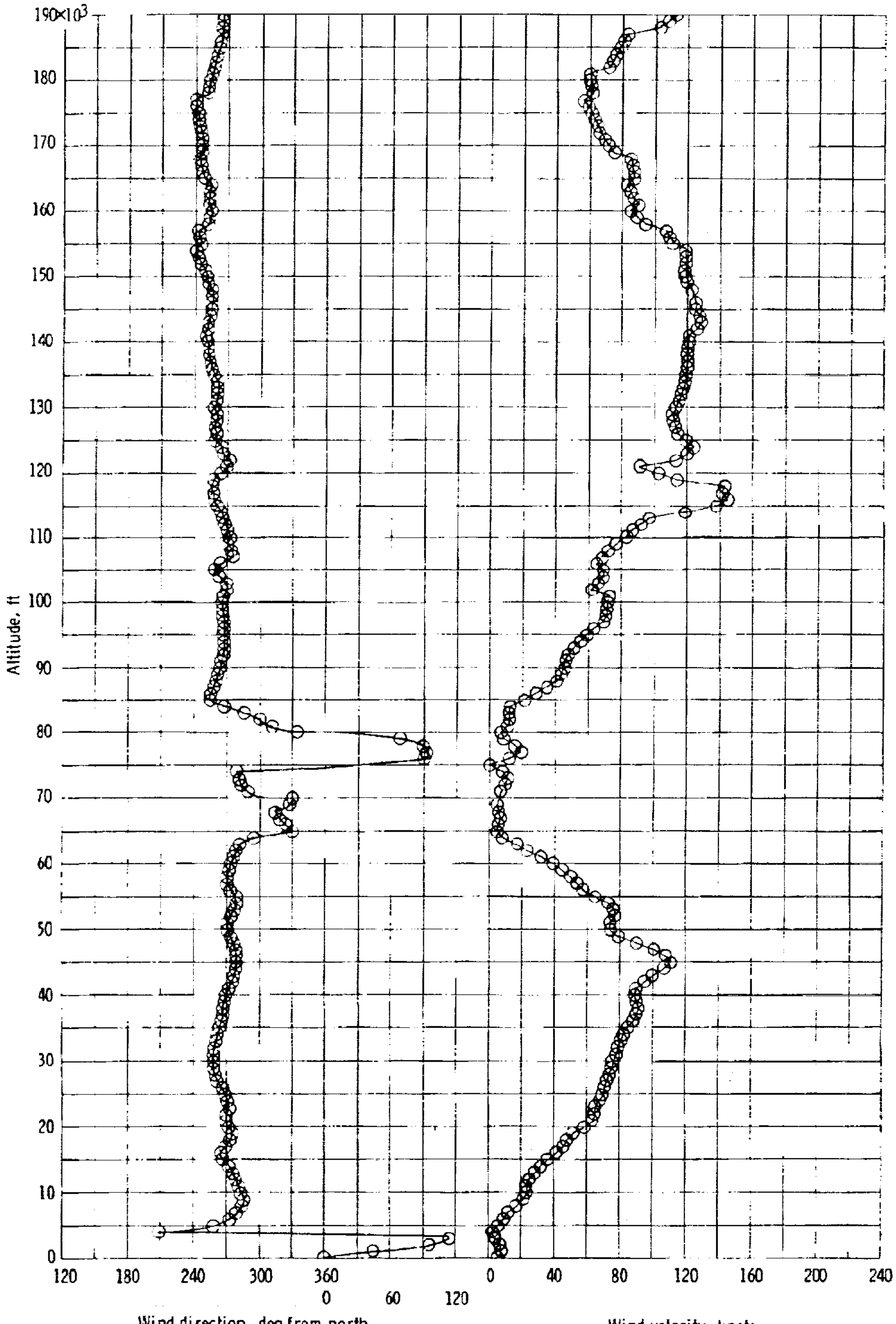

Figure 12.2-2. - Variation of wind direction and velocity with altitude for the reentry area at 14:20 G.m.t., December 18, 1965.

12.3 FLIGHT SAFETY REVIEWS

The flight readiness of the spacecraft and launch vehicle for the Gemini VII mission, as well as the readiness of all supporting elements, was determined at the review meetings noted in the following sections.

12.3.1 Spacecraft Readiness Review

The Flight Readiness Review was held on November 17 and 18, 1965, at the John F. Kennedy Space Center, Florida. The following items were to be accomplished prior to the Mission Briefing:

(a) Determine and record the hatch closing forces

(b) Provide documentation confirming flight qualification of the hydrogen squib-firing relay panel and the acquisition-lights relay panel

(c) Determine the failure mode of the M-1 experiment source pressure quick-disconnect

(d) Provide documentation concerning the fuel-cell back-pressure incident which occurred during the joint combined systems tests

Upon satisfactory completion of these items, the spacecraft was found ready for flight.

12.3.2 Launch Vehicle Readiness Review

A combined Technical Review and Readiness Review for the Gemini VII launch vehicle was held at Cape Kennedy, Florida, on November 30, 1965. The Air Force Space Systems Division and Aerospace Corporation presented the status of the launch vehicle and ground support systems. All systems were found to be in readiness for the launch.

12.3.3 Mission Briefing

The Gemini VII Mission Director convened the Mission Briefing on December 2, 1965, at the John F. Kennedy Space Center, Florida. Upon review, all elements were found to be in readiness to support the mission.

12.3.4 Flight Safety Review Board

The Air Force Space Systems Division Flight Safety Review Board met on December 3, 1965, at Cape Kennedy, Florida, and recommended to the Mission Director that the Gemini launch vehicle be committed to flight.

12.4 SUPPLEMENTAL REPORTS

Supplemental reports for the Gemini VII mission are listed in table 12.4-I. The format will conform to the external distribution format of NASA or of the external organization preparing the report. Each report will be identified on the cover and the title page as being a Gemini VII supplemental report. Before publication, the supplemental reports will be reviewed by the cognizant Senior Editor, the Chief Editor, and the Mission Evaluation Team Manager, and will be approved by the Gemini Program Manager. Distribution of the supplemental reports will be the same as this Gemini Program Mission Report.

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TABLE 12.4-I.- GEMINI VII SUPPLEMENTAL REPORTS

Number	Report title	Responsible organization	Completion date
1	Launch Vehicle Flight Evaluation Report - NASA Mission Gemini/Titan GT-7	Aerospace Corp.	Feb. 16, 1966
2	Launch Vehicle No. 7 Flight Evaluation	Martin Co.	Feb. 1, 1966
3	Manned Space Flight Network Performance Analysis for GT-6A/7 Mission	Goddard Space Flight Center	Feb. 16, 1966
4	Gemini GT-7 IGS Evaluation Trajectory Reconstruction	TRW Systems	Feb. 1, 1966
5	GT-7 Inertial Guidance System and Computer Analysis	International Business Machines Corp.	Feb. 1, 1966
6	Special High Frequency (HF) Voice Communications Test	MSC Engineering and Development Directorate	Mar. 15, 1966
7	Biomedical Analysis of the Extended Gemini Flights	MSC Center Medical Office	Mar. 30, 1966
8	Spacecraft 7 Fuel-Cell — Reactant Supply System Performance Analysis	McDonnell Aircraft Corp.	Mar. 14, 1966

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12.5 DATA AVAILABILITY

Tables 12.5-I to 12.5-III list the mission data which are available for evaluation. The trajectory and telemetry data will be on file at the NASA Manned Spacecraft Center (MSC), Computation and Analysis Division, Central Metric Data File. The photographic data will be on file at the MSC Photographic Technology Laboratory.

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TABLE 12.5-I.- INSTRUMENTATION

Data description	
Paper recordings Spacecraft telemetry measurements and selected parameters (Revolutions 1-6, 11-19, 26-34, 40-48, 55-65, 70-80, 84-95, 99-109, 113-122, 128-136, 145-153, 157-168, 172-181, 186-194, and 201-206.) GLV telemetry measurements (launch) Telemetry signal-strength recordings MCC-H plotboards (Confidential) Range safety plotboards (Confidential) Radar data IP-3600 trajectory data (Confidential) MISTRAM (Confidential) Natural coordinate system Final reduced C-band (launch phase - Confidential) Natural coordinate system Final reduced Trajectory data processed at MSC and GSFC Voice transcripts Air-to-ground On-board recorder (Confidential) Technical debriefing (Confidential) GLV reduced telemetry data (Confidential) Engineering units versus time plots	Spacecraft reduced telemetry data Engineering units versus time Ascent phase Parameter tabulations (statistical) Parameter plots (statistical) Selected time history tabulations Orbital phase Parameter tabulations and plots (statistical) for revolutions 1-6, 10, 11, 13-19, 21, 28, 29, 33, 44, 45, 59, 75, 76, 89, 104-109, and 124. Time history tabulations of selected parameters for selected times for revolutions 1, 2, 6, 15, 31, 32, 39, 40, 44, 59, 74-76, 88, 89, 104, 108, 109, 118, 163, 174, 175, and 180. Time history plots for selected parameters and selected times for revolution 163. Band pass tabulations for selected parameters for revolutions 1-6, 10, 11, 13-19, 21, 28, 29, 33, 44, 45, 59, 75, 76, 88, 89, 106-109, and for selected real time passes for revolutions 163, 175, and 177. Reentry phase Plots and tabulations of all systems parameters for approximately the following times (g.e.t.): 330:02:02-330:02:13 330:03:22-330:04:38 330:04:46-330:21:41 330:27:43-330:29:32 330:30:00-330:31:05 330:31:33-330:34:33

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TABLE 12.5-I.- INSTRUMENTATION - Concluded

Data description	
Event tabulations Sequence of event tabulations versus time (including thruster firings) for ascent, reentry and revolutions 1-6, 10, 11, 13-19, 21, 28, 29, 31-33, 39, 44, 45, 59, 74-76, 88, 89, 104-109, 118- 124, and for selected real time passes for revolutions 163, 164, 175, 177, and 181. **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 Ampere-hour calculations for revolutions 1-6, 10, 11, 13-19, 21, and 89. OAMS propellant remaining computations for revolutions 1-3, 44, 75-77, 175-177, 180 and 181. OAMS thruster activity computations for revolutions 1-3, 44, 45, 75, and 76. Experiment MSC-2 and 3 tabulations for revolutions 5 and 19. Reentry phase RCS propellant remaining and thruster activity computations.

TABLE 12.5-II.- SUMMARY OF PHOTOGRAPHIC DATA AVAILABILITY

Category of photographic data	Number of still photographs	Motion picture film, footage
Launch and prelaunch	50	[a]4886
Recovery		1000
Swimmer deployment and installation of collar	57	
Egress of flight crew	80	
Aircraft carrier		1300
Loading of spacecraft and arrival of flight crew	21	
Inspection of spacecraft	95	
Mayport, Florida		500
General activities	19	
RCS deactivation	24	
Cape Kennedy postflight inspection	35	
Onboard spacecraft		
16-mm sequential cameras		600
70-mm still camera	[b]499	
Experiments S-5 and S-6, Synoptic Terrain and Weather Photography	351	
Gemini VI and other miscellaneous photography	109	
Dim light photography	39	

[a]Engineering sequential and tracking film only.

[b]Sixty-one of these photographs were slightly degraded and ninety-eight were considerably degraded due to smudges on the spacecraft window.

TABLE 12.5-III.- LAUNCH PHASE ENGINEERING SEQUENTIAL CAMERA DATA AVAILABILITY

Sequential film coverage, item	Size, mm	Location	Presentation	Total length of film, ft
1.2-10	16	50-foot tower, 19-5	GLV launch	185
1.2-11	16	50-foot tower, 19-7A	GLV launch	182
1.2-12	16	50-foot tower, 19-7A	Spacecraft launch	100
1.2-13	16	50-foot tower, 19-2	Spacecraft launch	100
1.2-14	16	Stage II umbilical tower, second level	GLV, explosive bolt action	100
1.2-15	16	50-foot tower, 19-7A	GLV, launch	110
1.2-16	16	East launcher	GLV, possible fuel leakage	200
1.2-17	16	West launcher	GLV, possible fuel leakage	150
1.2-18	16	North launcher	GLV, engine observation	200
1.2-19	16	South launcher	GLV, engine observation	200
1.2-20	16	Umbilical tower, first level	GLV, umbilical disconnect	80
1.2-21	16	Umbilical tower, second level	GLV, umbilical disconnect	142
1.2-22	16	Umbilical tower, fourth level	GLV, umbilical disconnect	110
1.2-23	16	Umbilical tower, fifth level	GLV, umbilical disconnect	110
1.2-24	16	Umbilical tower, sixth level	GLV, umbilical disconnect	200
1.2-25	16	Umbilical tower, sixth level	GLV, umbilical disconnect	216
1.2-26	16	Umbilical tower, top level no. 1	GLV, upper umbilical disconnect	146
1.2-27	16	Umbilical tower, top level no. 2	J-bars and lanyard observation	146
1.2-28	16	50-foot tower, 70°50'	Spacecraft, umbilical disconnect	130
1.2-29	70	South of Pad 19	GLV and spacecraft launch	35
1.2-30	70	West of Pad 19	GLV and spacecraft launch	24
1.2-31	16	Pad 34, location 4	Tracking	399

TABLE 12.5-III.- LAUNCH PHASE ENGINEERING SEQUENTIAL CAMERA DATA AVAILABILITY - Concluded

Sequential film coverage, item	Size, mm	Location	Presentation	Total length of film, ft
1.2-32	16	West of Pad 19		330
1.2-33	16	Cape Kennedy	Tracking	331
1.2-34	16	South of Pad 19	Tracking	215
1.2-36	35	South of Pad 19	GLV engine observation	190
1.2-37	35	North of Pad 19	Tracking	213
1.2-38	35	South of Pad 19	Tracking, IGOR	200
1.2-39	35	Patrick Air Force Base	Tracking, IGOR	50
1.2-40	70	North of Pad 19	Tracking, IGOR	61
1.2-41	70	Cocoa Beach	Tracking, ROTI	26
1.2-42	70	Melbourne Beach	Tracking, ROTI	5

12.6 POSTFLIGHT INSPECTION

Following recovery, spacecraft 7 arrived at the John F. Kennedy Space Center on December 21, 1965, at 10:15 a.m. e.s.t., and the postflight inspection was started immediately. The work was accomplished according to, and is fully documented by, reference 14 and the 7000 series of Spacecraft Test Requests (STR).

Certain equipment was dispositioned from the U.S.S. Wasp (recovery) ship) as well as from Mayport Naval Station, Florida, where the reentry control system (RCS) was deactivated. This equipment is documented in the latest revisions of Spacecraft Test Requests 7000, 7003, 7005, and 7009. The items concerned with this disposition were the stowed items and the major electronic systems which will be preserved for possible use in ground tests or on later flights.

The spacecraft was returned in good condition and there were very few malfunctions to investigate. The following items were found and noted during the detailed inspection:

(a) As on previous spacecraft, the windows were covered with a residue.

(b) A hole was found in a Rene' shingle just forward of the right-hand hatch.

(c) The shingle around the bottom C-band antenna shifted its position enough to partially cover the antenna.

(d) Heating effects were again minimal, but some discoloration of the right-hand C-band antenna and charring of the rubber seal on the spacecraft umbilical were evident.

(e) A small amount of a "sticky" substance was found near the ports in the rendezvous and recovery section separation ring.

12.6.1 Spacecraft Systems

12.6.1.1 Structure.- The overall appearance of the structure was good. Some heat discoloration was noted. The stagnation point on the heat shield was measured and found to be 12-3/4 inches below and 1-5/8 inches to the right of the spacecraft centerline. Two plugs were removed from the heat shield for evaluation in accordance with STR 7016.

There was a hole in the René shingle just forward of the right-hand hatch. This was reported to be the result of recovery handling.

12.6.1.2 Environmental control system.- The external appearance of the system was good. The secondary oxygen system was removed and is scheduled for possible reuse in accordance with STR 7012. A detailed investigation is being accomplished to determine the effects of the long-duration mission as required by STR's 7501 through 7504.

12.6.1.3 Communication system.- STR 7022 was written to determine the source of a 400-cps noise on the voice recorder. As of the publication of this report, the test details have not been prepared. However, the objective is to reproduce the noise, determine the source, and take corrective action if required.

12.6.1.4 Guidance and control system.- The primary components of the guidance and control system were dispositioned for possible reuse according to STR's 7005 through 7009.

12.6.1.5 Pyrotechnics.- A foreign substance was found near the ports on the rendezvous and recovery section separation ring. Although the functioning of the pyrotechnics was apparently not impaired by the substance, it was analyzed for content. The analysis revealed a high content of silicon rubber and a dry lubricant.

12.6.1.6 Instrumentation and recording system.- The delayed-time telemetry tape recorder which failed in flight is being investigated as required by STR 7014. Refer to section 5.1.3 for results of this investigation.

STR's 7001 through 7003 and 7506 disposition some of this system's equipment for possible reuse.

12.6.1.7 Electrical system.- Prior to the flight of spacecraft 7, an intermittent short was discovered in the wiring for the main parachute single-point release and this wire was cut and a new wire inserted prior to flight. The original wiring was investigated after the flight in accordance with STR 7010. Examination revealed that a repair made to this insulation was insufficient. The damage had been dispositioned as a short between the spacecraft structure and the shield but had actually included a short between the shielding and the center conductor. Corrective procedures have been formulated that include a resistance check between the shields, spacecraft structure, and the center conductors of pyrotechnic wiring immediately after all repairs.

It was reported that the circuit breaker for fuel-cell section no. 2 opened twice during the flight. This is being investigated in accordance with STR 7507.

12.6.1.8 Crew station furnishings and equipment.- This area appeared clean and orderly. Most of the stowed items had been disposed of in accordance with STR 7000B prior to the spacecraft arrival at Cape Kennedy. The crew reported trouble during the flight with the following items: (a) film or coating on the windows, (b) the door on the centerline stowage structure, (c) the urine system quick disconnect, (d) the bright light on the optical sight, (e) the suit inlet temperature gage, and (f) food and urine bags. These items are being investigated by STR's 7013, 6031, 7028, 7026, 7508, and 7023, respectively.

12.6.1.9 Propulsion system.- The reentry control system was received in good condition with no fuel remaining. This system was deserviced, cleaned, and dried as soon as possible anticipating reuse of some of the major components.

12.6.1.10 Landing system.- The inspection revealed no indication of anomalies in this system.

12.6.1.11 Postlanding recovery aids.- Discussions with the recovery forces as well as a detailed inspection revealed that all conditions were as expected.

12.6.1.12 Experiments.- The majority of the experiment components were removed prior to the spacecraft arrival. However, experiment M-1, cardiovascular conditioner, was dispositioned in accordance with STR 7029 from Cape Kennedy because it was inaccessible until that time. The D-5 photometer was dispositioned for failure analysis as required by STR 7015.

12.6.2 Continuing Evaluation

The following is a list of STR's that are being investigated as of this writing.

UNCLASSIFIED

STR number	System	Purpose
7013	Structure	Determine constituents of window residue.
7014	Instrumentation and recording	Conduct failure analysis on PCM tape recorder.
7015	Experiments	Conduct failure analysis on D-5 photometer.
7016	Structure	Evaluate heat shield plugs.
7022	Communication	Determine noise source on voice tape recorder.
7023	Crew station	Determine cause of problems with food and waste equipment.
7026	Crew station	Conduct failure analysis delayed-time telemetry tape recorder.
7028	Crew station	Conduct failure analysis on urine system quick disconnect.
7032	Environmental control	Analyze LiOH charge for CO_2 and H_2O content.
7033	Crew station	Conduct a failure analysis on ECG biomedical harness.
7501	Environmental control	Determine effects of 14-day mission on the suit compressor.
7502A	Environmental control	Determine effects of 14-day mission on the suit heat exchanger.
7503	Environmental control	Determine effects of 14-day mission on the urine filter.
7504	Environmental control	Determine effects of 14-day mission on solids trap.
7507	Electrical	Conduct failure analysis on circuit breakers for fuel cell section 2
7508	Crew station	Conduct failure analysis on suit inlet temperature gage and wiring.
7510	Crew station	Conduct failure analysis on urine hose quick disconnect.