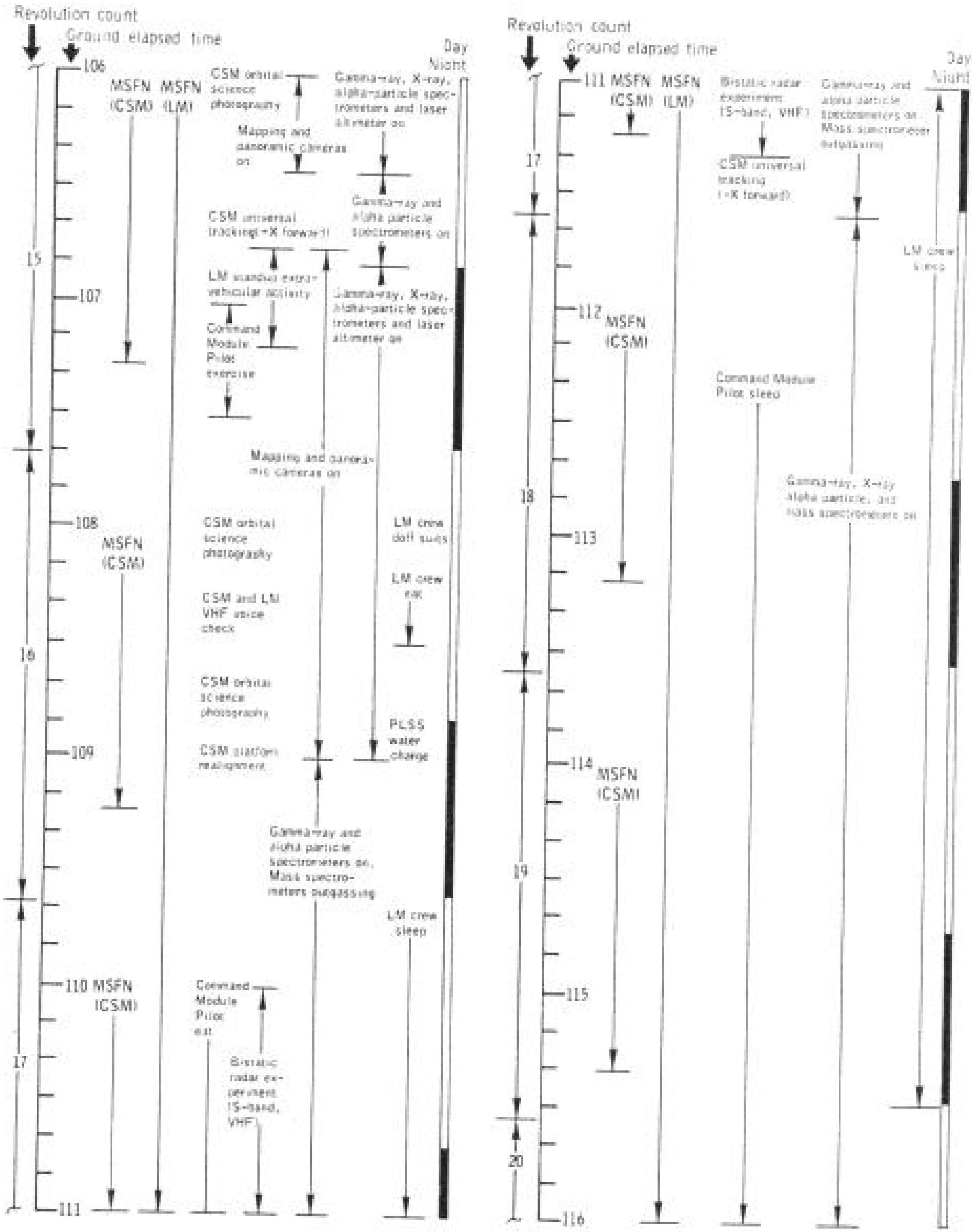
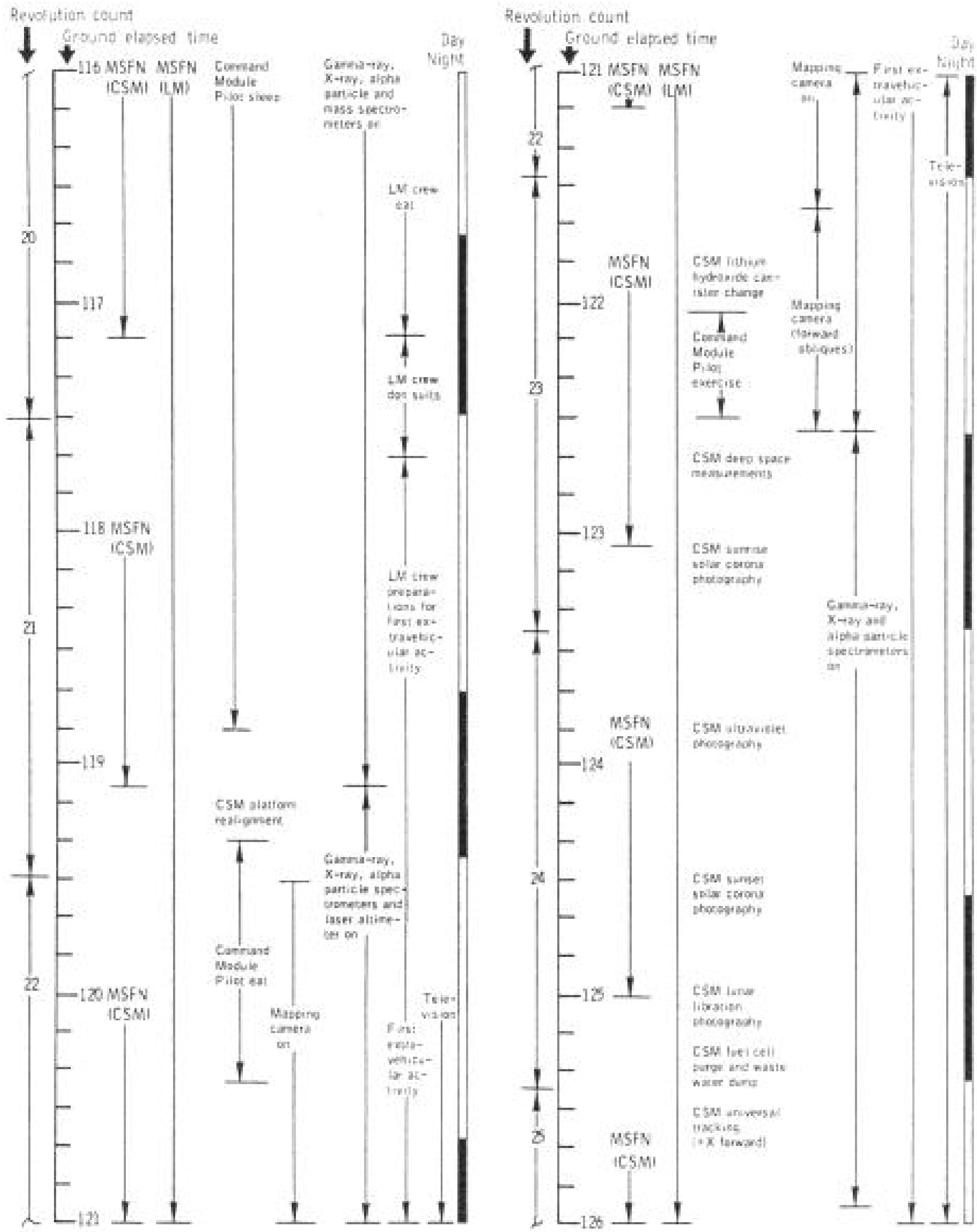
Abbreviated Timeline 8



(i) 106 to 116 hours.

Figure 9-1. - Continued.

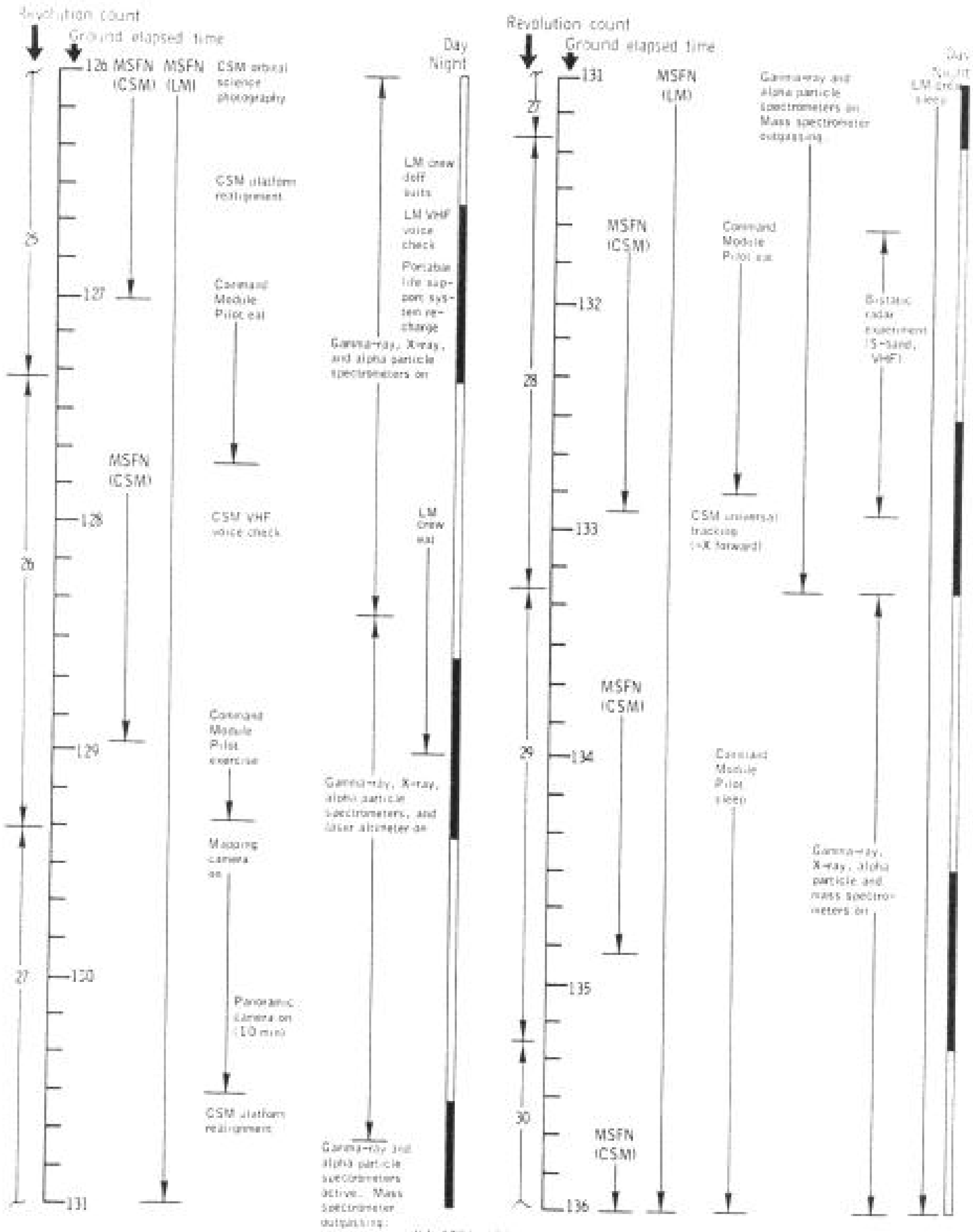
Abbreviated Timeline 9



(j) 116 to 126 hours.

Figure 9-1.- Continued.

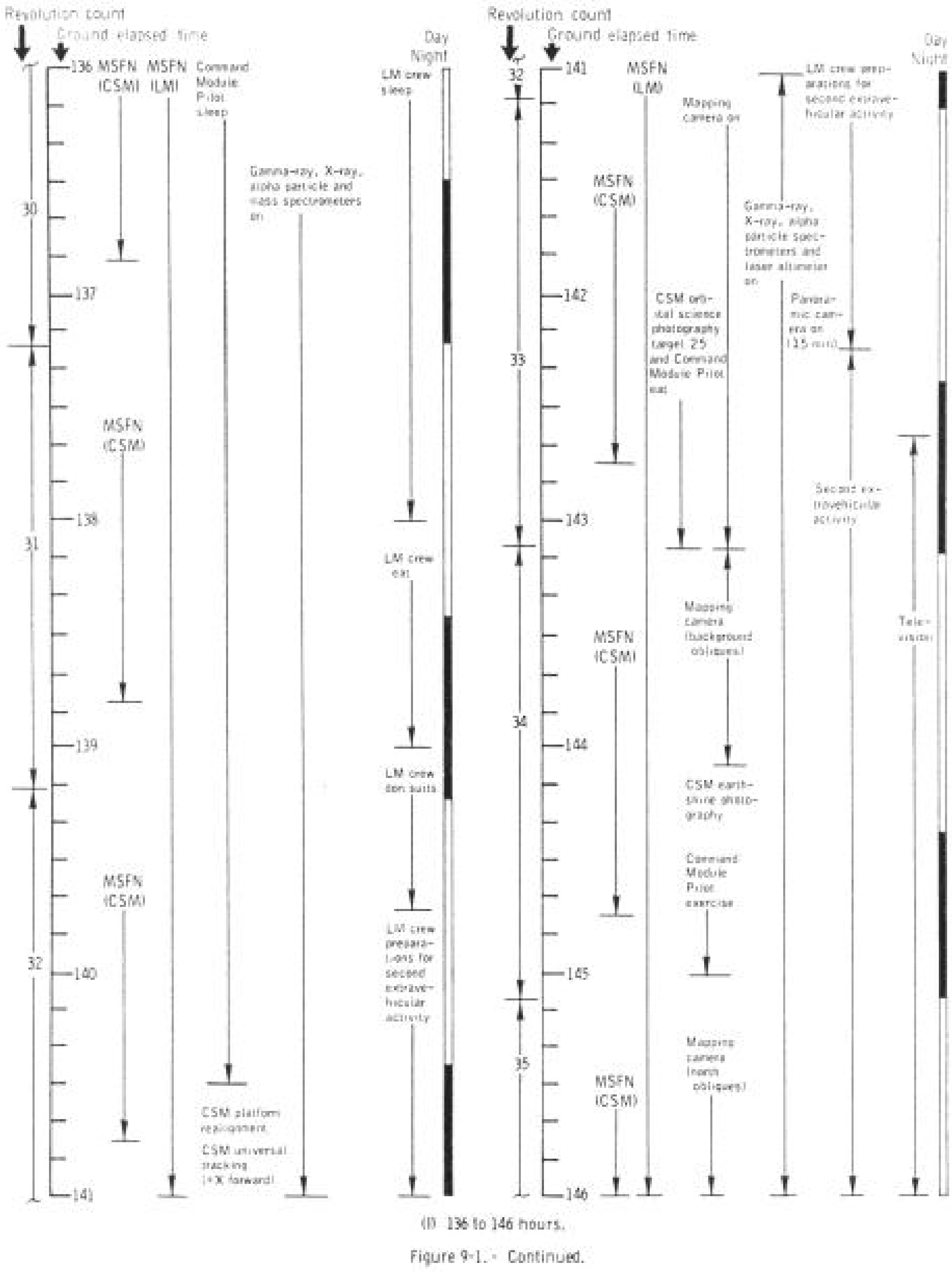
Abbreviated Timeline 10



(k) 126 to 136 hours.

Figure 9-1. - Continued.

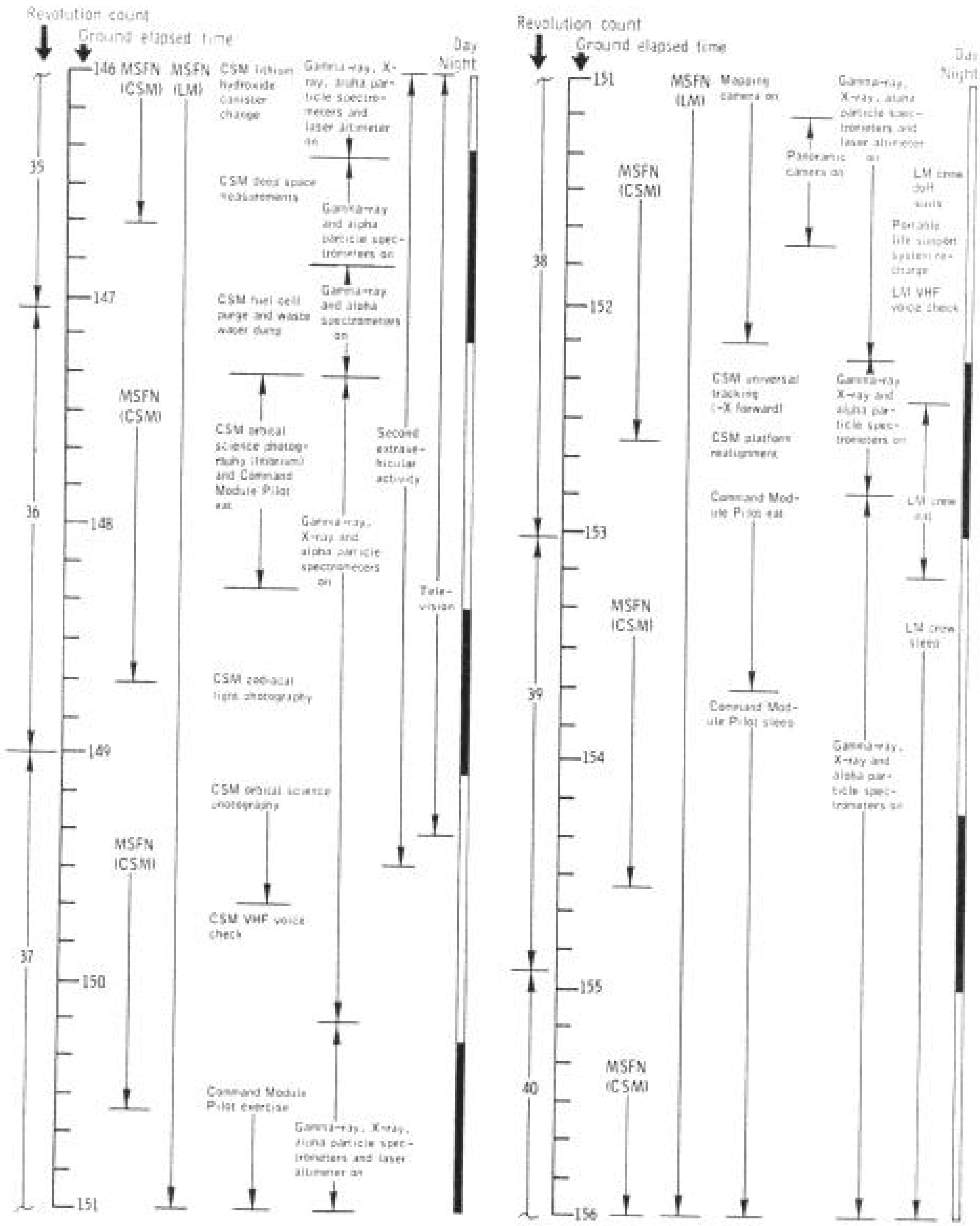
Abbreviated Timeline 11



(l) 136 to 146 hours.

Figure 9-1.- Continued.

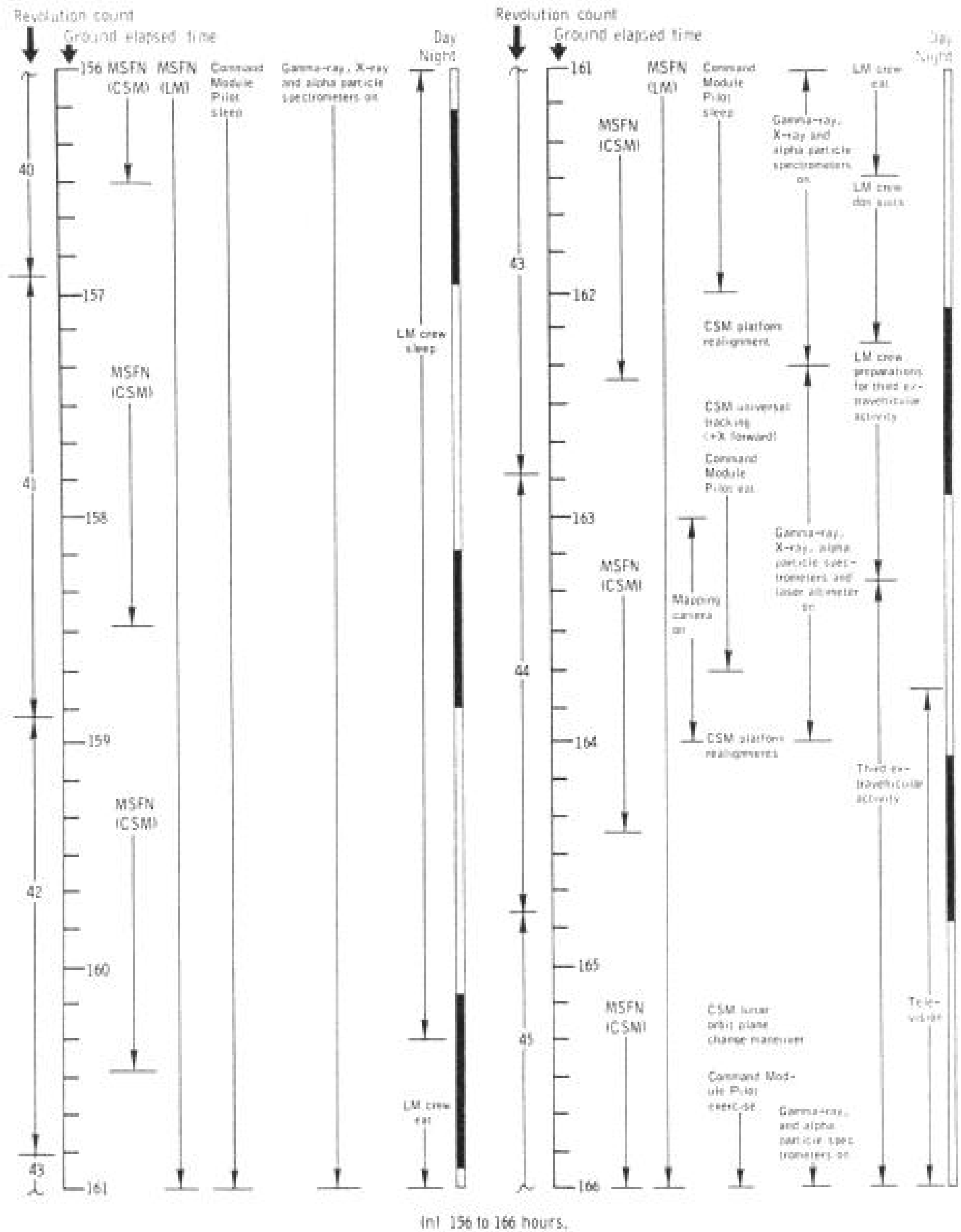
Abbreviated Timeline 12



(m) 146 to 156 hours.

Figure 9-1. - Continued.

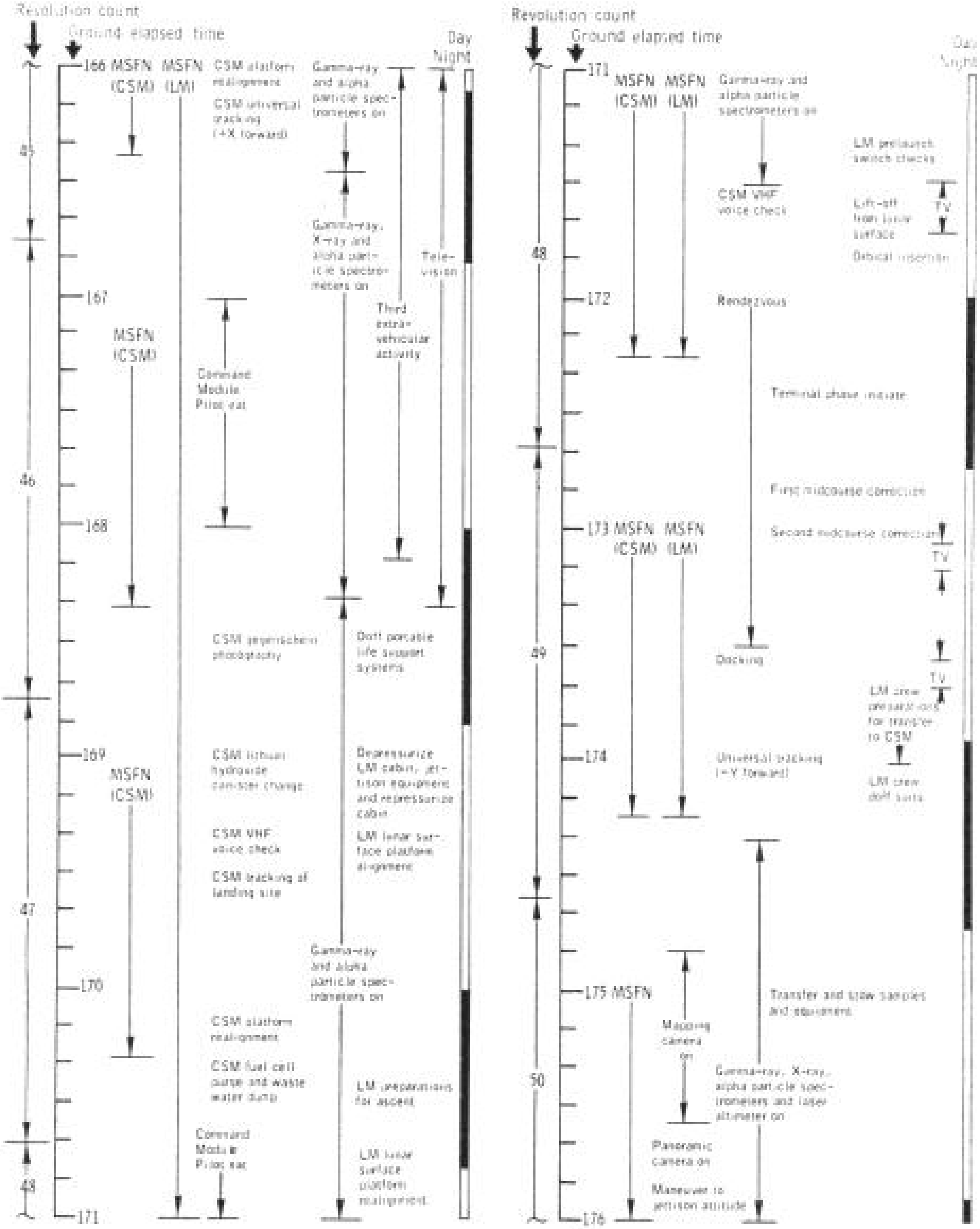
Abbreviated Timeline 13



(n) 156 to 166 hours.

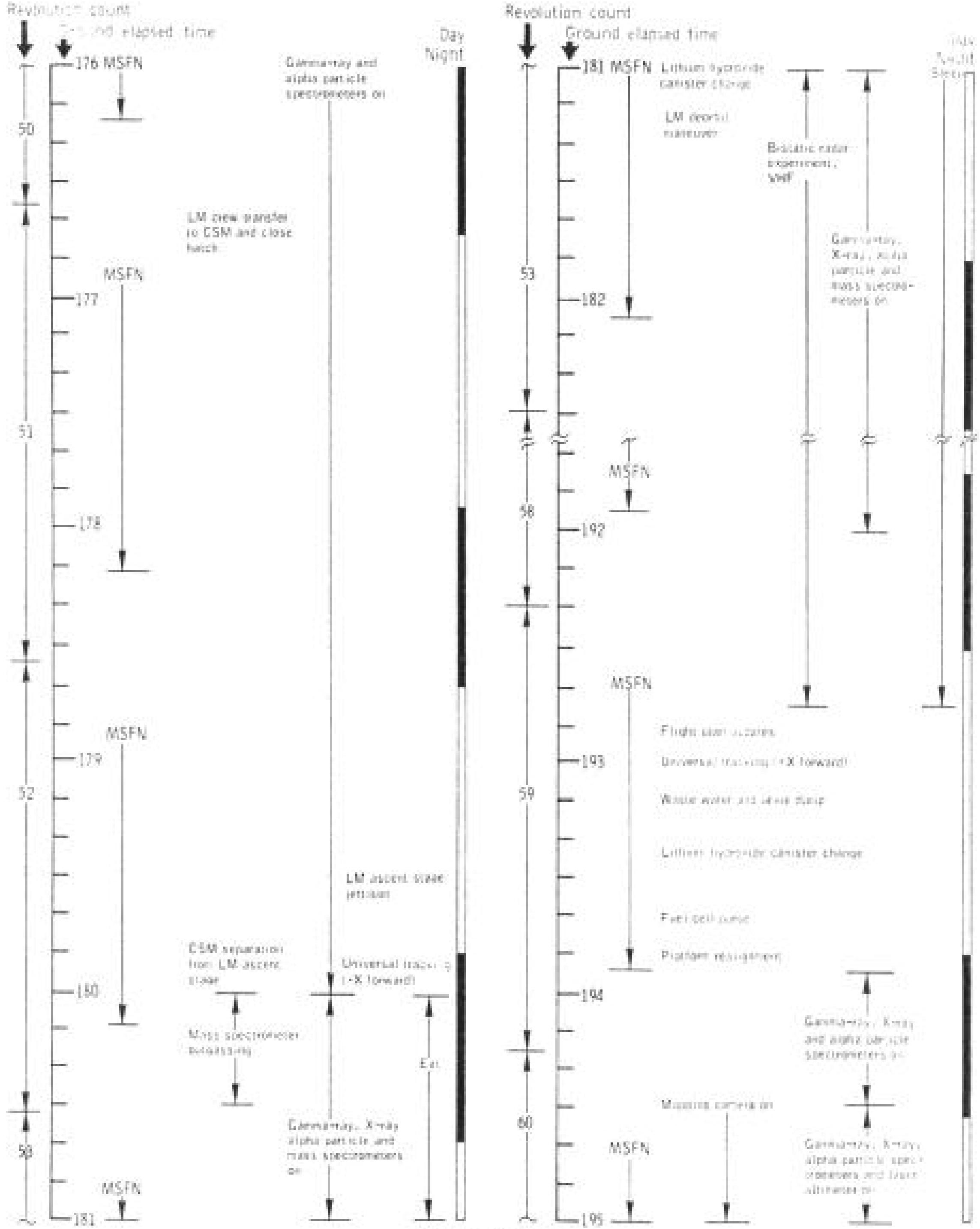
Figure 9-1. - Continued.

Abbreviated Timeline 14



(o) 166 to 176 hours.

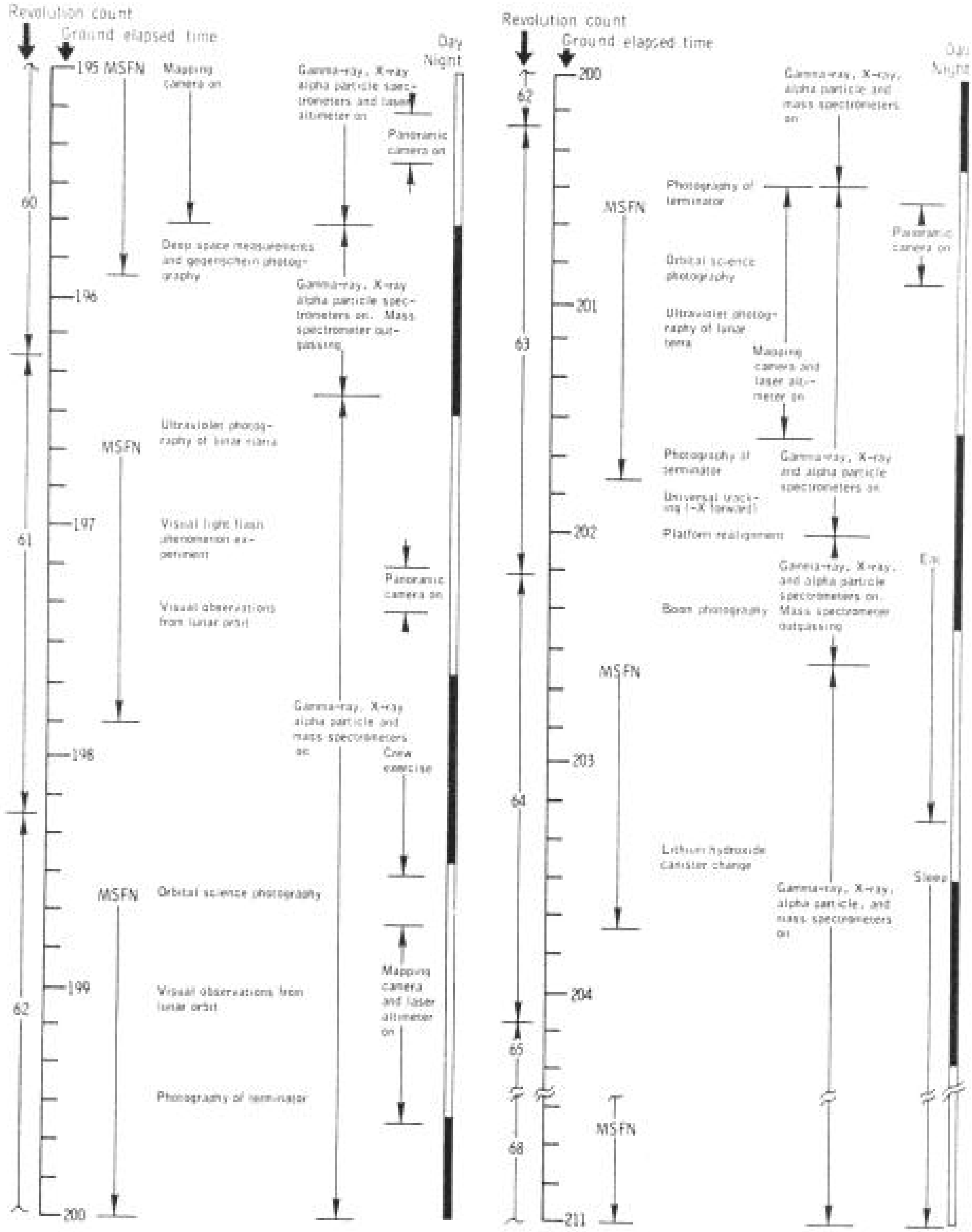
Figure 9-1. - Continued.



(p) 176 to 195 hours.

Figure 9-1. - Continued.

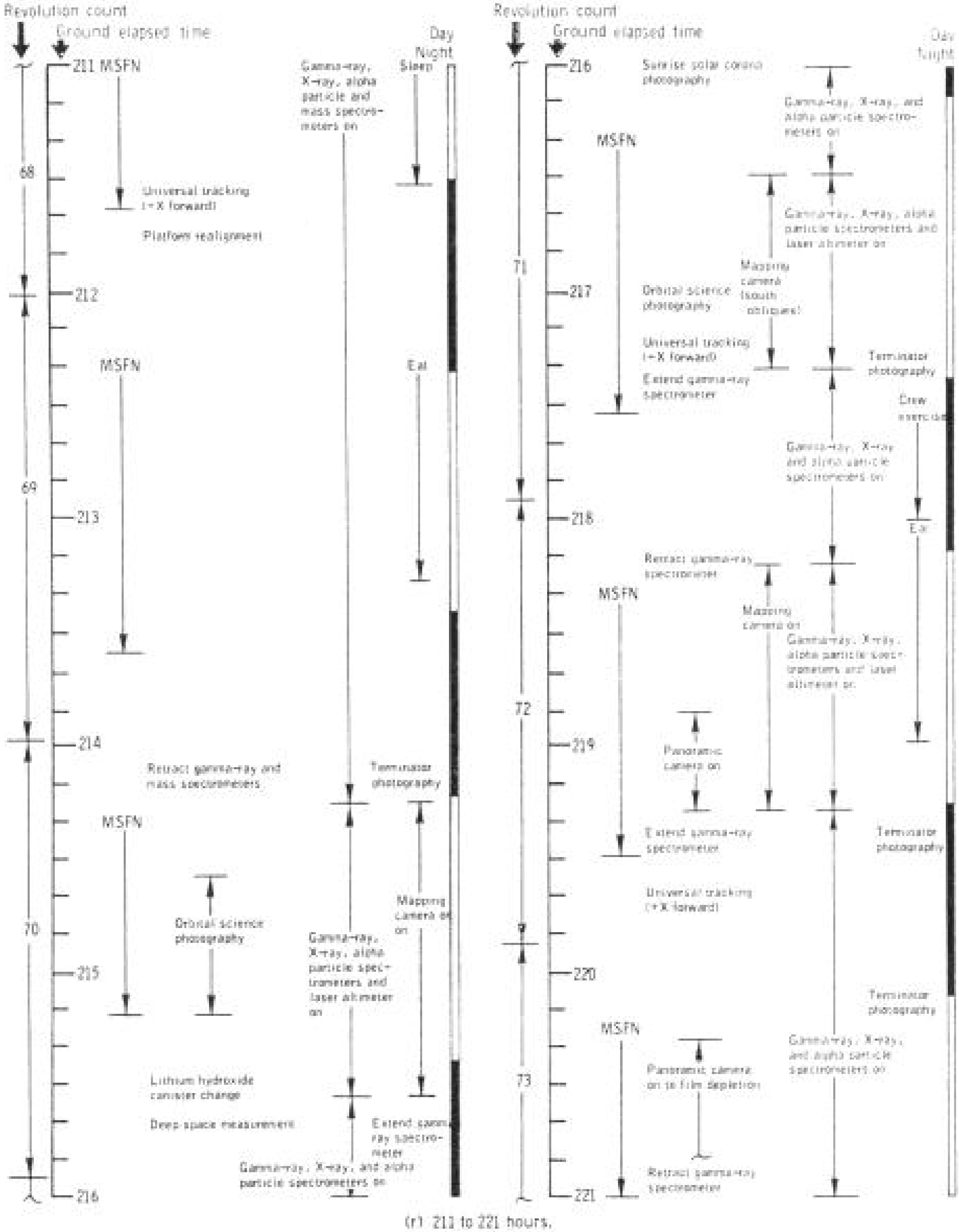
Abbreviated Timeline 15



(q) 195 to 211 hours.

Figure 9-1. - Continued.

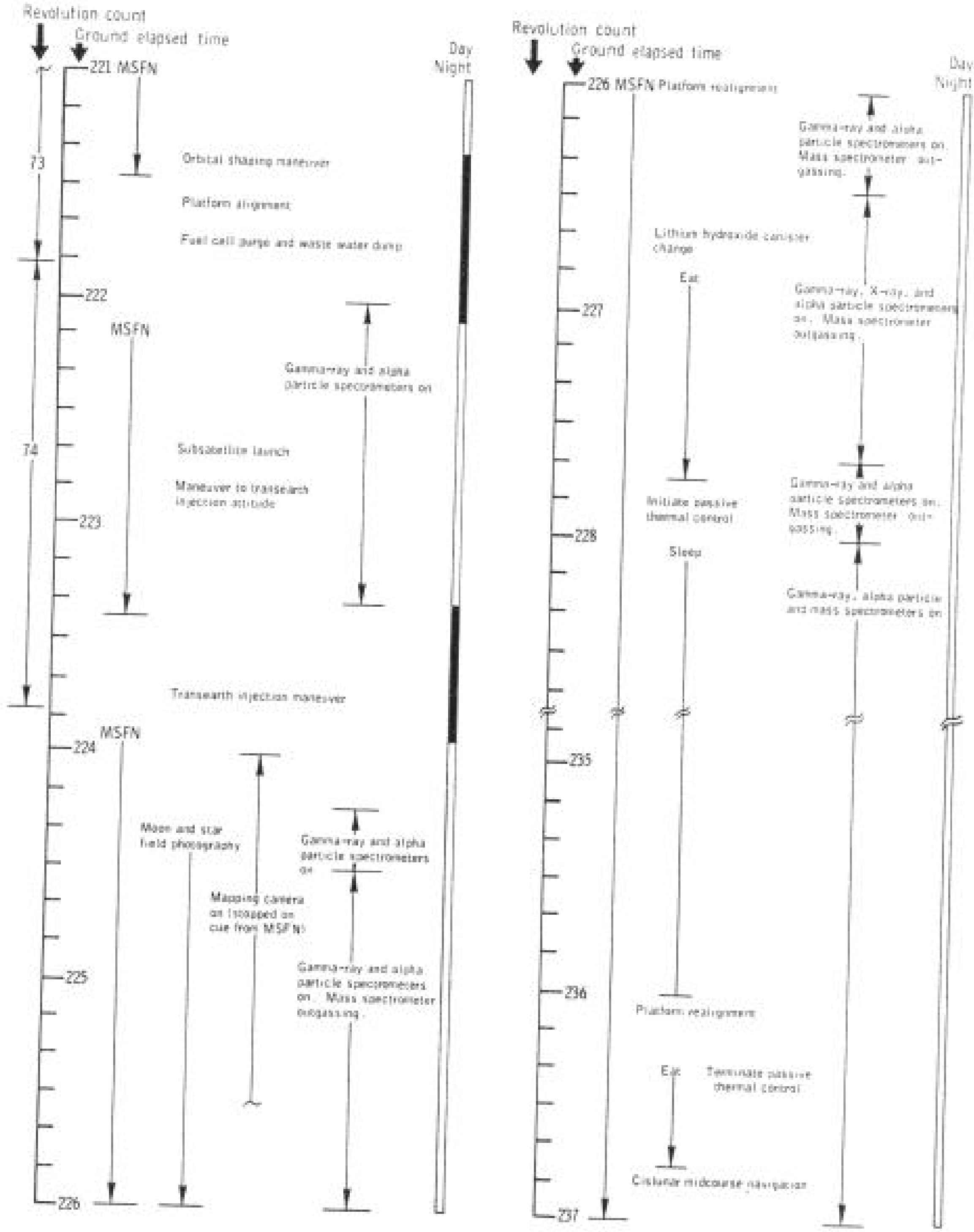
Abbreviated Timeline 16



(r) 211 to 221 hours.

Figure 9-1. - Continued.

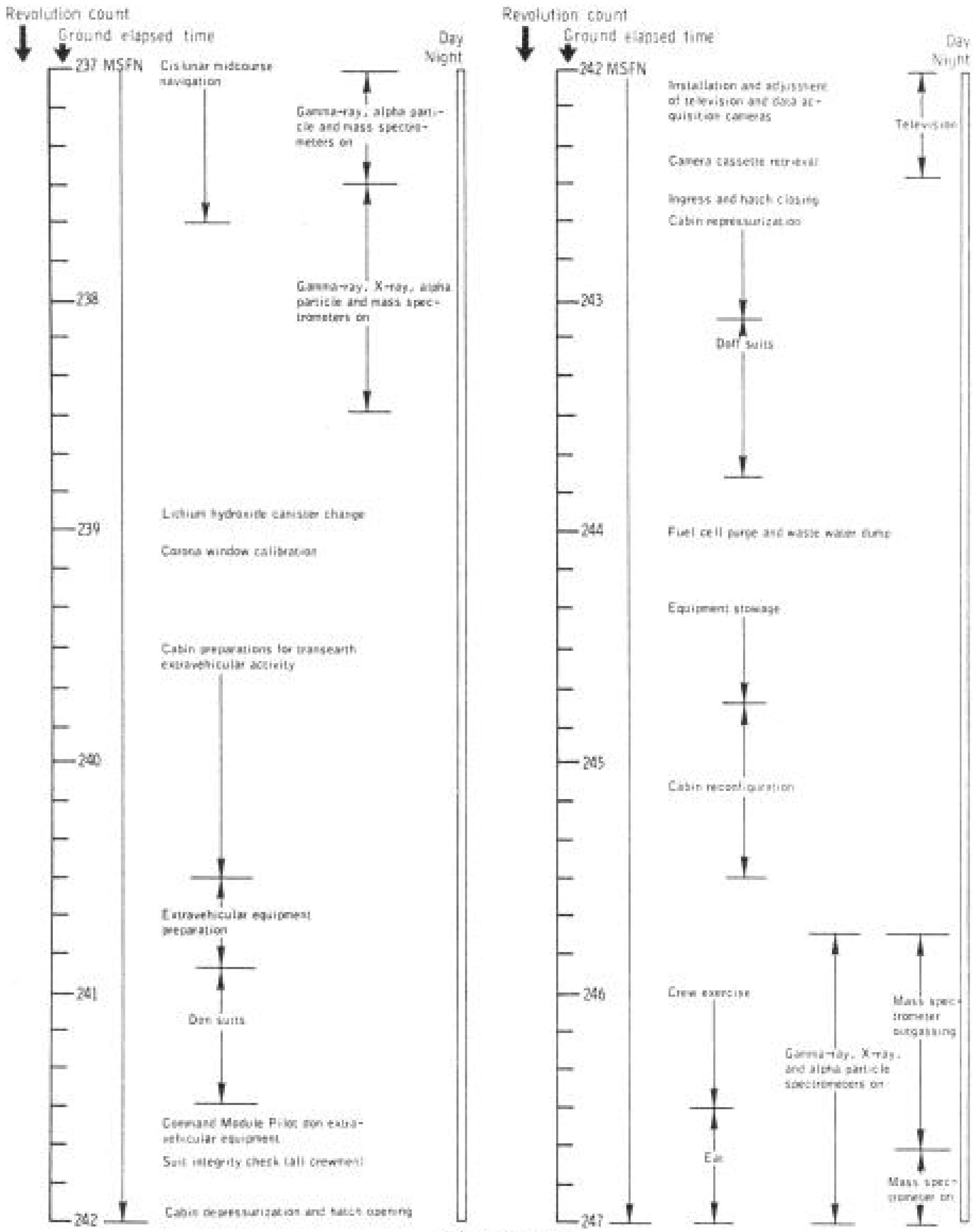
Abbreviated Timeline 17



(s) 221 to 237 hours.

Figure 9-1. - Continued.

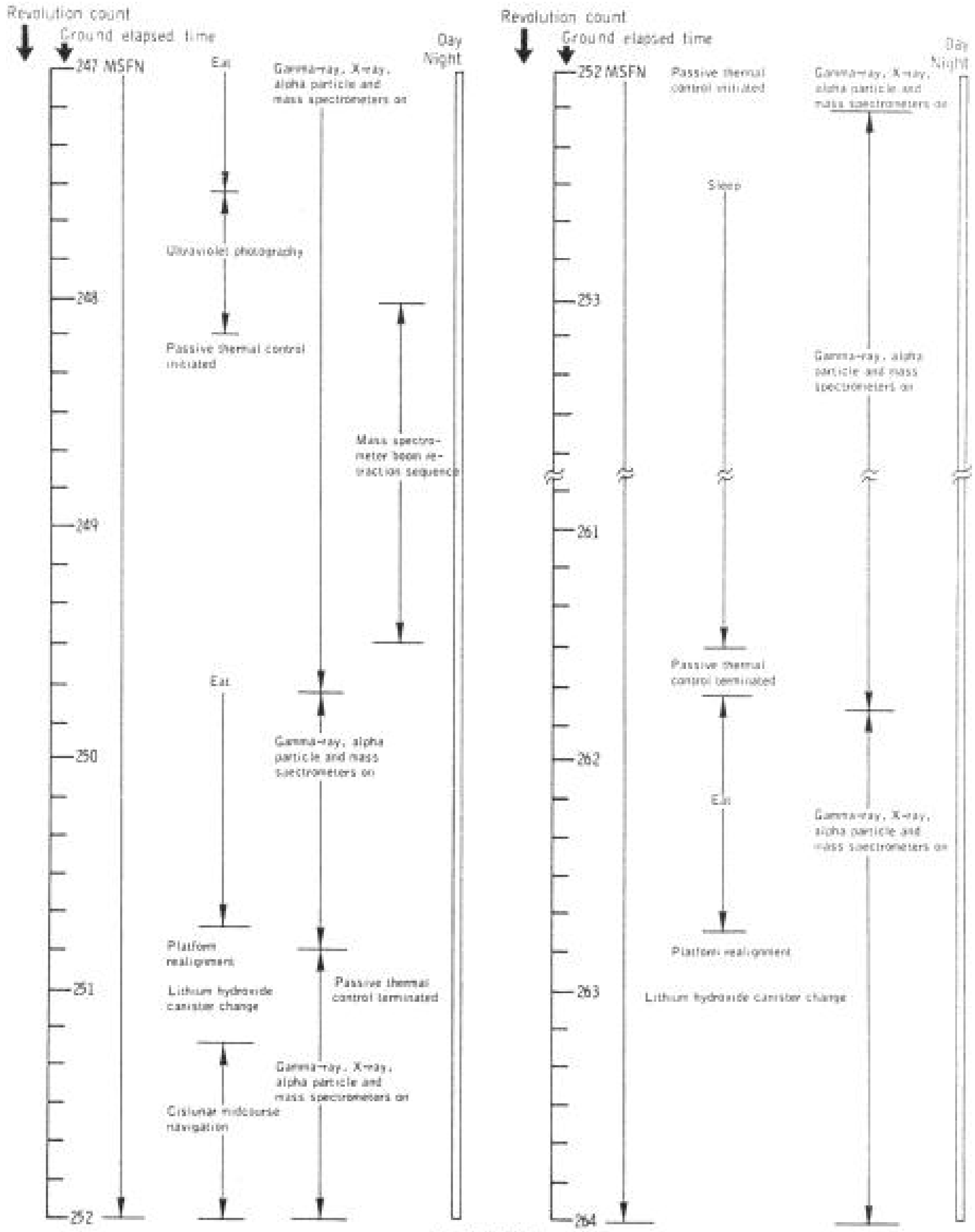
Abbreviated Timeline 18



(t) 237 to 247 hours.

Figure 9-1. - Continued.

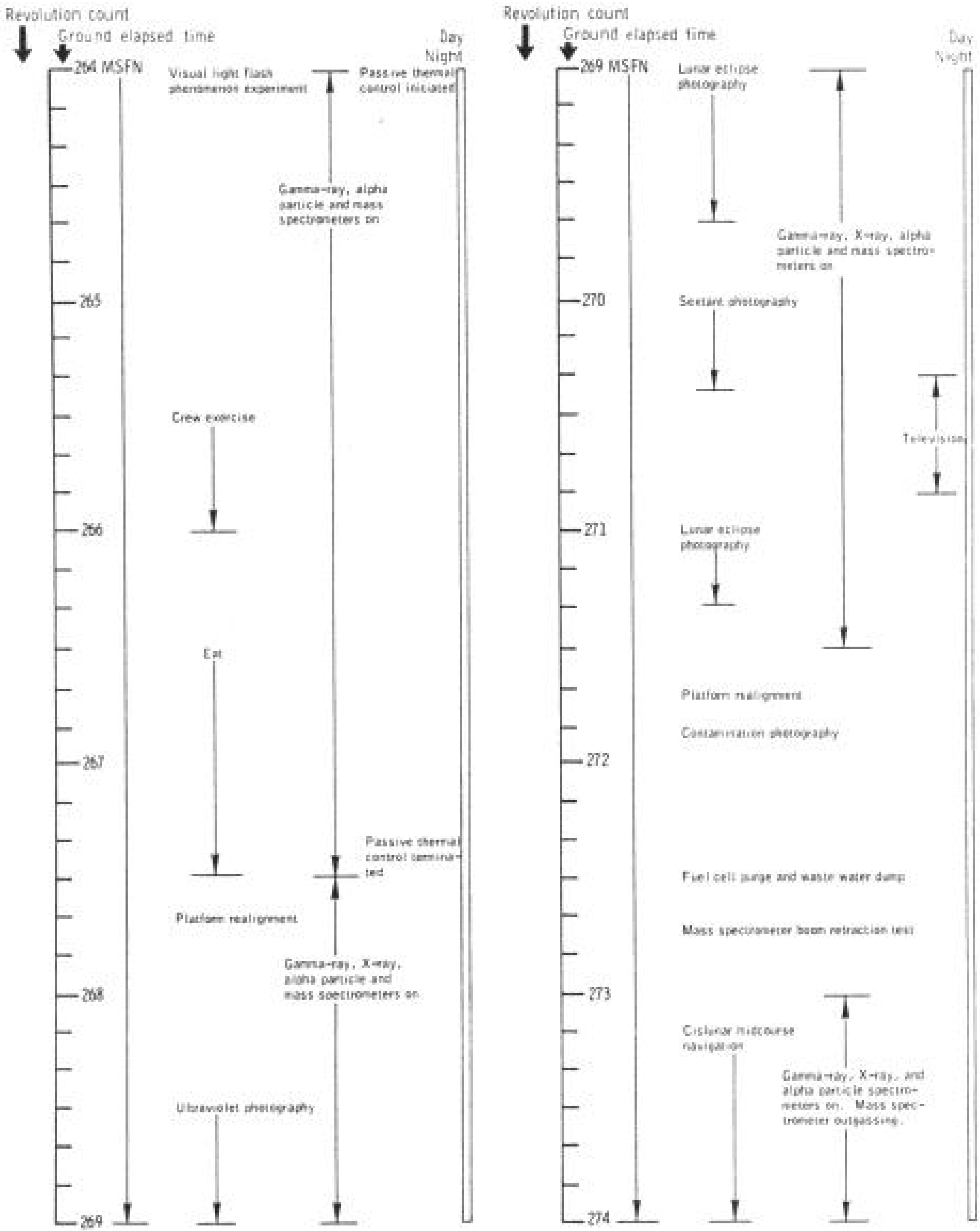
Abbreviated Timeline 19



(u) 247 to 264 hours.

Figure 9-1. - Continued.

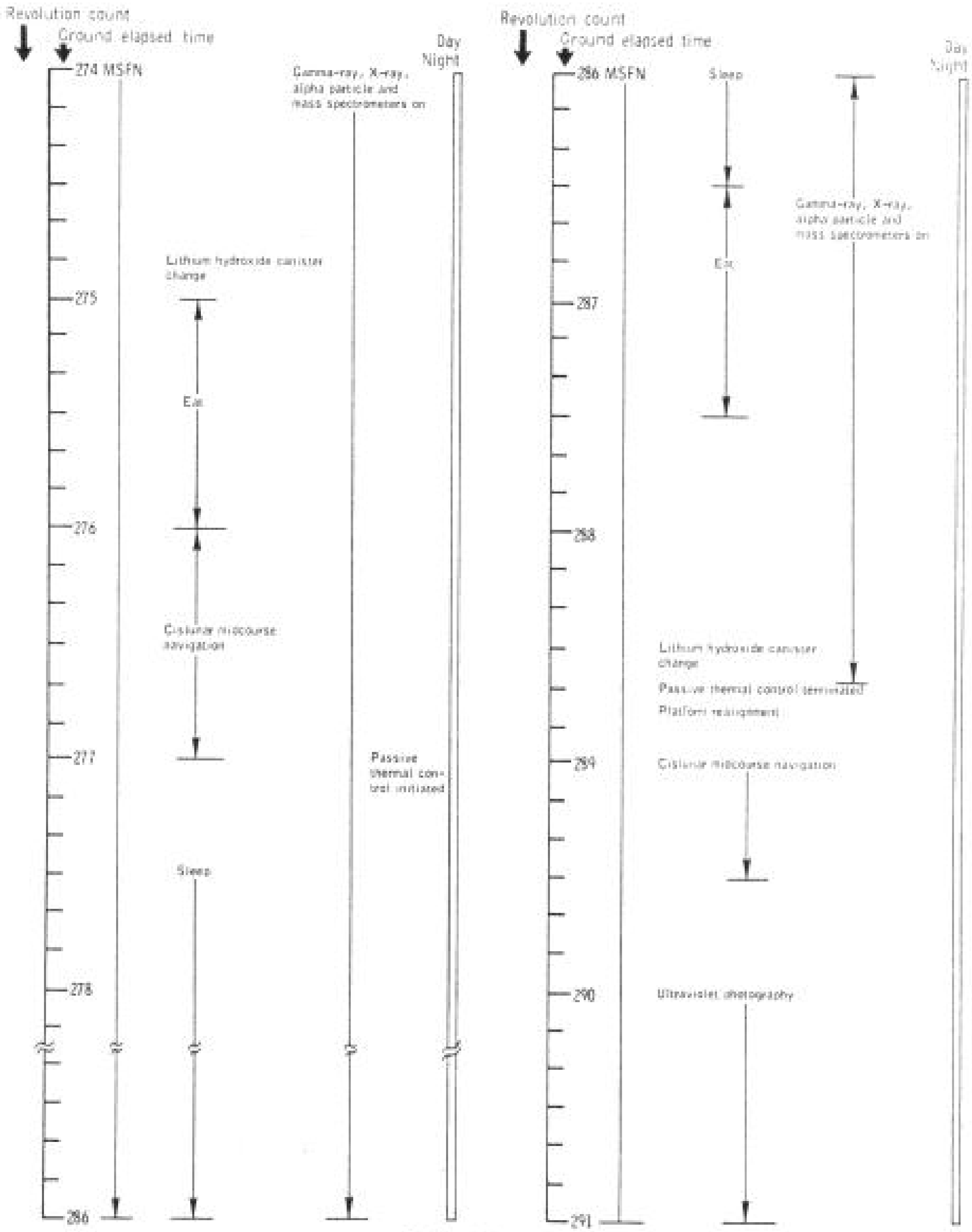
Abbreviated Timeline 20



(v) 264 to 274 hours.

Figure 9-1. - Continued.

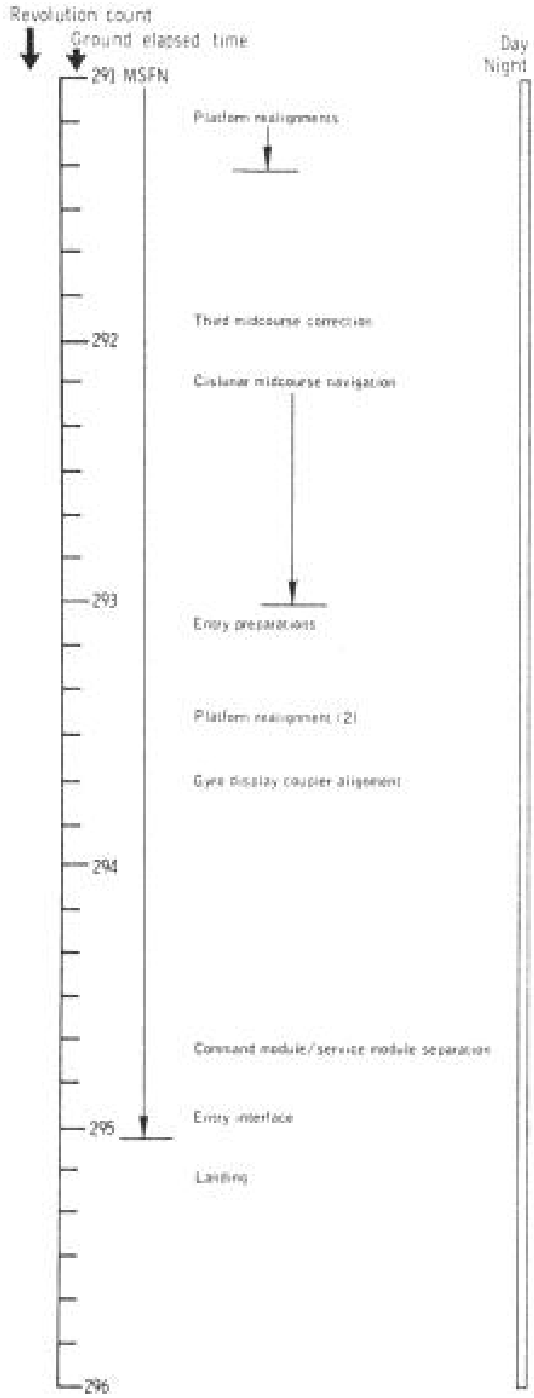
Abbreviated Timeline 21



(w) 274 to 291 hours.

Figure 9-1. - Continued.

Abbreviated Timeline 22



(a) 291 to 296 hours.

Figure 9-1. - Concluded.

Abbreviated Timeline 23

10 BIOMEDICAL EVALUATION

This section is a summary of the Apollo 15 medical findings based on a preliminary analysis of the biomedical data. A total of 885.5 manhours of space flight experience was accumulated during the 12.3 days of flight. The flight crew health stabilization program for this mission was similar to that for Apollo 14. Nine of the one hundred and sixty primary contact personnel were removed from primary contact duty because of infectious illness. This was the first lunar landing mission in which a postflight quarantine period was not required. The basis for the decision to discontinue the quarantine was the absence of pathologic or toxic properties attributable to the lunar materials returned on three previous lunar missions. The crewmen remained in good health throughout the mission.

10.1 BIOMEDICAL INSTRUMENTATION AND PHYSIOLOGICAL DATA

The Apollo 15 mission was the first on which sponge/pellet electrodes were used in the bioharness. This type of biosensor was developed to reduce skin irritation experienced with the previous continuous-wear electrodes. Only one crewman's bioharness was worn and monitored at a time during the translunar and transearth phases of the mission. The wearing time was alternated between work-days and sleep periods for each crewman. Physiological data were transmitted simultaneously from all three crewmen only during launch, extravehicular activities, and entry.

The quality of data obtained with these new electrodes was good. Less skin irritation was seen at the biosensor sites than has been seen on previous Apollo missions. The only biomedical instrumentation problem experienced during the flight occurred approximately 65 seconds after lift-off when the impedance pneumograms (respiratory function) for all three crewmen showed large baseline shifts which were caused by air trapped within the electrodes sponge. At about 14 hours, the crewmen restored their impedance pneumogram data by venting the electrodes. Preflight altitude chamber tests had shown that venting the electrodes would restore the data.

The Commanders heart rates ranged from 81 to 98 beats per minute during lunar descent and 65 to 88 beats per minute during ascent (**Figs. 10-1** and **10-2**). The metabolic rates of the two lunar surface crewmen during the three lunar surface extravehicular periods are correlated with their heart rates as shown in **Figures 10-3** Part 1, and 10-3 Part 2, 10-4 Part 1 and 10-4 Part 2 and 10-5 Part 1, and 10-5 Part 2. The Commander's average heart rates for the first, second, and third periods were 92, 84, and 85 beats per minute, respectively; and the Lunar Module Pilot's average heart rates for the three periods were 125, 107, and 105 beats per minute, respectively. A summary of the average metabolic rates and total production during all extravehicular activity periods is presented in Table 10-I.

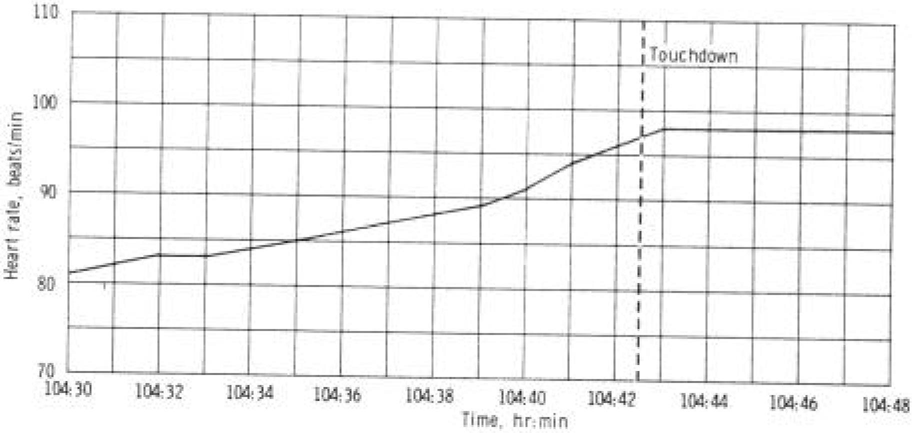
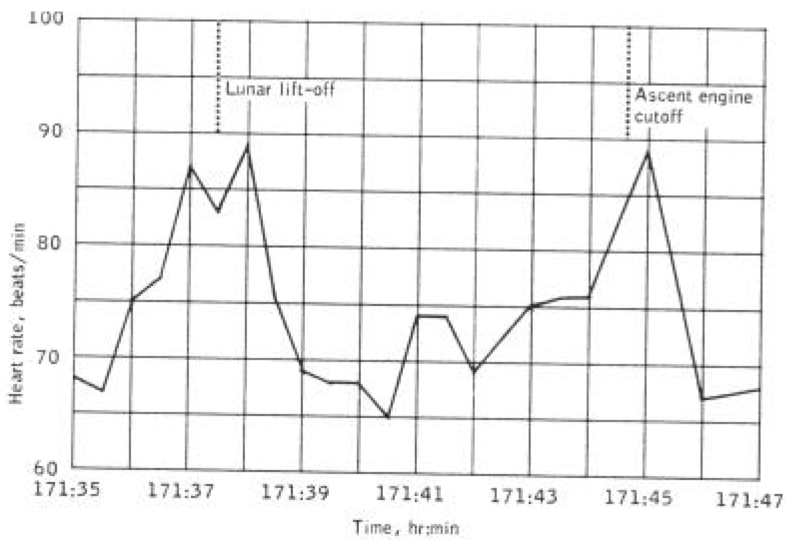
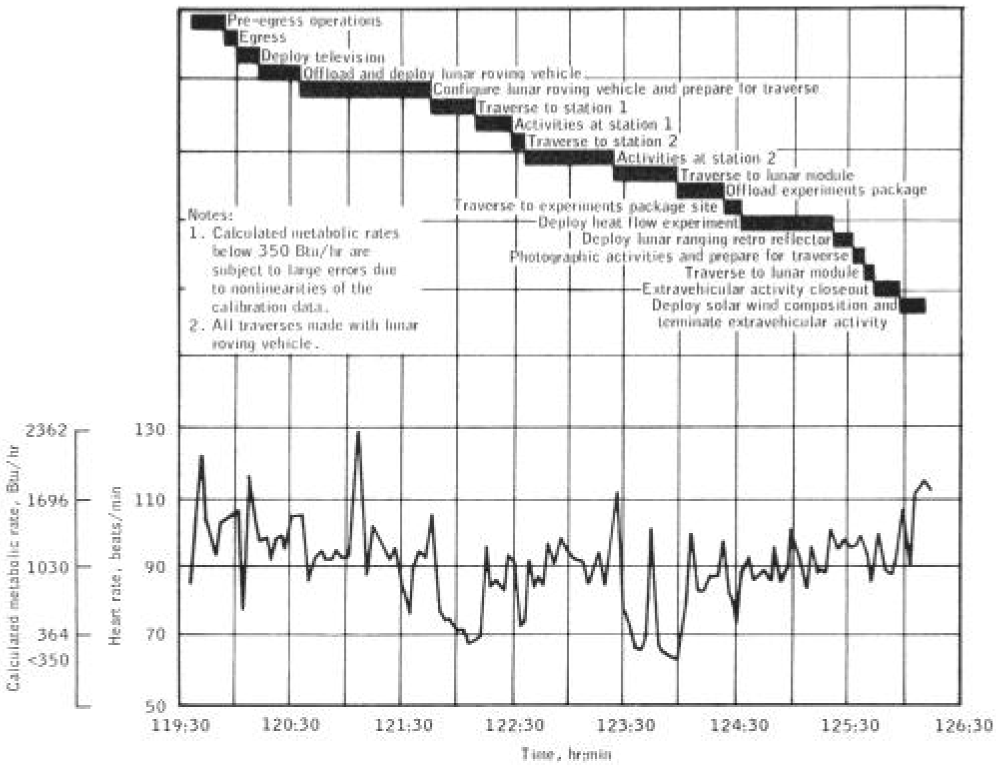


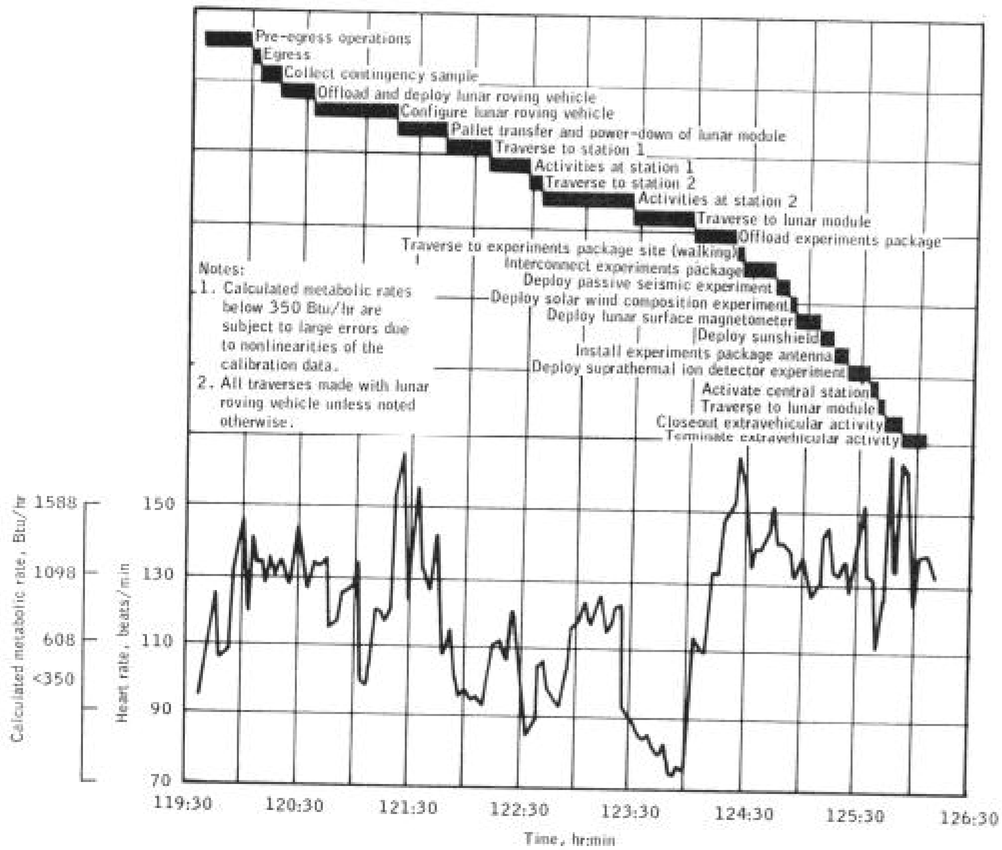
Figure 10-1.- Heart rates of the Commander





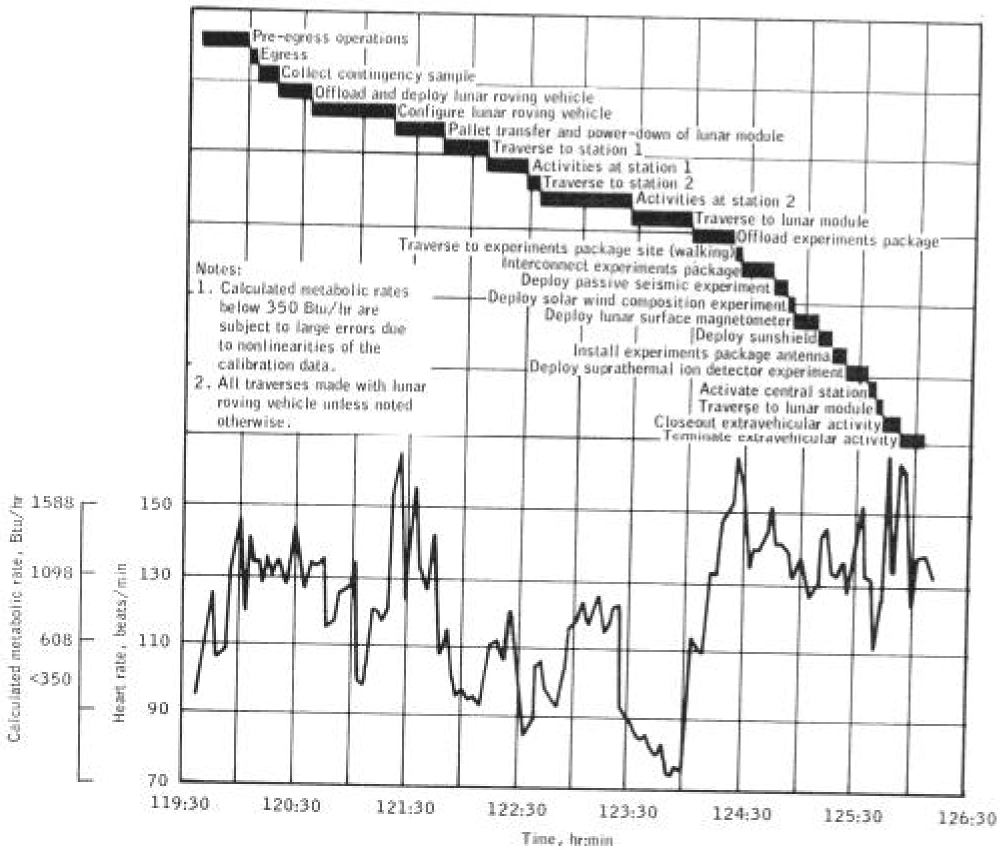
Pre-egress operations
Egress
Deploy television
Offload and deploy lunar roving vehicle
Configure lunar roving vehicle and prepare for traverse
Traverse to station 1
Activities at station 1
Traverse to station 2
Activities at station 2
Traverse to lunar module
Offload experiments package
Traverse to experiments package site
Deploy heat flow experiment
Deploy lunar ranging retro reflector
Photographic activities and prepare for traverse
Traverse to lunar module
Extravehicular activity closeout
Deploy solar wind composition and terminate extravehicular activity
Notes:
1. Calculated metabolic rates below 350 Btu/hr are subject to large errors due to nonlinearities of the calibration data.
2. All traverses made with lunar roving vehicle.
Calculated metabolic rate, Btu/hr
2362
1696
1030
364
<350
Heart rate, beats/min
130
110
90
70
50
119:30
120:30
121:30
122:30
123:30
124:30
125:30
126:30
Time, hr:min

(a) Commander.



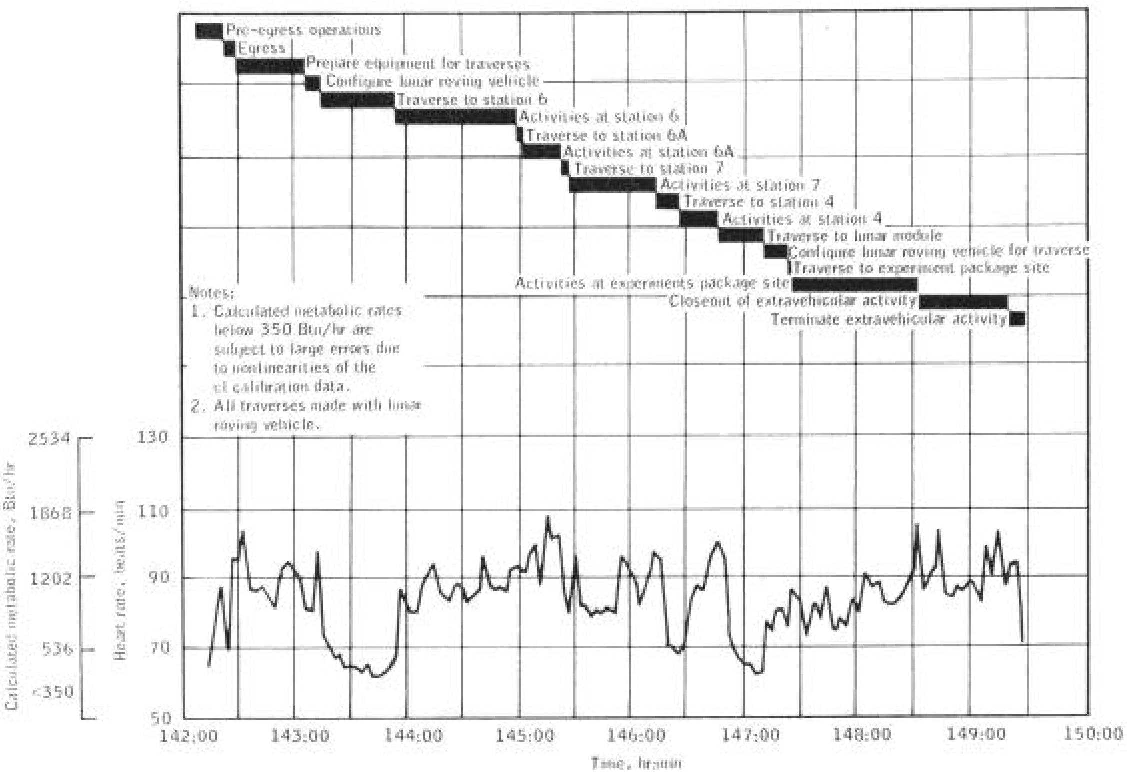
(b) Lunar Module Pilot.

Figure 10-3.- Concluded.

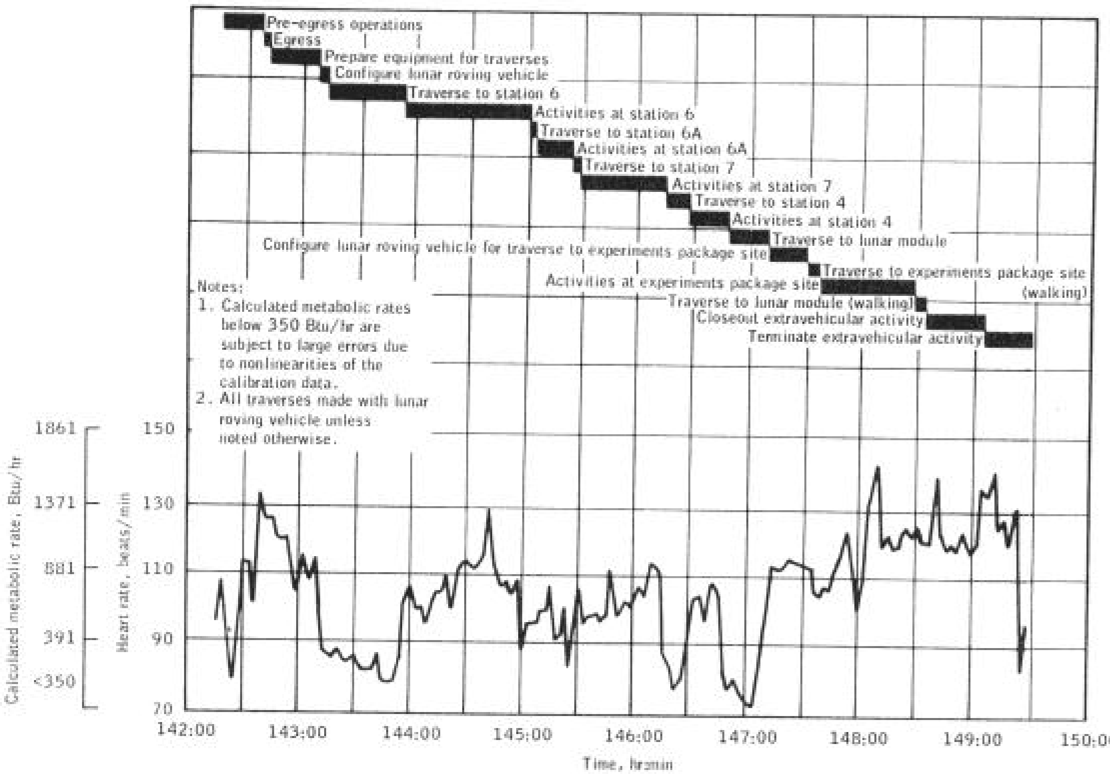


(b) Lunar Module Pilot.

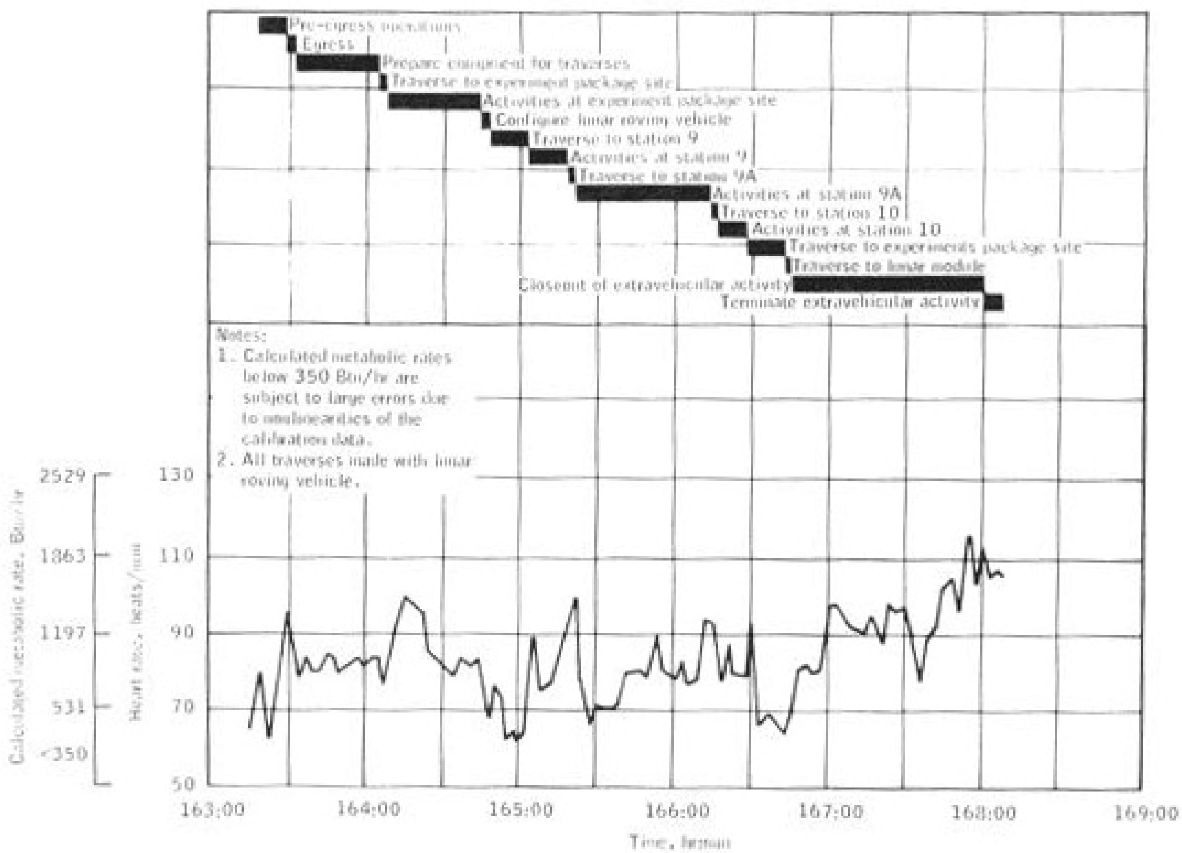
Figure 10-3.- Concluded.


Pre-egress operations
Egress
Prepare equipment for traverses
Configure lunar roving vehicle
Traverse to station 6
Activities at station 6
Traverse to station 6A
Activities at station 6A
Traverse to station 7
Activities at station 7
Traverse to station 4
Activities at station 4
Traverse to lunar module
Configure lunar roving vehicle for traverse
Traverse to experiment package site
Activities at experiments package site
Closeout of extravehicular activity
Terminate extravehicular activity
Notes:
1. Calculated metabolic rates below 350 Btu/hr are subject to large errors due to nonlinearities of the cl calibration data.
2. All traverses made with lunar roving vehicle.
Calculated metabolic rate, Btu/hr
2534
1868
1202
536
<350
Heart rate, beats/min
130
110
90
70
50
142:00
143:00
144:00
145:00
146:00
147:00
148:00
149:00
150:00
Time, hr:min

(a) Commander.

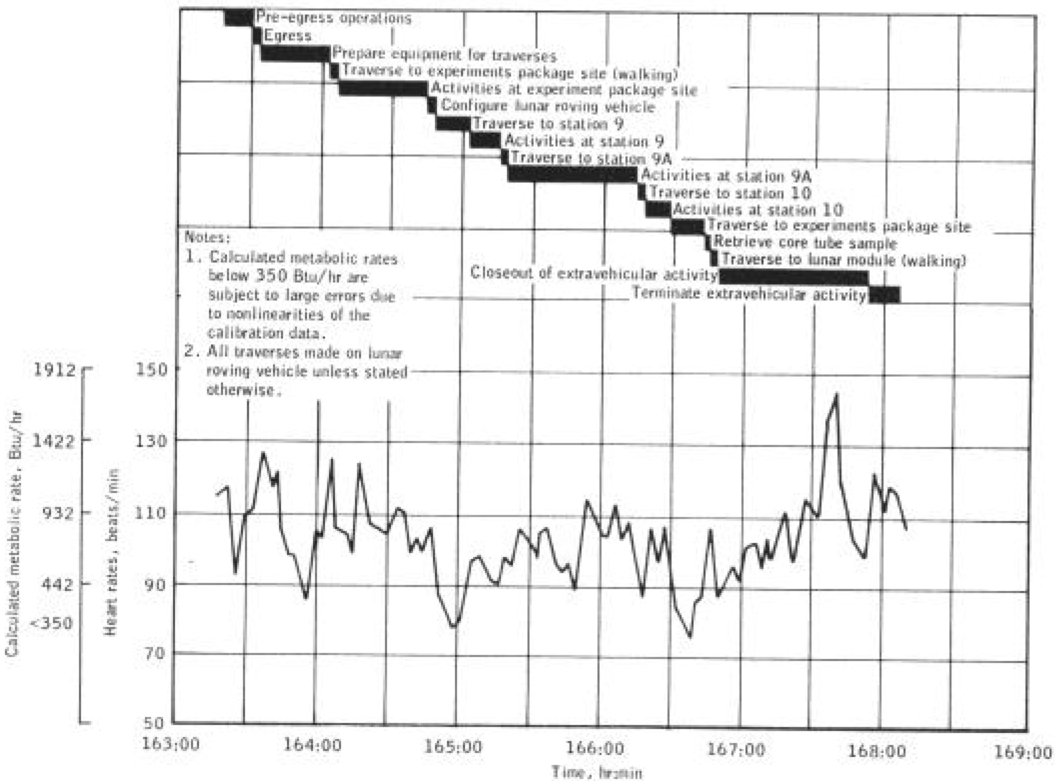


(b) Lunar Module Pilot.



Pre-egress operations
Egress
Prepare equipment for traverses
Traverse to experiment package site
Activities at experiment package site
Configure lunar roving vehicle
Traverse to station 9
Activities at station 9
Traverse to station 9A
Activities at station 9A
Traverse to station 10
Activities at station 10
Traverse to experiments package site
Traverse to lunar module
Closeout of extravehicular activity
Terminate extravehicular activity
Notes:
1. Calculated metabolic rates below 350 Btu/hr are subject to large errors due to nonlinearities of the calibration data.
2. All traverses made with lunar roving vehicle.
Calculated metabolic rate, Btu/hr
Heart rate, beats/min
2529
1863
1197
531
<350
130
110
90
70
50
163:00
164:00
165:00
166:00
167:00
168:00
169:00
Time, hr:min

(a) Commander.



(b) Lunar Module Pilot.

Crewmen	Standup	First		Second		Third		Transearth
	Btu/hr	Btu/hr	Total Btu	Btu/hr	Total Btu	Btu/hr	Total Btu	Btu/hr
Commander	997	1097	7167	1008	7231	1031	4983	464
Lunar Module Pilot	–	976	6377	808	5831	810	3915	834
Command Module Pilot	–	–	–	–	–	–	–	940

10.2 MEDICAL OBSERVATIONS

10.2.1 Adaptation to Weightlessness

Shortly after orbital insertion, each crewman experienced the typical fullness-of-the-head sensation that has been reported by all previous flight crews. The Commander adapted rapidly to weightlessness and noted that on this flight, in contrast to his Apollo 9 experience, he felt completely at ease in the weightless state and was able to move his head rapidly without discomfort.

The Command Module Pilot apparently experienced no difficulty in adapting to weightlessness; but the Lunar Module Pilot reported that his sensation of head-fullness lasted 3 days. In addition, the Lunar Module Pilot experienced slight giddiness which precluded rapid head or body movements. This sensation disappeared shortly after landing on the lunar surface and did not recur on returning to the zero-gravity environment.

None of the crewmen experienced nausea, vomiting, or disorientation during any phase of the mission. An observation made by the crew was that their facial features were distorted because of the lack of gravity. The crew also reported the discomfort and soreness of the lower back muscles associated with postural changes during weightlessness.

10.2.2 Medications

Aspirin and nose drops were the only medications used during the mission. The Commander took a total of 14 aspirin to relieve the pain he developed in his right shoulder after the difficult deep core tube drilling operation on the lunar surface. The Command Module Pilot used nose drops just prior to earth entry to prevent possible middle ear blockage.

10.2.3 Sleep

Very little shift of the crew's normal terrestrial sleep cycle occurred during the translunar and transearth coast phases of this mission. As a result, all crewmen received an adequate amount of sleep during these periods.

Displacement of the terrestrial sleep cycle during the three lunar surface sleep periods ranged from 2 hours for the first sleep period to 7 hours for the third sleep period. This shift in the sleep cycle, in addition to the difference between the command module and lunar module sleep facilities, no doubt contributed to the lunar module crewmen receiving less, sleep on the lunar surface than was scheduled in the flight plan. However, the most significant factors causing loss of crew sleep were operational problems. These included hardware malfunctions as well as insufficient time in the flight plan to accomplish assigned tasks. During the first sleep period, the crewmen went to sleep one hour later than planned and had to arise one hour early to fix a cabin oxygen leak. The crewmen again were an hour late in getting to sleep for the second lunar surface sleep period. The final sleep period was changed so that the beginning of the period was 2 1/2 hours later than originally planned. The period, which had been planned to last 7 hours, was terminated after 6 1/2 hours to begin preparations for the final extravehicular activity. Lengthening the work days and reducing the planned sleep periods on the lunar surface coupled with a significant alteration of the lunar module crewmen' circadian rhythm produced a sufficient fatigue level to cause them to operate on their physiological reserves until they returned to the command module.

10.2.4 Radiation

The Commander's personal radiation dosimeter failed to integrate the dosage properly after the first 24 hours of flight. In order to have f'unctional dosimeters on each lunar module crewman while on the lunar surface, the Command Module Pilot transferred his unit to the Commander prior to lunar module intravehicular transfer. The final readings from the personal radiation dosimeters yielded net integrated (uncorrected) values of 360 millirads for the Commander and 510 millirads for the Lunar Module Pilot. The passive dosimeters worn continously by all crewmen during the entire mission yielded an average of 300 millirads at skin depth. This dosage is well below the threshold of detectable medical effects.

10.2.5 Visual Light Flash Phenomenon

Three observation periods of approximately 1 hour were conducted during translunar and transearth coast as well as during lunar orbit. The crew reported seeing the point sources of light noted by previous Apollo crews. The frequency of the light flashes ranged from once every 2 minutes to once every 5 minutes for each crewman. The frequency of light flashes was greater during translunar flight than transearth flight.

10.2.6 Water

The crew reported that the taste of the drinking water in both the command module and the lunar module was good. All scheduled inflight chlorinations of the command module water system were reported accomplished. Preflight testing of the lunar module potable water system iodine levels showed that use of the bacterial filter would be necessary to prevent bacterial contamination during the mission. The crew reported the sporadic occurrence of gas bubbles in the command module drinking water, but this did not interfere with food hydration.

The Commander consumed about 16 ounces of water during the first extravehicular activity; however, his insuit drinking device slipped under his neck ring on the second extravehicular activity and he was unable to obtain any water. The Lunar Module Pilot was never able to obtain drinking water from his device. The insuit drinking devices were not used during the third extravehicular activity (see sec. 14-5.5).

Inflight water samples were taken on the first and last days of the flight to determine the nickel ion concentration. Analysis of these two inflight water samples revealed that the nickel ion concentration on the first day of flight rose from a prelaunch value of 0.35 parts per million to 6.3 parts per million. On the last day of the flight, 2.7 parts per million of nickel ion concentration were found. The latter was not a representative sample because of the reported water system anomaly (section 14.1.14) which occurred about 12 hours before the sample was taken. This anomaly resulted in only a portion, if any, of the chlorine/buffer/inhibitor solution being injected into the potable water tank and, subsequently, the hot water heater. The nickel ion concentration is believed to result from a chemical reaction between the purification inhibitors and the nickel brazing used in the hot water heater. Three postflight hot water port samples taken 8 hours, 13 hours, and 17 days after recovery yielded nickel ion concentrations of 2.34, 2.02, and 0.34 parts per million, respectively. These data indicate that the postflight nickel ion concentration diminishes as a function of time when the water system is deactivated rather than increases as previously presumed. Postflight analysis of the command module water showed no chlorine residual. The level of nickel ions in the potable water is not considered to be injurious to the crewmen.

10.2.7 Food

The food system on this flight was similar to that of previous Apollo missions with the exception that additional food stowage space was provided in both the command and service module and the lunar module to accommodate the extra food required for a 12.3-day lunar mission. Prior to flight, each crewman evaluated about 100 available foods and selected his menu. The food was arranged in meal packages for the first 10 days of flight. Menus and supplemental food for the remainder of the mission were selected in real time from the food pantry.

The inflight menus were designed to provide approximately 2400 kilocalories per man per day with 400 additional kilocalories in beverages and extra food supplied in the pantry. Thus a total of 2800 kilocalories were available for each crewman on a daily basis. On launch day, each crewman was also provided with a specially prepared and packaged frozen sandwich, suits.

Estimates of the crews' food consumption, based on the onboard food log and the returned food, indicate that an average of 2801, 2372, and 2568 kilocalories per day were consumed by the Commander, the Command Module Pilot, and the Lunar Module Pilot, respectively. The crew commented favorably after the flight on the quality of the inflight food and the food systems. The new insuit food bars were used by both lunar module crewmen on the first and second extravehicular activities. They did not carry the food bar on the third extravehicular activity.

10.3 PHYSICAL EXAMINATIONS

Each crewman received a comprehensive physical examination at 28, 13, and 5 days prior to launch, with brief examinations conducted daily during the last 5 days before launch.

A comprehensive physical examination conducted shortly after landing showed that the crew was in good health. Body weight losses incurred by the Commander, Command Module Pilot, and Lunar Module Pilot during the mission were 2-3/4, 3, and 5-1/2 pounds, respectively. All crewmen suffered varying degrees of minor skin irritiation at the biosensor sites. The cause of this irritation was mechanical friction rather than allergic reaction. The skin irritation subsided within 48 hours without medical treatment.

The Commander had hemorrhages under the fingernails of the middle finger, ring finger, and thumb of his right hand and on the ring finger of his left hand. These hemorrhages were attributed to an insufficient pressure suit arm-length size causing the finger tips to be forced too far into the extravehicular gloves during hard-suit operations. The pressure suit fit was adjusted to suit the Commander's preference to increase his sensitivity of touch. The Commander's painful right shoulder was due to a muscular/ligament strain which responded rapidly to heat therapy.

The time required by the crew to return to preflight baseline levels in lower body negative pressure measurements and bicycle ergometry tests was longer than for previous flights. Some individual variations in the return-to-baseline time occurred, but, in general, about 1 week was required for each crewman to reach his preflight baseline levels.

Both the Commander and the Lunar Module Pilot had a cardiovascular response to the bicycle ergometry tests not observed in previous missions. This response was characterized by an almost normal response at low heart rate levels and a progressively degraded response at the higher heart rate levels.

10.4 BONE MINERAL MEASUREMENT

The bone mineral measurement experiment (M-078) was conducted to deter mine the occurrence and degree of bone mineral changes in the Apollo crewmen which might result from exposure to the weightless condition. This study employed a new and more precise method of estimating bone mineral by using an X-ray technique that utilizes an iodine isotope mono-energetic beam possessing predictable photon absorption characteristics.

Essentially, no changes were observed in the mineral content of the radius, especially when the crew results are compared with the mineral changes seen in control subjects selected on the basis of availability, age, body build, weight, and sex. Immediate preflight and postflight values of radius bone and os calcis (heel) measurements are as follows: (Figure)

Subject	Change from preflight to postflight value, percent	
	Radius	Os calcis
Crewmen:		
Commander	+0.5	-6.8
Command Module Pilot	-2.0	-7.9
Lunar Module Pilot	-0.7	-0.6
Control subjects:		
A	-0.9	-2.3
B	-0.2	-0.8
C	-2.1	-0.7

The Commander regained his mineral content of these bones more rapidly than did the Command Module Pilot. Both were within baseline values at the end of 2 weeks. The magnitude of these losses and the variability observed in the postflight control subjects represent a loss of about 4 percent due to the weightlessness.

The changes in os calcis mineral content observed in the Lunar Module Pilot and on Apollo 14 are in concert with the results observed in bed-rest subjects. The Apollo 15 results are consistent when compared with all previous postflight bone density measurements.

10.5 APOLLO TIME AND MOTION STUDY

Analysis of the time and motion data indicates that the crewmen adapted readily and efficiently to the lunar surface environment. Changes in walking speed were noted during the first and second extravehicular activities as the crewmen gained experience and confidence in moving about the lunar surface. The walking speed for both crewmen under comparable conditions increased from 1.0 ft/sec to 1.5 ft/sec during the first extravehicular activity and from 1.5 ft/sec to 2.0 ft/sec during the second extravehicular activity. No further increase was observed on the third extravehicular activity.

The time to perform tasks on the lunar surface varied. On the average, tasks required 33 percent more time to perform on the lunar surface than on earth. However, some tasks took less time to perform on the lunar surface than in a 1-g environment.