NASA SP-6

RESULTS OF THE SECOND UNITED STATES MANNED ORBITAL SPACE FLIGHT

MAY 24, 1962

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Manned Spacecraft Center

PROJECT MERCURY

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FOREWORD

This document presents the results of the second United States manned orbital space flight conducted on May 24, 1962. The performance discussions of the spacecraft and launch systems, the modified Mercury Network, mission support personnel, and the astronaut, together with analyses of observed space phenomena and the medical aspects of the mission, form a continuation of the information previously published for the first United States manned orbital flight, conducted on February 20, 1962, and the two manned sub-orbital space flights.

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1. SPACECRAFT AND LAUNCH-VEHICLE PERFORMANCE

By John H. Boynton, *Mercury Project Office, NASA Manned Spacecraft Center;* and E. M. Fields, *Mercury Project Office NASA Manned Spacecraft Center*

Summary

The performance of the Mercury spacecraft and Atlas launch vehicle for the orbital flight of Astronaut M. Scott Carpenter was excellent in nearly every respect. All primary mission objectives were achieved. The single mission-critical malfunction which occurred involved a failure in the spacecraft pitch horizon scanner, a component of the automatic control system. This anomaly was adequately compensated for by the pilot in subsequent inflight operations so that the success of the mission was not compromised. A modification of the spacecraft control-system thrust units were effective. Cabin and pressure-suit temperatures were high but not intolerable. Some uncertainties in the data telemetered from the bioinstrumentation prevailed at times during the flight; however, associated information was available which indicated continued well-being of the astronaut. Equipment was included in the spacecraft which provided valuable scientific information; notably that regarding liquid behavior in a weightless state, identification of the airglow layer observed by Astronaut Glenn, and photography of terrestrial features and meteorological phenomena. An experiment which was to provide atmospheric drag and color visibility data in space through deployment of an inflatable sphere was partially successful. The flight further qualified the Mercury spacecraft systems for manned orbital operations and provided evidence for progressing into missions of extended duration and consequently more demanding systems requirements.

Introduction

The seventh Mercury-Atlas mission (MA–7) was planned for three orbital passes and was a continuation of a program to acquire operational experience and information for manned orbital space flight. The objectives of the flight were to evaluate the performance of the man-spacecraft system in a three-pass mission, to evaluate the effects of space flight on the astronaut, to obtain the astronaut's opinions on the operational suitability of the spacecraft systems, to evaluate the performance of spacecraft systems modified as a result of unsatisfactory performance during previous missions, and to exercise and evaluate further the performance of the Mercury Worldwide Network.

The Aurora 7 spacecraft and Atlas launch vehicle used by Astronaut Carpenter in successfully performing the second United States manned orbital mission (MA–7) were nearly identical to those used for the MA–6 flight. The Mercury spacecraft provided a safe and habitable environment for the pilot while in orbit, as well as protection during the critical flight phases of launch and reentry. The spacecraft also served as an orbiting laboratory where the pilot could conduct limited experiments which would increase the knowledge in the space sciences. The intent of this paper is to describe briefly the MA–7 spacecraft and launch vehicle

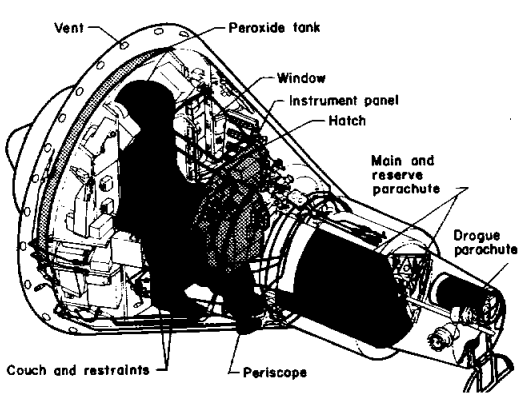

Figure 1–1.—Mercury spacecraft systems.

systems and discuss their technical performance.

The many systems which the spacecraft comprises may be generally grouped into those of heat protection, mechanical and pyrotechnic, attitude control, communications, electrical and sequential, life support, and instrumentation. The general arrangement of the spacecraft interior is schematically depicted in figure 1–1. Although a very basic description of each system accompanies the corresponding section, a more detailed description is presented in reference 1.

Heat Protection System

During flight through the atmosphere at launch and reentry, the high velocities generate excessive heat from which the crew and equipment must be protected. The spacecraft must also be capable of withstanding the heat pulse associated with the ignition of the launch escape rocket. To provide this protection, the spacecraft afterbody is composed of a double-wall structure with thermal insulation between the two walls. The outer conical surface of the spacecraft afterbody is made up of high-temperature alloy shingles, and the cylindrical portion is protected by beryllium shingles. The spacecraft blunt end is fitted with an ablation-type heat shield, which is constructed of glass fibers and resin. Additional description of the heat protection system can be found on pages 7 to 9 of reference 1.

Although the MA–7 reentry trajectory was slightly more shallow than for MA–6, the heating effects were not measurably different, as is evident in figure 1–2.

The performance of the MA–7 heat protection system was as expected and was quite satisfactory.

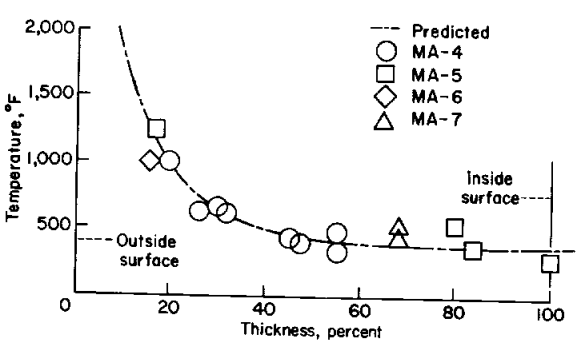

FIGURE 1–2.—Maximum ablation-shield temperatures.

Two temperature measurements were made in the ablation shield, one at the center and the other approximately 27 inches from the center. The maximum recorded values are graphically shown and compared with previously obtained orbital reentry values in figure 1–2. The magnitudes of these temperatures, as well as the ablation-shield weight loss during reentry, are comparable with previous flights. The supporting structure behind the ablation shield was found to be in excellent condition following the flight. A more complete temperature survey of points around the afterbody than on previous flights was conducted for MA–7. This survey was made possible by the addition of a low-level commutator circuit. The data, which are shown in figure 1–3, were within expected ranges, and the integrity of the structure was not affected by the thermal loads experienced.

Mechanical and Pyrotechnic Systems

The mechanical and pyrotechnic system group consists of the separation devices, the rocket motors, the landing system, and the internal spacecraft structure. This entire group functioned satisfactorily during the mission. Performances of individual systems are discussed in the following paragraphs.

Separation Devices

Separation devices generally use explosive charges to cause separation or disconnection of components. The major separation points are at the interface between the spacecraft and launch vehicle, between the spacecraft and the escape tower, at the heat shield, and around the spacecraft hatch. All separation devices worked properly during the mission. The explosive-actuated hatch was not used, since the pilot egressed through the top of the spacecraft after landing.

Rocket Motors

The rocket motor system consisted of three retrorocket motors, three posigrade motors, the launch escape rocket, and the small tower-jettison rocket. All of these motors are solid-propellant type. See page 9 of reference 1 for additional description of the rocket motor system. Nominal thrust and burning-time data are given in the following table:

Although ignition of the retrorocket motors was about 3 seconds later than expected, the per-

Rocket motor	Number of motors	Nominal thrust each, lb	Approximate burning time each, sec
Escape	1	52, 000	1
Tower jettison	1	800	1. 5
Posigrade	3	400	1
Retrograde	3	1, 000	10

formance of the rocket motors was satisfactory. An analysis of radar tracking data for the flight yielded a velocity increment at retrofire which indicated that the retrorocket performance was 3 percent lower than nominal. This was acceptable and within the allowable deviation from nominal performance of ±5 percent.

Landing System

The landing system includes the drogue (stabilization) parachute, the main and reserve parachutes, and the landing shock-attenuation system (landing bag). The latter system attenuates the force of landing by providing a cushion of air through the deployment of the landing bag and heat shield structure, which is supported by straps and cables. The landing system can be actuated automatically, or manually by the astronaut. The landing system is described in greater detail on pages 28 to 30 of reference 1. The landing system performed satisfactorily and as planned.

The MA–7 landing system differed from the MA–6 system in the manner of arming the barostats (pressure-sensing devices). These units initiate automatic deployment of the parachutes when the spacecraft descends to the proper pressure altitude during reentry. In the MA–6 and prior missions, the barostats were armed when above the atmosphere during exit flight and thus were in readiness to initiate the parachute-deployment mechanisms when the barostats sensed the appropriate pressure during spacecraft descent through the atmosphere. This armed status of the barostats would of course permit deployment of a parachute during orbital flight if a certain type of barostat malfunction should occur. While such barostat malfunctions had not been detected in previous flights or during ground tests, it was believed that an additional safety margin would be desirable, because of the unexplained early deployment of the drogue parachute during the MA–6 mission. Consequently, a control barostat was added to the automatic sequence circuit of the MA–7 spacecraft. This barostat sensed pressure in the cabin and func-

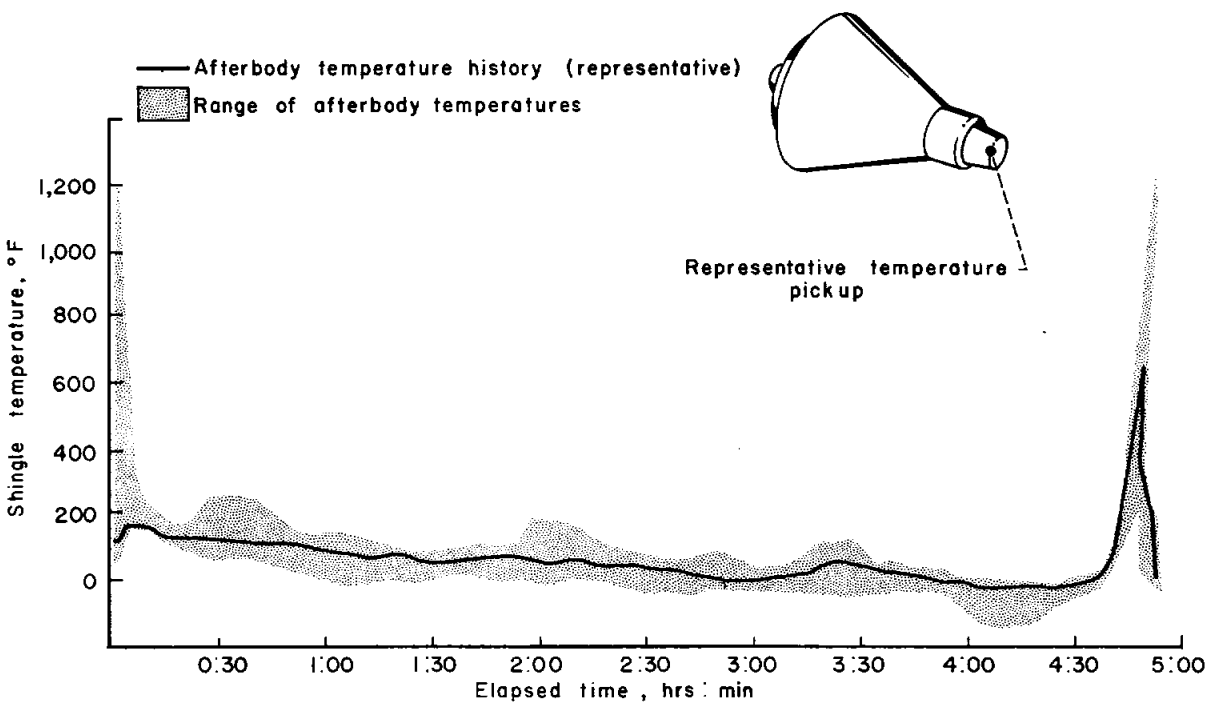

FIGURE 1–3.—Afterbody temperature from low-level commutator circuit.

tioned in a manner intended to prevent automatic deployment of the parachutes until the spacecraft cabin pressure corresponded to an acceptable altitude. The control barostat did not alter the circuitry that was available to the pilot for manual deployment of the parachutes. In the MA–7 mission, it was planned for the pilot to deploy the drogue parachute manually at an altitude of 21,000 feet or higher if added spacecraft stabilization prior to automatic deployment of the drogue parachute was desired. Astronaut Carpenter felt the need for additional spacecraft stabilization and manually deployed the drogue parachute at an altitude of approximately 25,500 feet. The pilot also planned a manual deployment of the main parachute routinely at an altitude of about 10,000 feet, rather than waiting for automatic deployment at approximately 8,200 feet altitude; the data show that manual deployment was effected at about 9,500 feet.

Flotation

After landing, the astronaut reported a severe list angle on the order of 60° from vertical, and postflight photographs of the spacecraft taken after egress of the pilot indicate approximately a 45° list angle. The time normally required for the spacecraft to erect to its equilibrium angle exceeds the period that Astronaut Carpenter used to initiate egress; therefore, this egress activity may have prevented the return to a more nearly vertical flotation attitude. Upon recovery, a considerable amount of sea water was found in the spacecraft, the majority of which is believed to have entered through the small pressure bulkhead when the pilot passed through the recovery compartment into the liferaft. In addition, small leaks in the internal pressure vessel which probably occurred upon landing were disclosed during the normal postflight inspection; but accounting for the 6 hours prior to spacecraft recovery, these leaks would have contributed only slightly to the water in the cabin. The pilot reported that at landing a small amount of water splashed onto the tape recorder in the cabin; it is believed that this resulted from a surge of water which momentarily opened a spring-loaded pressure relief valve in the top of the cabin.

Spacecraft Control System

The spacecraft control system is designed to provide attitude and rate control of the Mercury vehicle while in orbit and during reentry. Page 11 of reference 1 presents an additional description of the spacecraft control system. With the single exception of the pitch horizon scanner, all system components performed normally during the entire flight.

TABLE 1–I.—*Spacecraft Control System Redundancy and Electrical Power Requirements*

Control system modes	Corresponding fuel system (fuel supply, plumbing, and thrusters)	Electrical power required
ASCS	A	d-c and a-c
FBW	A	d-c
MP	B	None
RSCS	B	d-c and a-c

ASCS—Automatic stabilization and control system
FBW—Fly-by-wire
MP—Manual proportional system
RSCS—Rate stabilization control system
} Controlled by pilot actuation of control stick

The attitude control system, at the discretion of the pilot, is capable of operation in the modes listed in table 1–I.

The spacecraft was equipped with two separate reaction control systems (RCS) shown as A and B in table 1–I, each with its own fuel supply and each independent of the other. Combinations of modes ASCS and FBW, FBW and MP, or FBW and RSCS were available to provide "double authority" at the choice of the pilot. A "maneuver" switch was added to the instrument panel for MA–7 and was included in the control circuitry to allow the astronaut to perform maneuvers without introducing errors in his attitude displays. Actuation of the switch effectively disabled the yaw reference slaving system and the automatic pitch orbital precession of 4°/ min and thus prevented generation of erroneous gyro slaving signals during maneuvers.

The reaction control components were of the standard configuration, with the exception of the 1-pound and 6-pound thruster assemblies which had been slightly modified to correct deficiencies which occurred on earlier flights. The

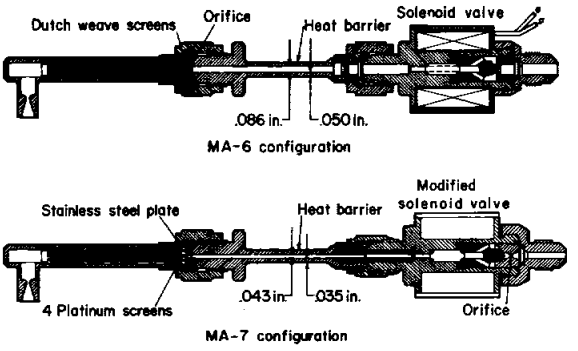

FIGURE 1–4.—Comparison between MA–6 and MA–7 thrusters.

modification to the 1-pound units involved replacing the stainless-steel fuel distribution (Dutch weave) screens (see fig. 1–4) with platinum screens and a stainless-steel fuel distribution plate, reducing the volume of the heat barriers of the automatic RCS, and moving the fuel-metering orifice to the solenoid inlet. The only modification to the 6-pound units was the replacement of the stainless-steel screens with platinum screens. These changes proved to be effective, as all thrust units operated properly throughout the flight.

Horizon Scanners

The horizon scanners are employed to provide a correction reference for the spacecraft attitude gyros which is indicated in the basic schematic diagram shown in figure 1–5. An error introduced by the pitch horizon scanner circuit was present during launch and apparently remained to some degree throughout the flight. Since the scanners were lost when the antenna canister was jettisoned during the normal landing sequence, postflight inspection and analysis of these units were impossible; however, the failure is believed to have been in the scanner circuit and was apparently of a random nature in view of the fact that the scanner system has been fully qualified on previous flights.

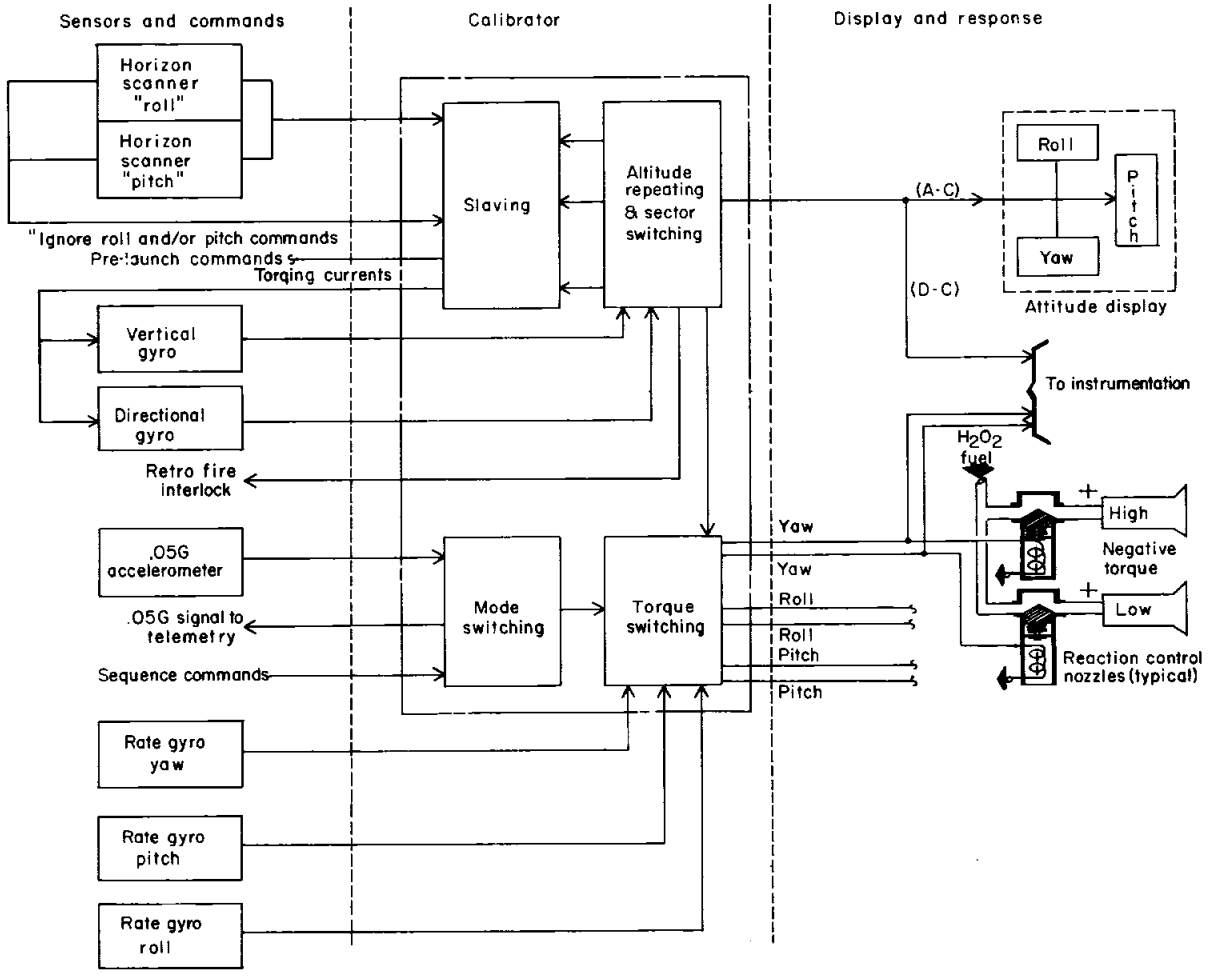

FIGURE 1–5.—Control system schematic diagram.

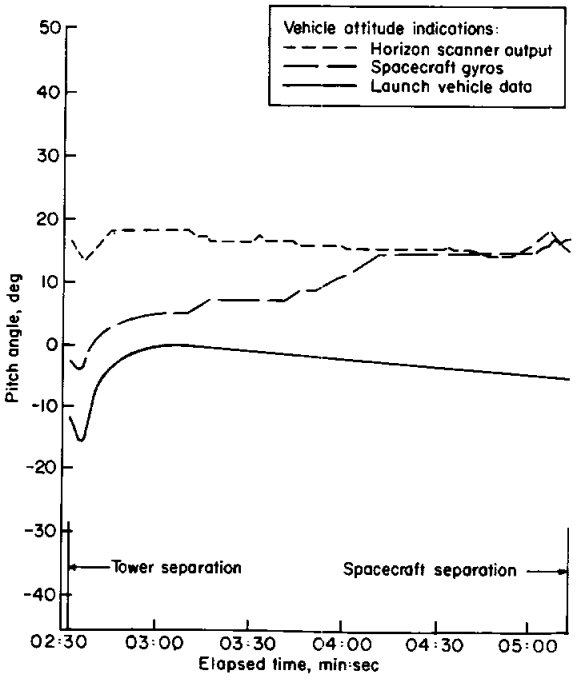

FIGURE 1–6.—Spacecraft attitudes during launch.

Some 40 seconds after escape tower separation, the output of the pitch scanner indicated a spacecraft attitude of approximately 17°, which is graphically depicted in figure 1–6. Also shown is the attitude of the launch vehicle and spacecraft as determined from launch vehicle data which is about −1° at this time, indicating a scanner error of about 18° in pitch. This error apparently increased to about 20° at spacecraft separation. Radar tracking data at the time of retrofire provided the only additional independent information source and the radar data verify, in general, the scanner error. The thrust vector which produced the postretrograde velocity was calculated by using the radar measurements, and since this vector is alined with the spacecraft longitudinal axis, a retrofire attitude of about −36° in pitch was derived. This calculated attitude was compared with a scanner-indicated attitude of −16° during retrofire, yielding a difference of 20°. Although these two independent measurements and calculations would support a theory that a constant bias of about 20° was present, the attitudes as indicated by instruments and compared with observations by the pilot disclose possible horizon scanner errors of widely varying amounts during the orbital flight phase. Because of the malfunctioning scanner which resulted in pitch errors in the spacecraft attitude-gyro system, the pilot was required to assume manual control of the spacecraft during the retrofire period.

Fuel Usage

Double authority control was inadvertently employed at times during the flight, and the fly-by-wire high thrust units were accidently actuated during certain maneuvers, both of which contributed to the high usage rate of spacecraft fuel indicated in figure 1–7. In addition, operation of the ASCS mode while outside the required attitude limits resulted in unnecessary use of the high thrust units. The manual-system fuel was depleted at about the end of the retrofire maneuver, and the automatic-system fuel was depleted at about halfway through the reentry period.

Because of the early depletion of automatic-system fuel, attitude control during reentry was not available for the required duration. As a result, attitude rates built up after the ASCS became inoperative because of the lack of fuel, and these rates were not sufficiently damped, as expected, by aerodynamic forces. These oscillations to diverge until the pilot chose to deploy the drogue parachute manually at an altitude of approximately 25,000 feet to stabilize the spacecraft.

In order to prevent inadvertent use of the high-thrust jets when using FBW mode of control, the MA–8 and subsequent spacecrafts will contain a switch which will allow the pilot to disable and reactivate the high-thrust units at his discretion. An automatic override will reactivate these thrusters just prior to retrofire. Additionally, a revision of fuel management and control training procedures has been instituted for the next mission.

Communication Systems

The MA–7 spacecraft communication system was identical to that contained in the MA–6 configuration with one minor exception. The voice power switch was modified to provide a mode whereby the astronaut could record voice on the onboard tape recorder without transmission to ground stations. Switching to the transmitting mode could be accomplished without the normal warmup time, since the transmitter was maintained in a standby condition

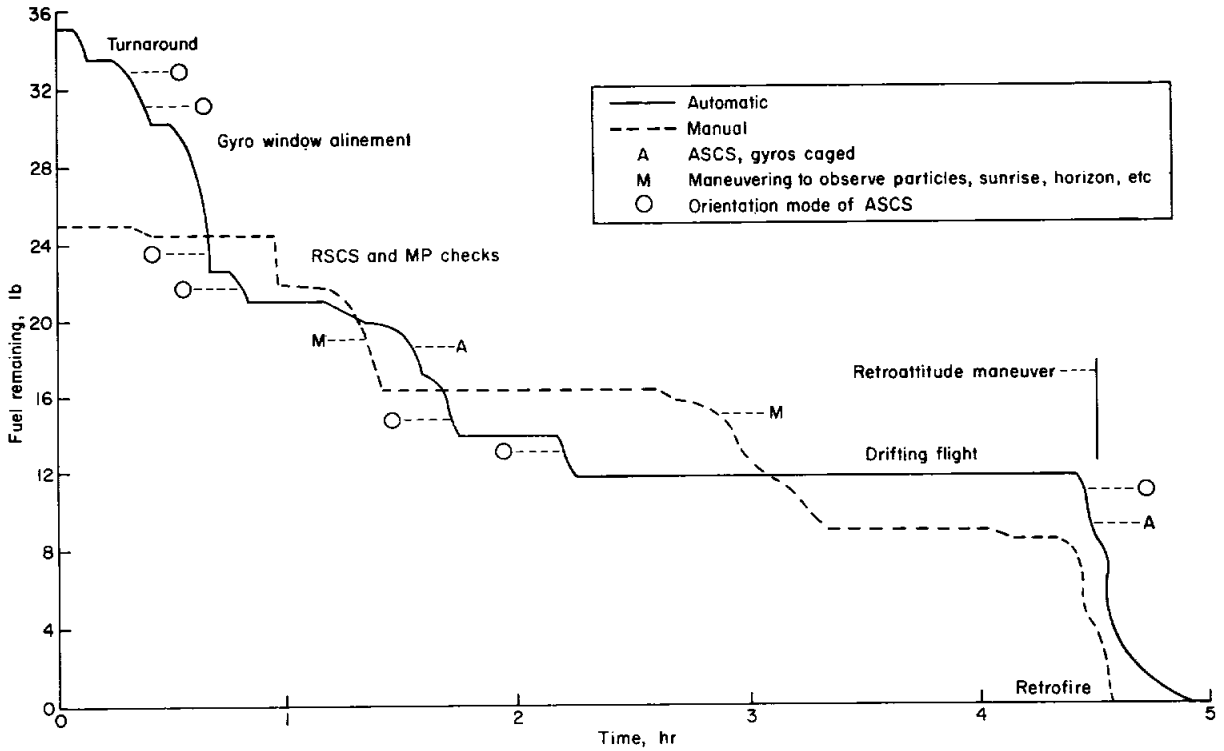

FIGURE 1-7.—Fuel usage rates.

when the switch was in the record position. The communications system is described in more detail beginning on page 12 of reference 1. The MA-7 communication system, with certain exceptions discussed below, performed satisfactorily.

Voice Communications

The UHF voice communications with the spacecraft were satisfactory. Reception of HF voice in the spacecraft was satisfactory; however, attempts on the part of the astronaut to accomplish HF voice transmission to the ground were unsuccessful. The reason for the poor HF transmission has not been determined.

Radar Beacons

Performance of the C- and S-band beacons was entirely satisfactory, although slightly inferior to that of the MA-6 mission. Several stations reported some beacon countdown (missed pulses) and slight amplitude modulation on the C-band beacon. The amplitude modulation was possibly caused by the modulation presented by the phase shifter and the drifting mode of the spacecraft, which resulted in a less than optimum antenna orientation, as expected. Both beacons were rechecked after the mission and found to be essentially unchanged from their preflight status.

Location Aids

The recovery beacons employed as postlanding location aids include the SEASAVE (HF/DF), SARAH (UHF/DF), and Super SARAH (UHF/DF) units. Recovery forces reported that the auxiliary beacon (Super SARAH) and UHF/DF signals were received. The Super SARAH beacon was received at a range of approximately 250 miles. Both the SARAH beacon and UHF/DF transmitter were received at ranges of 50 miles from the spacecraft.

The SEASAVE rescue beacon (HF/DF) was apparently not received by the recovery stations. The whip antenna used by this beacon was reported by the recovery forces to be fully extended and normal in appearance. The beacon was tested after the flight and found to be operating satisfactorily. The reason for lack of reception of this beacon has not been established, but the large list angles of the spacecraft after landing placed the whip antenna near the surface of the water, and this may have been a contributing factor.

Command Receivers

The two command receivers operated effectively during the MA–7 flight. One exercise was successfully accomplished with the emergency-voice-mode of the command system while over Muchea. The second exercise of this mode, attempted during reentry, was unsuccessful because the spacecraft was below the line-of-sight of the range stations at this time.

Instrumentation System

The spacecraft instrumentation system was basically the same as that for the MA–6 mission which is described on page 19 of reference 1. Performance of the system was satisfactory except for those items discussed below.

The instrumentation system sensed information pertinent to over 100 items throughout the spacecraft. The biological parameters of the pilot, namely electrocardiogram (ECG) traces, respiration rate and depth, body temperature, and blood pressure, were of primary concern to flight control personnel. In addition, many operational aspects of spacecraft systems were monitored. These aspects included significant sequential events, control system operation and component outputs, attitudes and attitude rates, electrical parameters, ECS pressures and temperatures, accelerations along all three axes, and temperatures of systems and structure throughout the spacecraft. These quantities were transmitted to Mercury Network stations and recorded onboard the spacecraft. The system also included a 16-mm motion picture camera which photographed the astronaut and surrounding portions of the spacecraft. The instrumentation system had direct readouts on the MA–7 spacecraft display panel for many of the instrumented parameters.

System Modifications

The changes made since the MA–6 flight included the incorporation of an additional, low-level commutator circuit which provided a more complete temperature survey, rewiring of the circuitry which monitored closure of the limit switches that sensed heat-shield release and the substitution of a semi-automatic blood pressure measuring system (BPMS) for the manual device used for MA–6. In addition, the earth-path indicator and the instrument-panel camera were deleted for MA–7.

Instrumentation Anomalies

A problem in the instrumentation system occurred just after lift-off when erroneous ECG signals were temporarily recorded. These extraneous signals were primarily attributed to rapid body movements of the pilot and possibly excessive perspiration during this period.

For a short period during the orbital phase, the instrumentation indicated that the astronaut's temperature had increased to 102° F. and this caused momentary concern. However, other medical information indicated that this 102° F. value was erroneous. The respiration rate sensor provided adequate preflight data, but the inflight measurements were marginal because of the variations in head position and air density. This anomaly has been experienced on previous flights and was of little concern.

The data transmitted from the blood-pressure measuring system were questionable at times during the flight, primarily because of the magnitude of the data and the intermittency with which it was received. The intermittent signals were found to have resulted from a broken cable in the microphone pickup, shown in figure 1–8. This malfunction, however, could not have affected the magnitude of the transmitted information, since an intermittent short either sends valid signals or none at all. The BPMS was thoroughly checked during postflight tests in the laboratory using actual flight hardware, with the exception of the microphone and cuff. Tests of the controller unit and amplifier were also conducted, and no component failure or damage in the BPMS has been detected to date. However, a number of uncertainties regarding the calibration and operation of the BPMS still

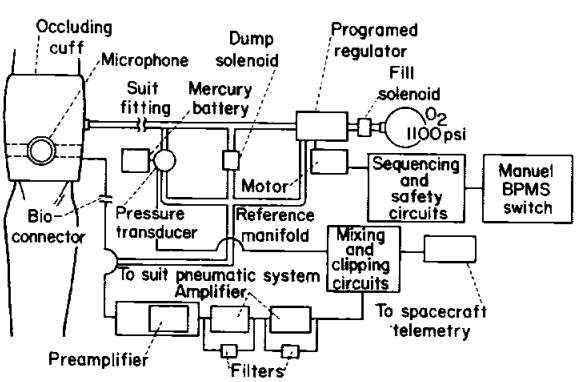

FIGURE 1–8.—Semiautomatic blood-pressure measuring system.

exist. Extensive testing is being conducted to correlate postflight and inflight BPMS readings more accurately with clinically measured values.

The remainder of the instrumentation system performed satisfactorily, with the exception of a noncritical failure of one temperature pickup, a thermocouple located at the low clockwise automatic thruster. A brief indication of spacecraft descent occurred on the rate-of-descent indicator toward the end of the orbital phase; but since this unit is activated by atmospheric pressure, the indication was obviously false. This indicator apparently operated satisfactorily during descent through the atmosphere and was found to be operating properly during postflight evaluation. The pilot-observer camera film suffered sea-water immersion after the flight, and its quality and usefulness were somewhat limited.

Life Support System

The life support system primarily controls the environment in which the astronaut operates, both in the spacecraft cabin and in the pressure suit. Total pressure, gaseous composition, and temperature are maintained at acceptable levels, oxygen is supplied to the pilot on demand, and water and food are available. Both the cabin and suit environmental systems operate automatically and simultaneously from common oxygen, coolant water, and electrical supplies. In-flight adjustment of the cooling system is provided for, and the automatic-supply function of the oxygen system has a manual override feature in case of a malfunction. The suit and cabin pressures are maintained at 5.1 psia, and the atmosphere is nearly 100-percent oxygen. The environmental control system (ECS) installed in the MA–7 spacecraft, schematically shown in figure 1–9, differed from that for MA–6 in only two respects: The constant bleed of oxygen into the suit circuit was eliminated, and the oxygen partial pressure of the cabin atmosphere was measured, rather than that of the suit circuit. Pages 21 and 31 of reference 1 contain additional description of the life support system.

Higher-than-desired temperatures in the spacecraft cabin and pressure suit were experienced during the MA–7 flight, and these values

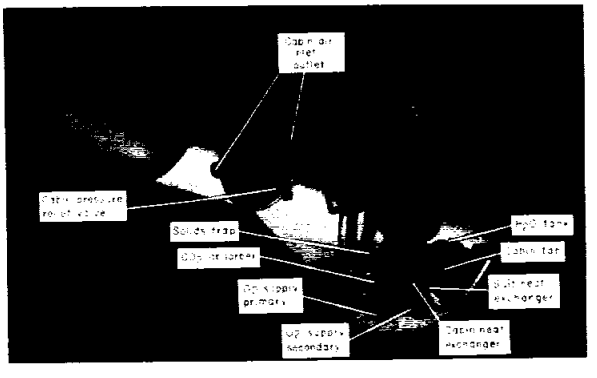

FIGURE 1–9.—Schematic diagram of the environmental control system.

are plotted in figures 1–10 and 1–11, respectively. In the same figures, the cabin and suit temperatures measured during the MA–6 mission are shown for comparison. The high temperatures were the only anomalies evident in the ECS during the flight.

The high cabin temperature is attributed to

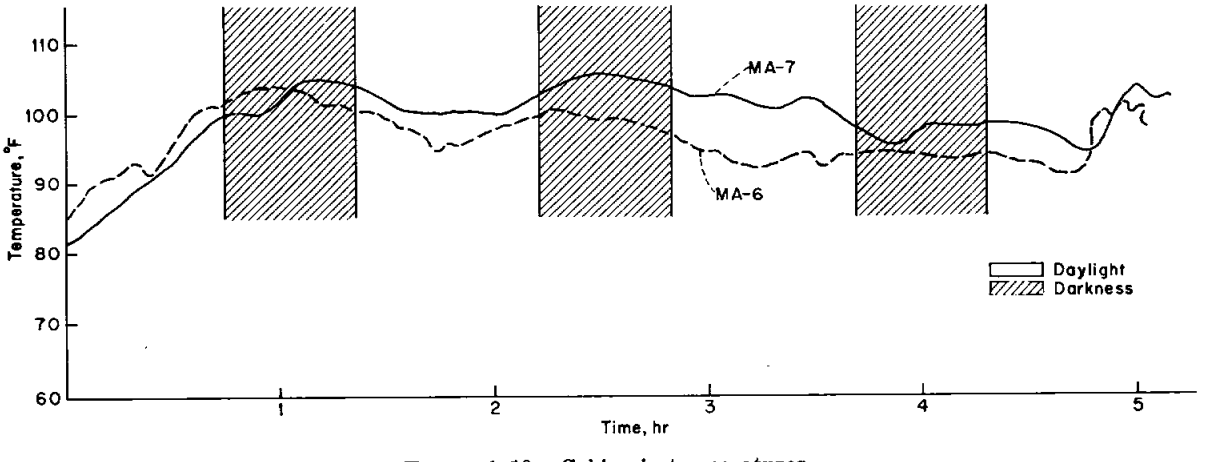

FIGURE 1–10.—Cabin-air temperatures.

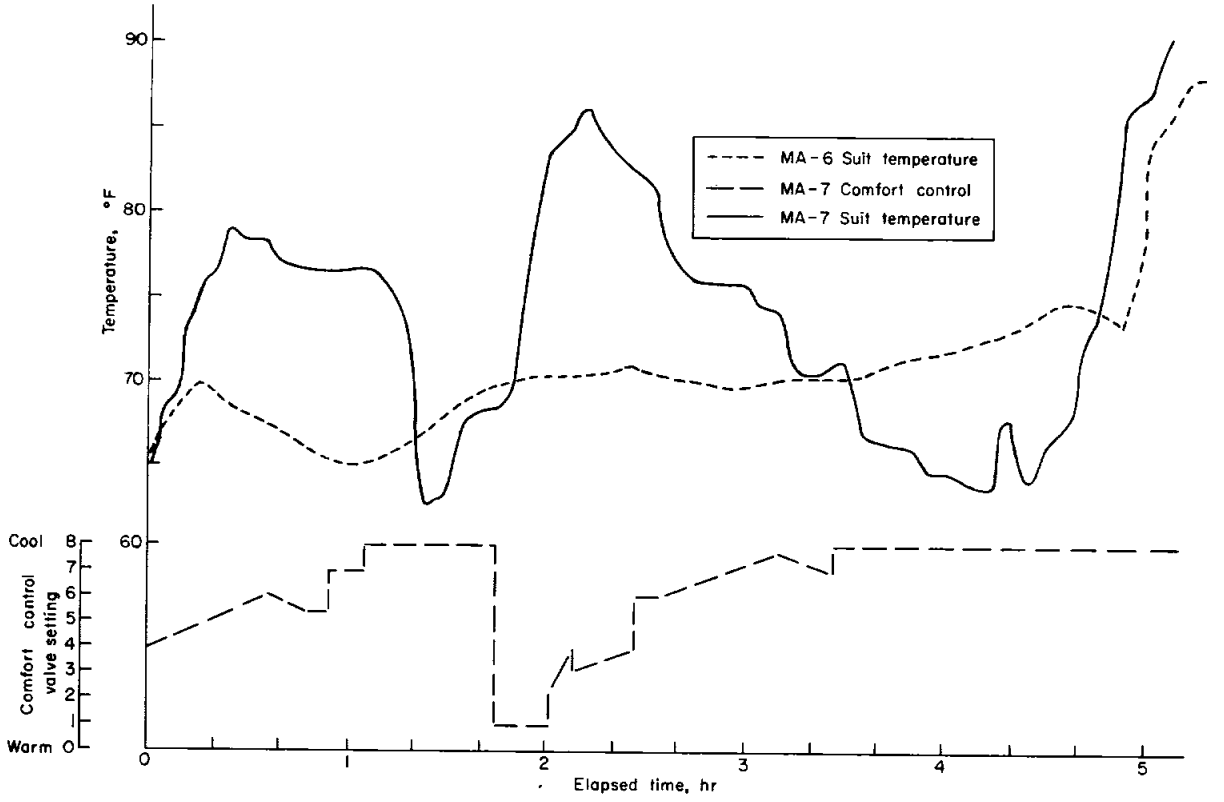

FIGURE 1–11.—Suit-inlet temperature and comfort control valve setting.

a number of factors, such as the difficulty of achieving high air-flow rates and good circulation of air in the cabin and vulnerability of the heat exchanger to freezing-blockage when high rates of water flow are used. Tests are currently being made to determine if the cabin temperature can be lowered significantly without requiring substantial redesign of the cabin-cooling system.

In the case of the high suit temperatures, some difficulty was experienced in obtaining the proper valve setting for the suit-inlet temperature control, mainly because of the inherent lag at the temperature monitoring point with control manipulations. The comfort control valve settings are presented in figure 1–11, and a diagonal line reflects a lack of knowledge as to when the control setting was instituted. It has been further ascertained in postflight testing in the altitude chamber that the suit temperature did respond to control valve changes. Based on the satisfactory performance of the suit system in the MA–6 flight, it is believed that the suit-inlet temperature could have been maintained in the 60° to 65° F range for the MA–7 flight, had not the comfort control valve been turned down early in the flight. The valve setting was reduced by the pilot during the first orbital pass when the cabin heat exchanger indicated possible freezing. It is believed that some freezing at the heat exchanger did occur during the flight which may have resulted in less efficient cooling, but this is not the primary cause of the above-normal temperature.

A study of the metabolic rate associated with a manned orbital flight was conducted in this mission, and the results yielded a metabolic oxygen consumption of 0.0722 pound/hour or 408 standard cubic centimeters (scc) per minute. This level under weightlessness is comparable to that in a normal gravity field with similar work loads and is within the design specification of 500 scc/min for the ECS.

Electrical and Sequential System

The electrical power system for MA–7 was of the same type as that used for MA–6. This system is described more fully on page 21 of reference 1. The MA–7 electrical power system performed satisfactorily during the MA–7 mission.

The sequential system for MA–7 deviated only slightly from that used for MA–6, which is described in detail on page 26 of reference 1. The major change involved the addition of a control barostat in the landing sequence circuit, which is discussed in a previous section. The MA–7 sequential system performed adequately during the mission. The one anomaly that was experienced is discussed subsequently.

Inverters

Temperatures of the inverters were, as in previous flights, above expected values. However, a change in the coolant valve setting by the astronaut later in the flight did decrease the rate of rise in the inverter temperatures.

Squib Fuses

As expected, squib-circuit fuses were found to be blown, including the number 1 retrorocket switch fuse which also had a small hole on the side of the ceramic housing. Postflight testing demonstrated that at the electric current levels experienced in flight, the casing of these fuses could be ruptured and significant quantities of smoke could be produced. It was confirmed by the astronaut during postflight tests, where he observed two similar fuses being blown, that these fuses produce a smoke having the same color and odor as that encountered in flight at the time of retrofire.

Sequential System

The differences between the MA–6 and MA–7 sequential systems included changing of the horizon scanner slaving signal from programed to continuous and locking-in of the ¼-g relay at sustainer engine cutoff to prevent reopening by posigrade thrust.

One sequential system anomaly was indicated in the mission when retrofire was reported to have been delayed about 1 second after the pilot actuated the manual switch to ignite the retrorockets. Figure 1–12 shows schematically the retrosequence circuitry. Since the attitude gyro in pitch indicated that the spacecraft pitch attitude was not within ±12° of the nominal −34°, the attitude-permission circuitry could not pass the retrofire signal from the clock and thus, the automatic clock sequence could not ignite the retrorockets; this lack of permission was proper and indicated that sequential circuitry performance was according to design. After waiting for about 2 seconds, Astronaut Carpenter actuated the manual retrofire switch. He reported that an additional delay of about 1 second occurred before the retrorockets actually ignited, which normally would take place instantaneously. No explanation is available for this additional 1-second delay, since exhaustive postflight testing has failed to reveal any trouble source in the ignition sequence circuitry.

Scientific Experiments

It was planned that a series of research experiments would be conducted by Astronaut Carpenter during the MA–7 mission. This series included a balloon experiment, a zero-gravity study, a number of photographic exercises, a ground flare visibility experiment, and observations of the airglow layer witnessed by Astronaut Glenn. Results of the last experiment are presented in paper 4 and will not be discussed here. Most Mercury experiments were proposed and sponsored by agencies outside the Manned Spacecraft Center. Each was carefully evaluated prior to its approval for inclusion in the flight plan. Sponsoring agencies for the MA–7 experiments are shown in the following table.

Experiment	Sponsoring organization
Balloon	Langley Research Center
Zero-gravity	Lewis Research Center
Ground flare visibility	Manned Spacecraft Center
Horizon definition	MIT Instrumentation Laboratory
Meteorological photography	U.S. Weather Bureau
Airglow layer	Goddard Space Flight Center

Balloon Experiment

The objectives of the balloon experiment were to measure the drag and to provide visibility data regarding an object of known size and shape in orbital space. The balloon was 30 inches in diameter, and was constructed of five equal-sized lunes of selected colors and surface finishes. The sphere was constructed of a plastic and aluminum foil sandwich material, and

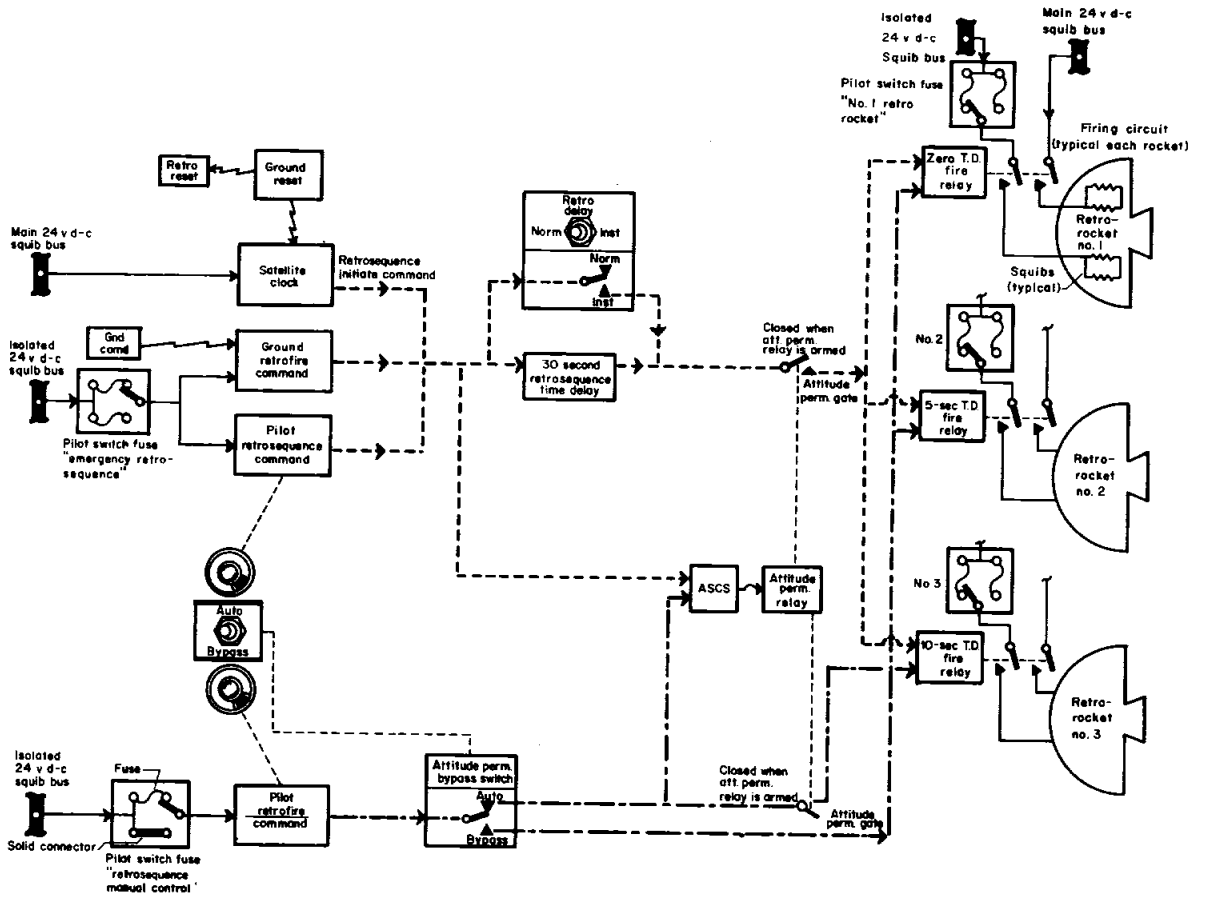

FIGURE 1–12.—Retrosequence schematic diagram.

was to be inflated with a small nitrogen bottle immediately after release from the antenna canister at the end of the first orbital pass. In addition, numerous ¼-inch discs of aluminized plastic were placed in the folds of the balloon and dispersed when the balloon was deployed. As intended, the pilot observed the rate of dispersion and the associated visual effects of the "confetti."

The balloon was deployed at 01:38:00 ground elapsed time, but it failed to inflate properly. The cause has been attributed to a ruptured seam in the skin. Aerodynamic measurements were taken with the strain-gage pickup, but these are of little use since the actual frontal area of the partial inflated balloon is not known. The visibility portion of the experiment was also only partially successful because only two of the surface colors were visible, the orange and aluminum segments. While the balloon was deployed, a series of spacecraft maneuvers evidently fouled the tethering line on the destabilizing flap located on the end of the cylindrical portion of the spacecraft, thus preventing the jettisoning of the balloon. No difficulty was encountered during retrofire and the balloon burned up during reentry.

Zero-Gravity Experiment

The objective of the zero-gravity experiment was to examine the behavior of a liquid of known properties in a weightless state using a particular container configuration. The apparatus consisted of a glass sphere containing a capillary tube which extended from the interior surface to just past the center, as shown in figure 1–13. A liquid mixture representing the viscosity and surface tension of hydrogen peroxide was composed of distilled water, green dye, aerosol solution and silicon, and consumed about 20 percent of the interal volume. The diameter of the sphere was 3⅜ inches. The application of the results of this experiment is primarily in the design of fuel tanks for fu-

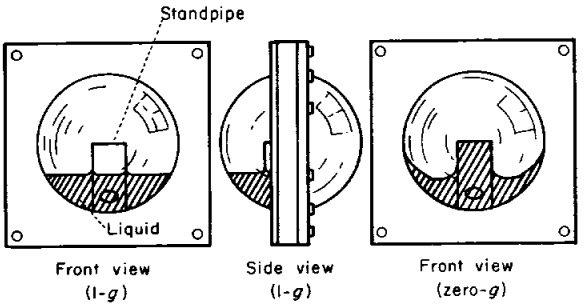

FIGURE 1–13.—Zero-gravity experiment.

ture spacecraft. The surface configuration of the liquid under zero-gravity was expected to assume the position indicated in the final view of figure 1–13. An astronaut report during the third pass over Cape Canaveral (see appendix) and a postflight analysis of the pilot-observer film verified the predicted behavior of the liquid. The results of the experiment showed that the liquid filled the capillary tube during weightless flight and during the low-acceleration portion of reentry.

Ground-Flare-Visibility Experiment

The major objective of the ground-flare-visibility experiment was to determine the capability of the astronaut to acquire and observe a ground-based light of known intensity and to determine the attenuation of this light source through the atmosphere. The earth-based apparatus consisted of ten 1,000,000-candle-power flares located at Woomera, Australia. The pilot was supplied with an extinction photometer with a filter variation from 0.1 neutral density to 3.8 neutral density (99.98-percent light reduction). The flares, with a burning time of about 1½ minutes, were to be ignited approximately 60 seconds apart during passes over this station. The experiment was attempted and failed to yield results because of heavy cloud cover during the first pass. It was therefore discontinued for the remainder of the flight because of continuing cloud cover. This cloud cover, which was also experienced during a similar experiment in MA–6, was approximately eight-tenths at 3,000 feet. The exercise is scheduled to be repeated in a future flight.

Photographic Studies

A series of photographic exercises were planned for the MA–7 flight, but since operational requirements assume priority over scheduled flight activities, some of these studies were not conducted. The Massachusetts Institute of Technology sponsored a study and supplied the necessary equipment to determine horizon definition as applied to the design of navigation and guidance systems. A few mosaic prints were derived from a series of exposures taken of the horizon. The MIT photographic study is discussed, and a sample photograph is shown in the Pilot Performance paper (paper 6).

A meteorological experiment involving a series of special photographs for the U.S. Weather Bureau was not accomplished because of the lack of time.

Astronaut Carpenter exposed an extensive series of general interest color photographs of subjects ranging from terrestrial features and cloud formations to the launch-vehicle tankage and the tethered balloon. Some of these photographs are displayed in the Pilot's Flight Report (paper 7).

Launch Vehicle Performance

The launch vehicle used to accelerate Astronaut Carpenter and his Aurora 7 spacecraft into orbit was an Atlas D missile modified for the Mercury mission. The MA–7 launch vehicle was essentially the same as that used for the MA–6 mission and is described in paper 4 of reference 1.

The differences between the Atlas 107–D (MA–7) and the Atlas 109–D used for MA–6 involved retention of the insulation bulkhead and reduction of the staging time from 131.3 to 130.1 seconds after lift-off. The performance of the launch vehicle was exceptionally good, with the countdown, launch, and insertion conforming very closely to planned conditions. At sustainer engine cutoff (SECO), all spacecraft and launch-vehicle systems were go, and only one anomaly occurred during launch which requires mention.

Although the abort sensing and implementation system (ASIS) performed satisfactorily during the flight, hydraulic switch no. 2 for the sustainer engine actuated to the abort position at 4:25 minutes after lift-off. This switch and the pressure transducer H52P for the sustainer hydraulic accumulator are connected to a common pressure-sensing line as shown in figure 1–14. For an unknown reason this transducer was apparently faulty and showed a gradual

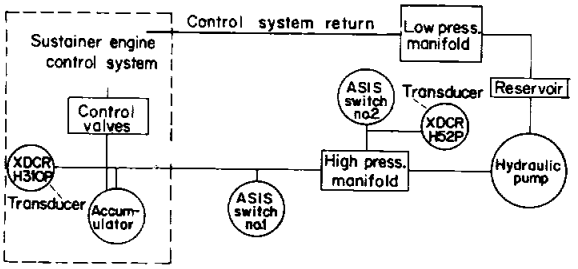

FIGURE 1-14.—Launch-vehicle hydraulic diagram.

decrease in pressure from 2,940 psia to 0 between 190 and 312 seconds after lift-off. Another transducer located in the sustainer control circuit indicated that pressure had remained at proper levels throughout powered flight; therefore, this pressure switch did not actuate until the normal time after SECO. Since both of these switches must be activated to initiate an abort, the signal which would have unnecessarily terminated the flight was not generated.

Reference

1. ANON: *Results of the First U.S. Manned Orbital Space Flight, Feb. 20, 1962.* NASA Manned Spacecraft Center.

2. MERCURY NETWORK PERFORMANCE

By JAMES J. DONEGAN, *Manned Space Flight Support Division, NASA Goddard Space Flight Center; and* JAMES C. JACKSON, *Manned Space Flight Support Division, NASA Goddard Space Flight Center*

Summary

The Mercury Network performed very well in support of the Mercury Atlas–7 mission. All systems required to support the mission were operational at the time of launch and in some instances utilized backup equipment in the place of primary equipment. No problems were encountered with computing and data flow. The computers at the Goddard Space Flight Center accurately predicted the 250 nautical mile overshoot immediately after the FPS–16 tracking data from Point Arguello, California, were received. Radar tracking was generally horizon to horizon, and the resulting data provided to the Goddard computers resulted in good orbit determination during the mission.

The ground communications network performance was generally better than that of the MA–6 mission. The ground-to-spacecraft communications were slightly inferior to MA–6 performance, particularly when patched onto the conference network to allow monitoring by other stations. Telemetry reception, as in the MA–6 flight, was good.

Introduction

The purpose of this paper is twofold. The first is to present a description and the performance during the MA–7 mission of the Mercury Network and its associated equipment. The second is to describe briefly the Mercury real-time computing system of the network and to give a brief account of its performance during the MA–7 mission.

Mercury Network

The Mercury Network configuration for the MA–7 flight shown in figure 2–1, was the same as that for MA–6, with but minor exceptions. For MA–7 there was no Mid-Atlantic Ship, the Indian Ocean Ship was repositioned in the Mozambique Channel as shown in figure 2–1.

The Mercury Network consists of 15 Mercury sites supplemented by several Atlantic Missile Range (AMR) stations, and the Goddard Space Flight Center communications and computing facility. The major functions of this Network during the MA–7 mission were to:

(1) Provide ground radar tracking of the spacecraft and data transmission to the Goddard computers.

(2) Provide launch and orbital computing during the flight with real-time display data transmitted to the Mercury Control Center.

(3) Provide real-time telemetry display data at the sites and summary messages to Mercury Control Center (MCC) for flight control purposes.

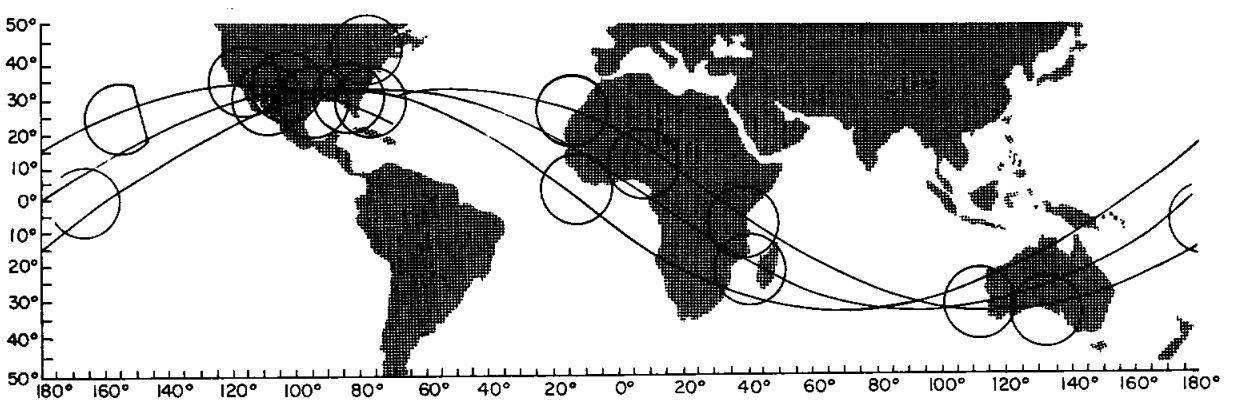

FIGURE 2–1.—Mercury Network configuration for MA–7.

(4) Provide command capability from various stations for astronaut backup of critical spacecraft control functions.

(5) Provide ground-to-spacecraft voice communications and remote station-to-MCC voice and teletype communications.

The major equipment subsystems located at each site are shown in table 2–I. Generally, the overall performance of all major equipment of the Mercury Network during the MA–7 mission was excellent. A brief description of the performance of each specific network subsystem and an introduction to the equipment is presented in the following sections.

Radar Tracking and Acquisition

Two principal types of precision tracking radars are used in the Mercury ground range to track the spacecraft: the AN/FPS–16 and Verlort radars. The AN/FPS–16, shown in figure 2–2, is a precision C–band tracking radar with a 12–foot dish. It operates on a frequency of 5,500 to 5,900 mc and has a beam width of approximately 1.2°. It is the most accurate of our tracking devices. The S–band, or Verlort, radar, shown in figure 2–3, is a very long-range tracking radar with a 10–foot dish. It operates on a frequency of 2,800 to 3,000 mc and has a beam width of approximately 2.5°. The redundancy provided by both of these radar systems supplies the computers with sufficient data to determine the orbit, should one of the spacecraft beacons fail. The active acquisition aid has a quad-helix antenna, which is shown in figure 2–4. It has a broad beam width of 20°, operates on telemetry frequencies (215 to 265 mc), and normally acquires the target first. The acquisition aid console and equipment racks are shown in figure 2–5.

This acquisition capability is most critical at sites with the FPS–16 radar since this radar is a narrow-beam device requiring precise pointing information to locate the target. Once the radar has acquired the spacecraft, the radar

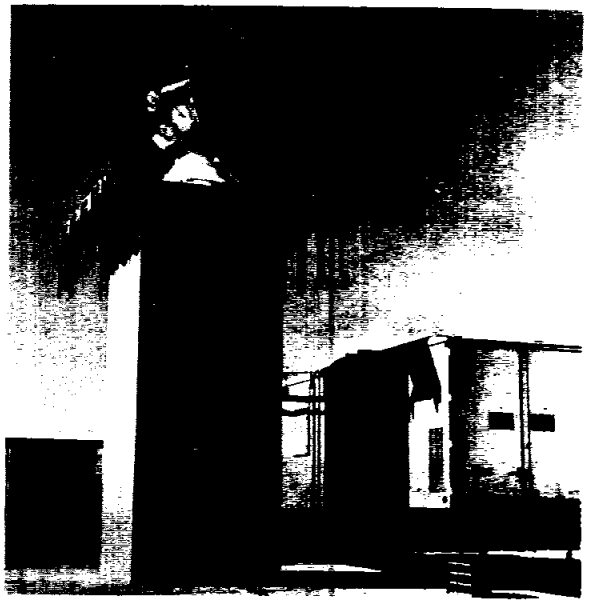

FIGURE 2–3.—Verlort radar installation at Guaymas, Mexico.

FIGURE 2–2.—AN/FPS–16 radar installation at Bermuda.

FIGURE 2–4.—Acquisition aid quad-helix antenna at Bermuda.

TABLE 2-I.—*Ground Communications*

Station	Orbital-pass coverage	Command control	Telemetry reception	Air-ground voice	FPS-16 radar	Verlort radar	Acquisition aid	Computer	Ground Communications		Timing
									Voice	Telemetry	
Mercury Control Center (MCC)	1, 2, and 3	X	X	X			X	B/GE 1P7090	X	X	X
Cape Canaveral (CNV)					X						
Grand Bahama (GBI)[a]	1, 2, and 3	X	X	X	X				X	X	X
Grand Turk (GTI)[a]	1, 2, and 3	X	X	X					X	X	X
Bermuda (BDA)	1, 2, and 3	X	X	X	X	X	X	IBM-709	X	X	X
Grand Canary Island (CYI)	1 and 2		X	X		X	X		X	X	X
Kano, Nigeria (KNO)	1 and 2		X	X			X			X	X
Zanzibar (ZZB)	1 and 2		X	X			X			X	X
Indian Ocean Ship (IOS)	1, 2, and 3		X	X			X			X	X
Muchea, Australia (MUC)	1, 2, and 3	X	X	X		X	X		X	X	X
Woomera, Australia (WOM)	1 and 2		X	X	X		X		X	X	X
Canton Island (CTN)	1 and 2		X	X			X			X	X
Kauai Ialand, Hawaii (HAW)	2 and 3	X	X	X	X	X	X		X	X	X
Point Arguello, Calif. (CAL)	1, 2, and 3	X	X	X	X	X	X		X	X	X
Guaymas, Mex. (GYM)	1, 2, and 3	X	X	X		X	X		X	X	X
White Sands, N.M. (WHS)[b]	1, 2, and 3				X		X		X	X	X
Corpus Christi, Tex. (TEX)	1, 2, and 3		X	X		X	X		X	X	X
Eglin, Florida (EGL)[b]	1, 2, and 3				X	MPQ-31	X		X	X	X
Goddard Space Flight Center (GSFC).								IBM-7090	Comm. Center		

[a] No monitoring facilities; downrange antennas for MCC.
[b] Radar tracking station only.

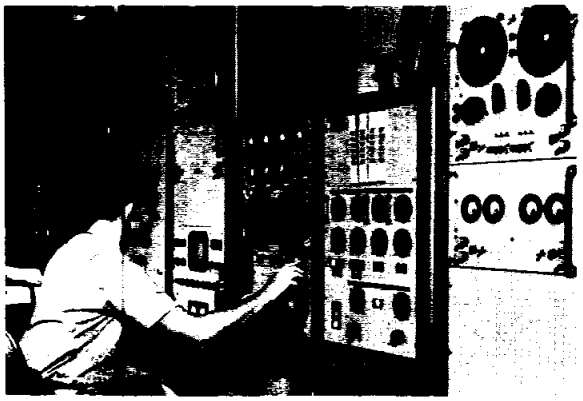

FIGURE 2–5.—Acquisition aid console and equipment racks.

system begins automatic tracking and does not require additional acquisition assistance unless the tracking is interrupted.

The acquisition system performance was very good; the only difficulty encountered was the failure of the elevation drive motor at the Zanzibar station. This failure did not influence the reception of data since the operator was able to operate successfully the antenna elevation in the manual mode. The coverage periods of the acquisition system for the Network are shown in figure 2–6.

A comparison of the radar coverage for MA–6 and MA–7, for both C– and S–band systems, is shown in figure 2–7. From an examination of this figure, it can be ascertained that the acquisition system received signals beyond the meaningful limits of horizon-to-horizon track. The standard errors in range, azimuth, and elevation as a result of noise in the radar data collected by the Goddard computers and the quantity of data received are given in table 2–II for the MA–7 flight. These data reveal that the radar tracking was comparable with the horizon-to-horizon coverage obtained during MA–6.

Tracking was consistent from horizon to horizon. The spacecraft beacons functioned very well during the launch phase and satisfactorily throughout the flight. Some amplitude modulation and slight beacon countdown were noted at times. However, these conditions caused no noticeable deterioration of data presented to the computers. Signal strengths received by the radars were noticeably weaker than in the MA–6 flight. The radar data transmission (via automatic teletype) was excellent with only minor errors in transmission of several lines of data from Muchea, Australia, during the first orbital pass. There was a total of 67,354 characters transmitted by the network radars with no error.

Computing

By way of introduction to the Mercury real-time computing system, a brief description is given. Data from the worldwide Mercury Tracking Network are transmitted to the Goddard Communications Center via the data circuits shown in figure 2–8. From the Communications Center, the data are transmitted to the Goddard Computing Center, shown in figure 2–9, which is located in an adjacent room. Here, real-time equipment places the radar data from each tracking station automatically in the core storage of the computers. Two IBM 7090 computers operating independently but in a parallel fashion process the data. Should a computer malfunction during the mission, the other computer may be switched on-line to sup-

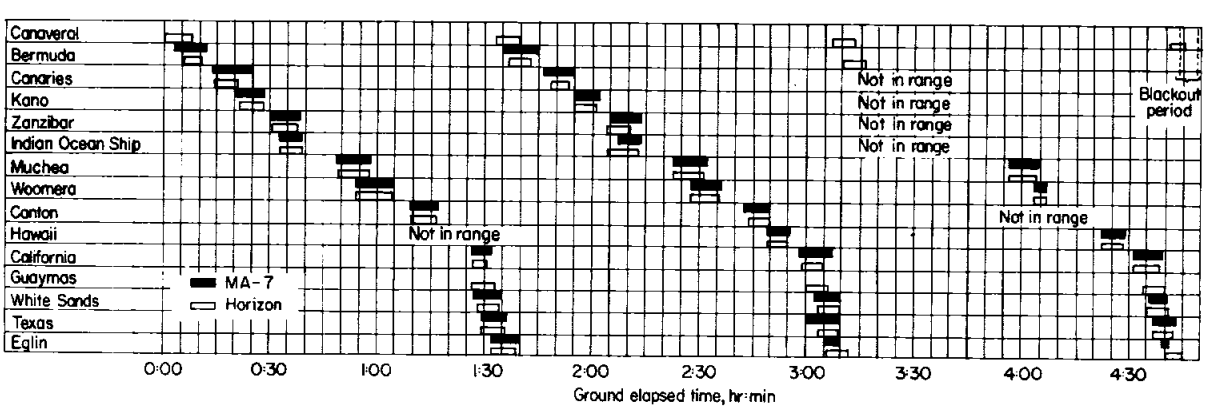

FIGURE 2–6.—Acquisition system coverage.

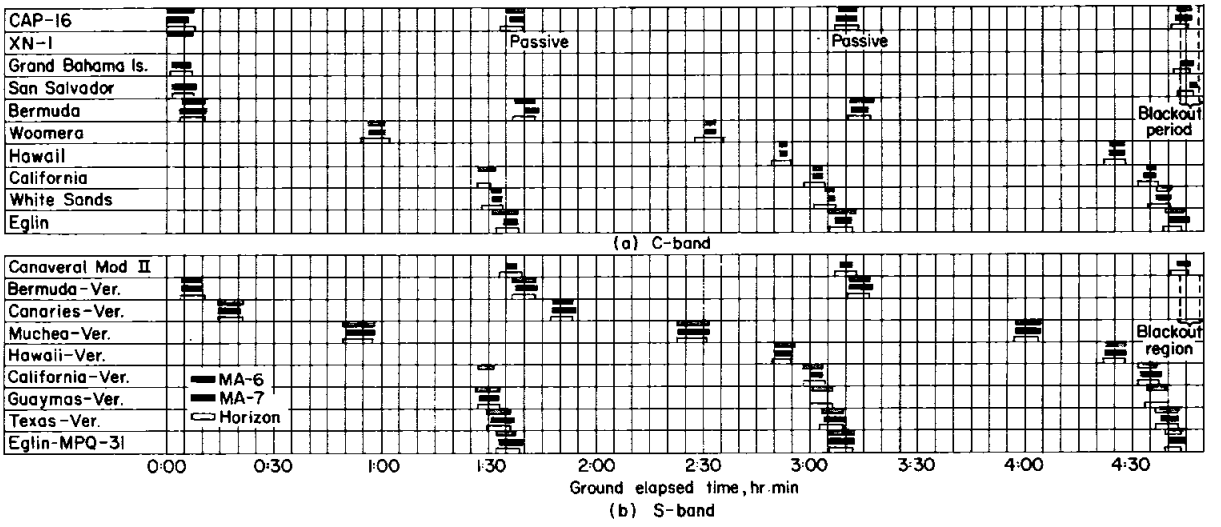

FIGURE 2–7.—Comparison of radar coverage for MA–6 and MA–7.

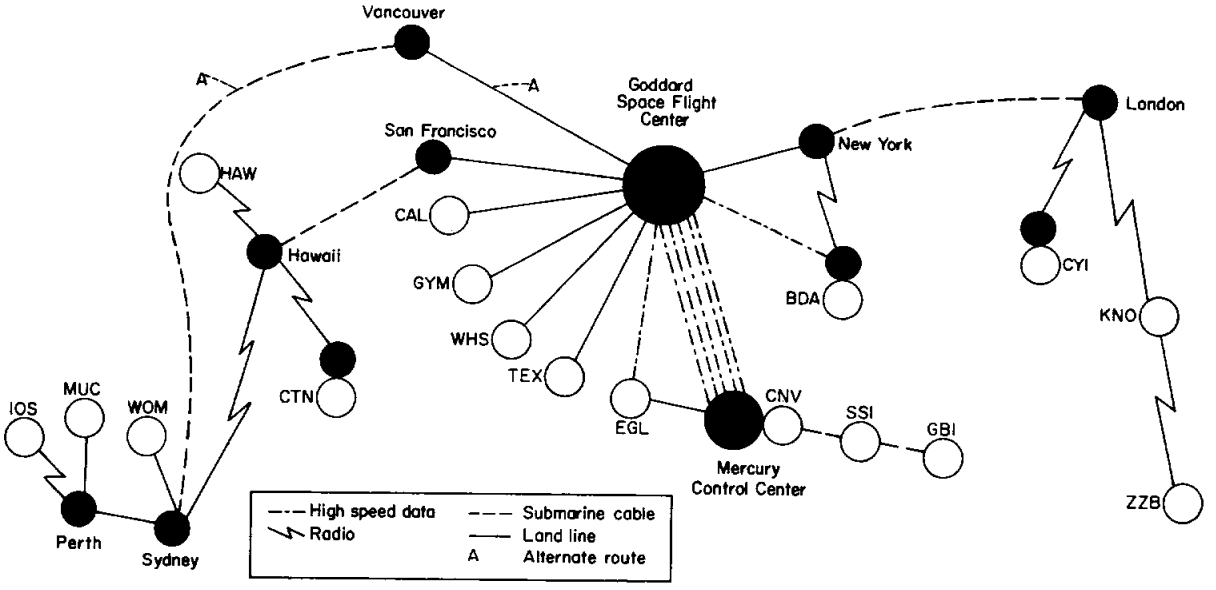

FIGURE 2–8.—Data circuits for Project Mercury.

port the mission while the malfunctioning computer is taken off-line and repaired.

The Mercury computing program is a real-time automatic computing program designed to provide trajectory information necessary to the flight control of the Mercury mission. The heart of the real-time computing system is the monitor system which is shown schematically in figure 2–10. This monitor control system directs the sequence of computer operations in real time. Simply stated, the monitor system accepts data from the remote sites, places the data in the correct block of computer memory, calls on the correct processor (whether it be

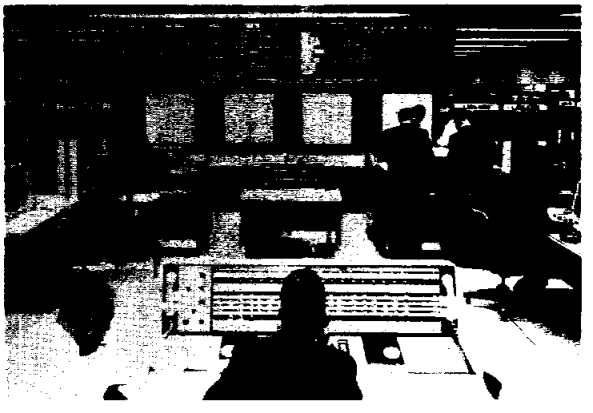

FIGURE 2–9.—Goddard Computing Center.

TABLE 2–II.—*Standard Deviations of MA–7 Low-Speed Radar Data*

Station	Radar	Total points	Standard deviations		
			Range, yards	Azimuth, mils	Elevation, mils
First orbital pass					
Bermuda	FPS–16	74	31. 0	0. 11	0. 54
Bermuda	Verlort	74	62. 8	1. 28	2. 15
Canaries	Verlort	68	18. 5	1. 18	. 67
Muchea	Verlort	84	17. 8	1. 05	1. 15
Woomera	FPS–16	79	4. 5	. 17	. 14
Guaymas	Verlort	52	11. 0	1. 44	1. 58
White Sands	FPS–16	29	4. 9	. 23	. 41
Texas	Verlort	72	31. 9	2. 55	2. 20
Eglin	FPS–16	82	10. 0	. 35	. 24
Eglin	Verlort	81	40. 1	1. 67	1. 78
Cape Canaveral	FPS–16	61	7. 6	. 12	. 56
Second orbital pass					
Bermuda	FPS–16	76	10. 1	0. 16	0. 57
Bermuda	Verlort	71	62. 2	1. 65	2. 71
Canaries	Verlort	61	12. 0	2. 31	1. 80
Muchea	Verlort	82	22. 9	1. 28	1. 34
Woomera	FPS–16	74	2. 5	. 10	. 22
Hawaii	FPS–16	53	5. 4	. 24	. 21
Hawaii	Verlort	52	16. 7	1. 33	1. 23
California	FPS–16	45	10. 1	. 30	. 40
California	Verlort	45	12. 0	1. 42	1. 56
White Sands	FPS–16	38	17. 7	. 14	. 39
Texas	Verlort	70	76. 7	2. 50	2. 44
Eglin	FPS–16	88	7. 0	. 54	. 29
Eglin	FPS–16	89	89. 1	1. 82	2. 53
Cape Canaveral	FPS–16	59	6. 6	. 16	. 73
Third orbital pass					
Bermuda	FPS–16	66	8. 2	0. 30	0. 50
Bermuda	Verlort	66	34. 7	1. 84	2. 09
Muchea	Verlort	64	8. 8	. 74	. 60
Hawaii	FPS–16	62	11. 5	. 19	. 34
Hawaii	Verlort	64	21. 8	1. 83	1. 71
Reentry					
California	FPS–16	61	11. 6	0. 84	0. 66
California	Verlort	61	20. 5	1. 93	1. 64
White Sands	FPS–16	41	21. 7	. 23	1. 14
Texas	Verlort	61	91. 6	2. 37	2. 19
Eglin	Verlort	74	39. 4	1. 17	. 32
Cape Canaveral	FPS–16	20	10. 0	. 14	. 43
San Salvador	FPS–16	14	30. 8	. 21	. 36

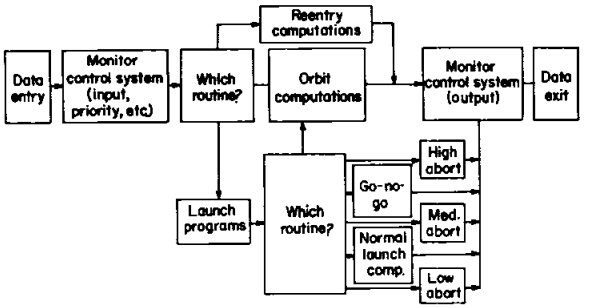

FIGURE 2–10.—Real-time monitor control system.

launch, orbit, or reentry) to perform the proper computation on the data, then provides the required output quantities to be transmitted to the proper destination at the correct time.

During the MA–7 mission the computing system at Goddard performed well. The equipment, the launch subsystem, and the high-speed line functioned properly during the entire mission. Especially gratifying was the performance of the Bermuda high-speed data system and computations which were implemented after the MA–6 mission. The new dual-compilation system also worked well.

Launch.—All the computing and data transmission equipment was operational during the entire countdown. High-speed input data were continuous during the powered phase of the flight from each of the three data sources, the AMR range safety computer, the launch-vehicle guidance computer, and the Bermuda range station. See figure 2–11. The data received from Atlantic Missile Range sources during the launch were excellent. At lift-off FPS–16 data processed through the AMR IP 7090 computer were used as the data source for the Goddard computers for approximately the first 35 seconds of launch. Mark II Azusa data processed by the AMR IP 7090 computer were used for the next 37 seconds as source data for the Goddard computers. The launch-vehicle guidance complex acquired the vehicle in both rate and track at 00:01:02 g.e.t. and was used throughout the powered-flight phase and during the "go-no-go" computation as the selected data source by the Goddard computers. Minor deviations in flight-path angle, for example, 1.2° at booster-engine cutoff, and altitude during powered flight were corrected by steering prior to insertion by the Atlas guidance system. Time of the telemetry discretes observed by Goddard during launch are shown in table 2–III. Insertion conditions computed on the basis of the three independent launch sources of data were in close agreement. The data from all sources during the launch were excellent. From a trajectory point of view it was a nearly perfect launch.

TABLE 2–III.—*Launch Phase Discrete and Telemetry Events*

Event	Time "tag" of arrival at GSFC, sec since lift-off unless indicated	
	General Electric/ Burroughs line	Nominal
Lift-off	7:45:16 e.s.t.	
BECO	128.964	130. 1
Tower release	153.464	152. 2
Tower separation	153.464	142. 0
SECO	310.464	304. 7
Spacecraft separation.	313.964	306. 3
Posigrade 1	317.964	
Posigrade 2	318.464	
Posigrade 3	318.964	
Orbit-phase switch	350.964	

Orbital phase.—As a result of the extremely good insertion conditions provided by the Atlas launch vehicle, the orbit phase was nearly nominal. The orbit was determined accurately and verified early in the first pass. The orbital computation equipment functioned normally and automatically during the mission. A basic parameter which is usually indicative of the performance of the tracking-computing network is the computed time for retrorocket ignition for a landing in the normal mission recovery area. This parameter varied a maximum of 2 seconds from launch throughout the mission after the Bermuda correction. As stated previously, the tracking data were plentiful and accurate during orbit.

Reentry phase.—A retrofire time of 4 hr 32 min 58 sec g.e.t. was recommended by the Goddard computers based on a nominal landing point of 68° W. longitude. The retrofire time actually used was 4 hr 33 min 06 sec g.e.t. based on a more realistic reentry weight because of the actual fuel usage. The retrorockets were fired at approximately 04:33:09 g.e.t. Point Arguello, Calif., tracked the spacecraft during

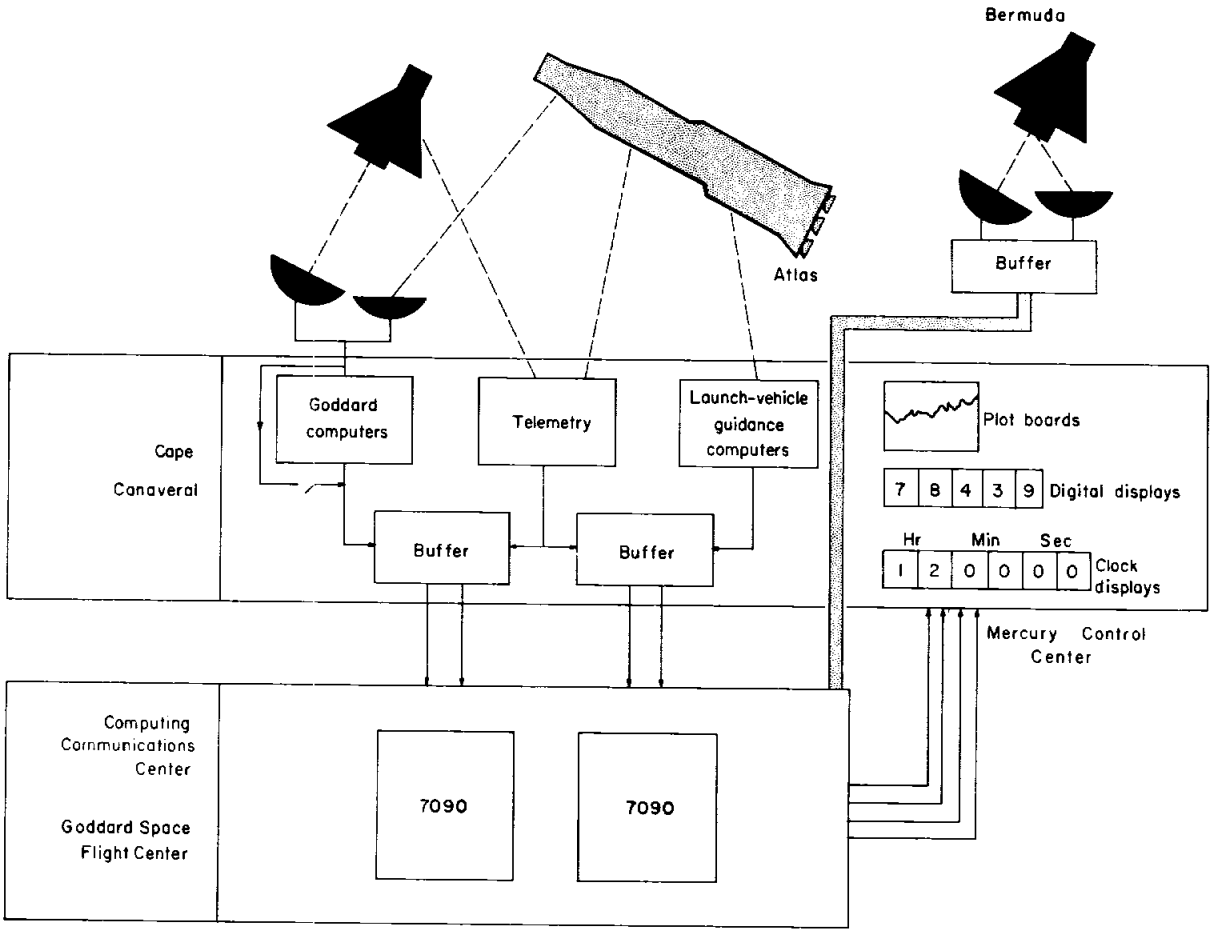

FIGURE 2–11.—Computer data sources during launch.

and after retrofire. Based on the Point Arguello FPS–16 tracking information, the Goddard computers immediately predicted an overshoot of 246 nautical miles. The overshoot point was confirmed by the data from the White Sands and Texas stations and all subsequent tracking data. The position of the spacecraft was continuously and accurately displayed on the wall map of the Mercury Control Center in real time to an altitude of 60,000 feet.

From an analysis of the data, it appears the tracking and computing systems performed their primary tasks normally and without exception. No computer or equipment problems were encountered during the mission.

Telemetry and Timing

The telemetry system provides reception of the aeromedical data for display of astronaut heartbeat rate, respiration, ECG, blood pres-

FIGURE 2–12.—Telemetry antenna installation at Kano, Nigeria.

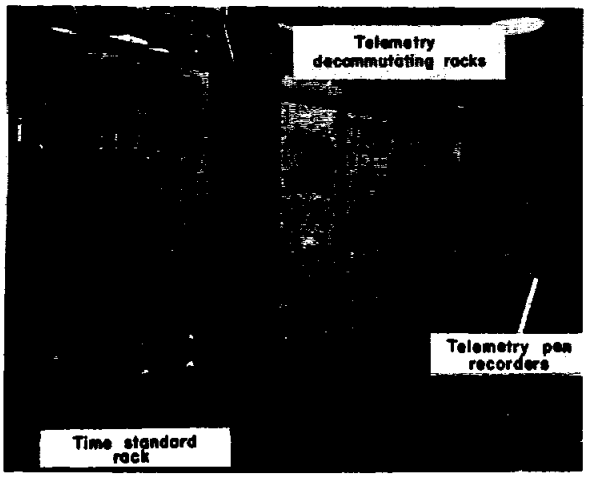

FIGURE 2–13.—Typical telemetry receiving equipment.

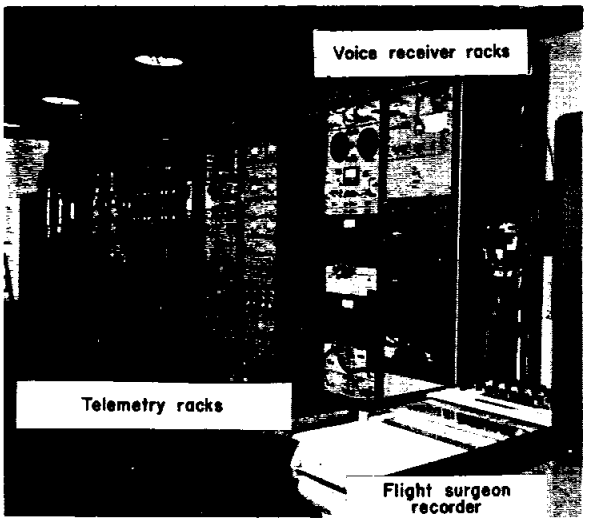

FIGURE 2–13.—Continued.

sure, and body temperature. It also provides the reception and display of data indicative of spacecraft performance for use by the Flight Control team at each tracking station.

A typical telemetry antenna installation is shown in figure 2–12, and the associated electronic receiving and decommutation equipment is shown in figure 2–13. A typical arrangement of display consoles for Flight Control at remote sites is shown in figure 2–14. Although not all spacecraft systems quantities are displayed at the Flight Control consoles, all data received are recorded either on magnetic tape or on direct-writing oscillograph recorders. The timing system provides time marks on all records for later verification and also provides time "tags" with the radar data transmitted to the computers.

In general, all tracking stations received telemetry signals from horizon to horizon. Because the telemetry transmission frequency is severely attenuated by the reentry ionization sheath, a blackout of ground reception results. This effect was recorded for MA–7 as commencing at a ground-elapsed time of 4 hours, 43 minutes and 58 seconds. Signal contact was regained at 4 hr 48 min and 47 sec for approximately 12 seconds at Grand Turk Island. Final loss of telemetry during the landing phase was the result of extreme range and low elevation angle.

A comparison of telemetry reception coverage for each site for MA–6 and MA–7 is given in figure 2–15 and the received signal strengths are given in table 2–IV. The reception periods for each station, identified in figure 2–15, are almost identical to the results shown for the MA–6 mission.

Command

The dual ground command system was installed at specific command sites shown in table 2–I. This system provides ground command backup to critical spacecraft functions such as abort and retrofire. Out of a total of 16 command functions transmitted to the spacecraft, 15 were effectively received. The one exception was a calibration command transmitted from Muchea, Australia, which was attempted when the spacecraft had passed beyond the optimum transmitting time.

As backup means of voice communications from the ground to spacecraft, the ground com-

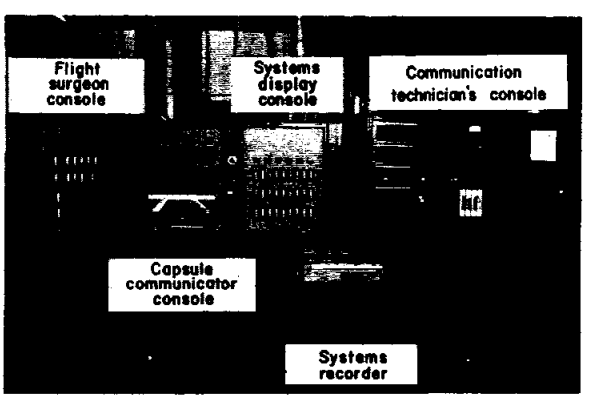

FIGURE 2–14.—Typical display consoles at remote stations.

TABLE 2–IV.—*Telemetry Receiver Signal Strengths*

Station	Estimated mean, microvolts			
	Low (receiver 1, model 1415)	Low (receiver 2, model 1434)	High (receiver 1, model 1415)	High (receiver 2, model 1434)
First orbital pass				
Mercury Control Center				
Bermuda	100	100	100	100
Canaries	90	275	60	80
Kano	90	70	150	70
Zanzibar	37	90	50	40
Indian Ocean Ship	80	70	20	30
Muchea	195	175	195	180
Woomera	300	300	300	250
Canton	100	120	100	150
Hawaii	Not in range			
Guaymas	80	80	75	80
California	30	30	30	30
Texas	300	300	195	300
Second orbital pass				
Mercury Control Center				
Bermuda	150	150	100	110
Canaries	110	170	40	40
Kano	40	30	60	30
Zanzibar	46	46	48	26
Indian Ocean Ship	80	200	50	60
Muchea	195	185	180	165
Woomera	300	190	160	120
Canton	45	45	40	50
Hawaii	100	50	45	40
Guaymas	70	75	60	55
California	80	Not recorded		75
Texas	30	80	30	50
Third orbital pass				
Mercury Control Center				
Bermuda	60	60	40	40
Canaries	Too low to estimate			
Kano	Not in range			
Zanzibar	Not in range			
Indian Ocean Ship	120	200	65	90
Muchea	135	100	150	95
Woomera	60	60	64	59
Canton	Not in range			
Hawaii	200	100	100	200
Guaymas	70	70	50	60
California	Not recorded	100	80	80
Texas	200	300	50	325

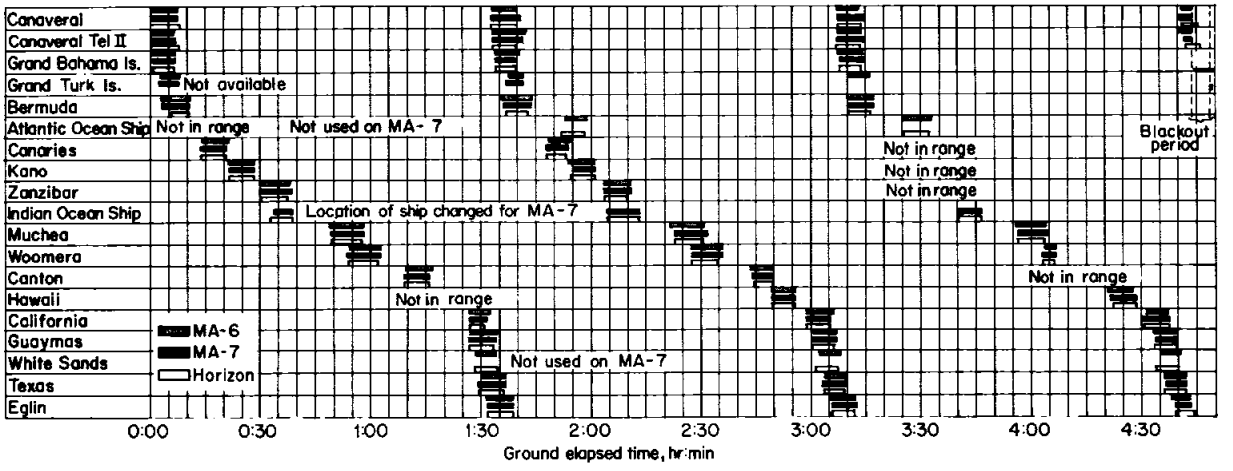

FIGURE 2–15.—Comparison of telemetry coverage times for MA–6 and MA–7.

mand system employs a voice modulator which may be utilized in the event both the HF and UHF voice systems are inoperative. This back-up technique was tested successfully during the first orbital pass over Muchea, Australia.

Standby systems were called upon to maintain command coverage at two stations. Minor trouble was experienced at the California station during the first orbital pass when a fuse opened in the primary system, and the transmitter in the primary command system at Guaymas failed during the third pass. In both cases the standby system functioned satisfactorily. The command system operated normally in spite of several minor malfunctions and had no effect on the mission.

Communications

The communications facilities for the Mercury Network consist of:

(1) Teletype between all remote stations and the Mercury Control Center through the Goddard Space Flight Center.

(2) Direct-line telephone communications between selected stations and Mercury Control Center.

(3) HF and UHF communications from all stations except Eglin, Fla., and White Sands, N. Mex., to the spacecraft.

The teletype circuits are utilized for flight-control message traffic and radar data from radar tracking stations to the Goddard computers. This sharing of circuits restricts all but priority messages from a station during the radar tracking period.

The voice communications circuits between the Mercury Control Center and selected remote stations provide a direct and rapid means of information transfer between the Flight Control personnel at these locations.

The HF and UHF receiving and transmitting equipment permits direct and successive voice contact during the flight between the astronaut and the Flight Control team over each station. A patching arrangement permits all stations which have ground voice communications to the Control Center to monitor all ground-to-spacecraft communications during the flight.

Teletype and ground voice.—All regular, part-time, and alternate circuits were active and operative on launch day. The propagation prediction was for good conditions for those teletype circuits which utilize radio links to reach certain stations. The teletype network performed well with only three difficulties occurring:

(1) The teletype circuit between Goddard and Guaymas was open for a 7-minute period beginning at 00:36 g.e.t. The spacecraft was not over Guaymas at the time, and retransmission assured message continuity.

(2) The Australian cable gave trouble for a short period at 01:00 g.e.t., which resulted in loss of four lines of Woomera radar data.

(3) Teletype traffic to the Indian Ocean Ship was interrupted for about 6 minutes due to propagation; however, the interrup-

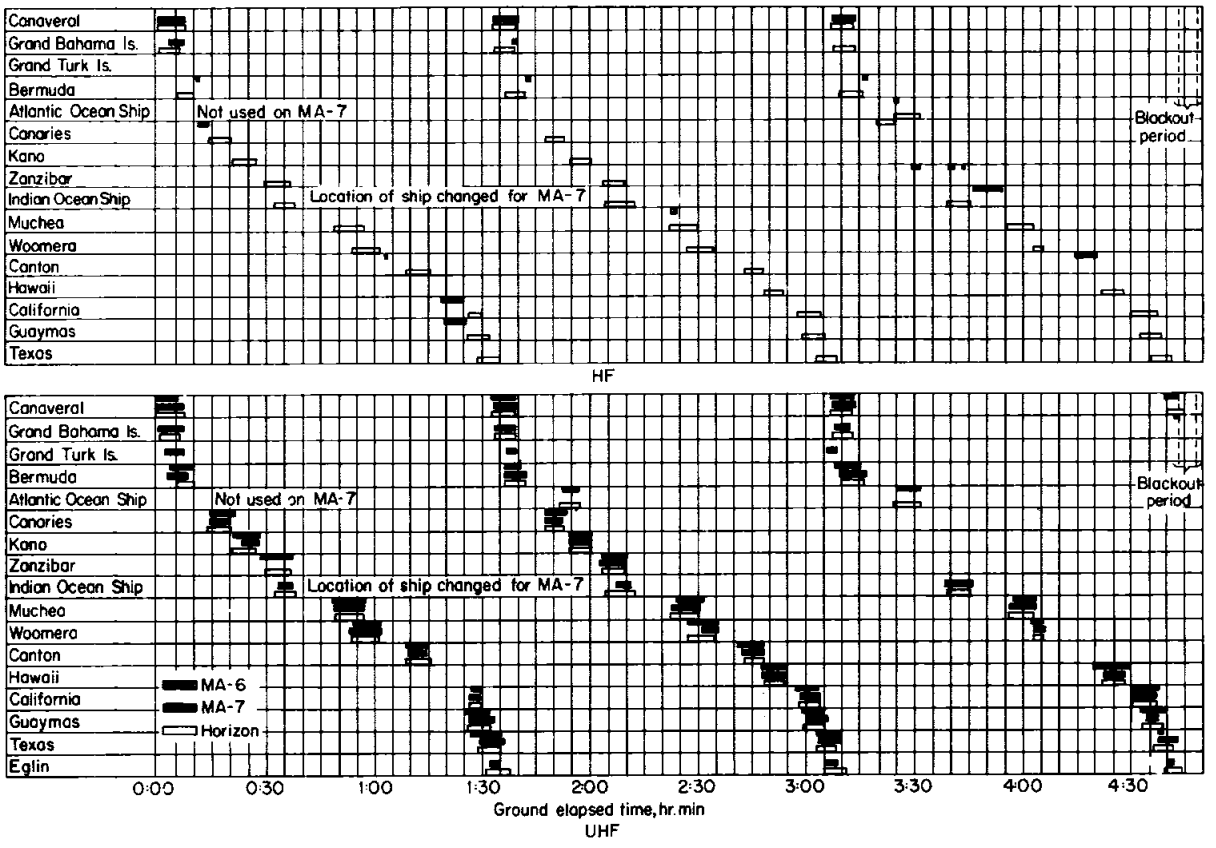

FIGURE 2–16.—HF and UHF coverage for MA–6 and MA–7.

tion occurred at a time when the spacecraft was approaching the west coast of the United States and did not interrupt critical traffic.

HF and UHF voice.—The quality of the ground-to-spacecraft communications was acceptable throughout the mission; however, it was not as good as that for the MA–6 mission. A study of the character of the average signal strength at the ground systems reveals that the majority of the stations reported a lower signal level for MA–7 than was experienced during MA–6. In some of these cases the signal level was 2 to 5 times greater for the earlier mission.

It was noted that when the ground-to-spacecraft circuit was patched to the between-stations voice conference, the quality was not as good as the MA–6 mission. This effect is being investigated by studying the recordings made at various locations on the circuits. The generally weaker signal strength may account for part of this problem. Figure 2–16 shows the HF and UHF coverage for both the MA–6 and MA–7 missions.

3. MISSION OPERATIONS

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Summary

A discussion of the detailed operational support provided during the MA–7 mission, including prelaunch, launch, flight, and recovery phases, is presented. Since the launch vehicle countdown and prelaunch phase was nearly identical to that for MA–6, this activity is given only minor emphasis. The launch phase proceeded almost perfectly, with only a last-minute hold for weather. Powered flight was normal, and the Mercury spacecraft was inserted into a nominal orbit with exceptional precision. The flight was satisfactorily monitored by the ground stations of the Mercury Network, and their activities are presented chronologically. No major flight discrepancies were evident during the orbital phase until just prior to retrofire, when it was discovered that the automatic control system was not operating properly. The astronaut was instructed by ground personnel to effect a manual retrofire maneuver. Radar tracking data subsequent to this maneuver indicated that the spacecraft would land 250 nautical miles downrange of the planned landing point. Following contingency recovery procedures, the astronaut was recovered by helicopter some 3 hours after landing, and the spacecraft was retrieved by a recovery destroyer approximately 3 hours later.

Introduction

In the present paper, the flight control and recovery operations for the MA–7 mission will be discussed in detail. Since the launch support procedure was discussed in the MA–6 flight report (ref. 1), it will be only discussed briefly. Some small changes from the MA–6 operational support were made, most of which were associated with the development of appropriate support procedures for the future missions of longer duration. Network support is discussed in detail in paper 2. Based on previous experience, it was found that the total recovery support used for MA–6 could be slightly reduced for MA–7. The flight plan was basically the same as that for the MA–6 mission with two significant differences: the astronaut was given a greater amount of manual-control tasks to perform; and a large number of experiments were to be accomplished.

Prelaunch Activities

During the prelaunch period, four flight controller network exercises were performed. A new network countdown was used, and a high degree of confidence was established in the countdown format during this time. These drills were very similar in content to those performed for the MA–6 mission. Flight Controllers quickly obtained a high degree of confidence in various site and network procedures and reached a high level of performance very early in the schedule. They maintained this performance level throughout all the network simulations and during the actual MA–7 flight. The countdown for launching the Mercury-Atlas vehicle is conducted in two parts. The first part is conducted on the day before the launch and lasts approximately 4½ hours. This part of the countdown was conducted with no major problems or delays. The second part of the countdown was probably as close to perfect for the launch vehicle, spacecraft, and network as could ever be expected. There were some minor problems throughout the network; however, none of these resulted in the necessity for a hold, and the coordination between the various agencies involved was excellent. A hold of about 45 minutes occurred at T–11 minutes

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in anticipation of better camera coverage and to allow aircraft to check the atmospheric refraction index in the vicinity of Cape Canaveral for the launch-vehicle guidance equipment.

Powered Flight Phase

The launch occurred at 07:45:16 a.m. e.s.t. on May 24, 1962. Sustainer engine cutoff occurred at 5 minutes 10 seconds ground elapsed time (g.e.t.). The "go" capability as indicated by the Goddard Space Flight Center computers was obtained and transmitted to the astronaut at 5 minutes 32 seconds. The powered portion of flight was completely normal, and the astronaut was able to make all of the planned communications and observations throughout this period. The Mercury Control Center go-no-go decision at cutoff was made rapidly, and there was no doubt that conditions very close to nominal had been achieved. Table 3–I presents the actual cutoff conditions that were obtained. A comparison of the planned and actual times at which the major events occurred are given in table 3–II.

TABLE 3–I.—*Actual Flight Conditions*

Cutoff conditions:	
Altitude, ft	527,859
Velocity, ft/sec	25,717
Flight-path angle, deg	−0.0004
Orbit parameters:	
Perigee altitude, nautical miles	86.87
Apogee altitude, nautical miles	144.96
Period, min:sec	88:32
Inclination angle, deg	32.55
Maximum conditions:	
Exit acceleration, g units	7.8
Exit dynamic pressure,[a] lb/sq ft	967
Entry acceleration, g units	7.5
Entry dynamic pressure, lb/sq ft	429

[a] Based on the atmosphere at Cape Canaveral.

TABLE 3–II.—*Sequence of Events During MA–7 Flight*

Event	Preflight predicted time, hr:min:sec	Actual time, hr:min:sec
Booster-engine cutoff (BECO)	00:02:10.1	00:02:08.6
Tower release	00:02:32.2	00:02:32.2
Escape rocket firing	00:02:32.2	00:02:32.2
Sustainer-engine cutoff (SECO)		00:05:09.9
Tail-off complete	00:05:05.3	00:05:10.2
Spacecraft separation	00:05:06.3	00:05:12.2
Retrofire sequence initiation	04:32:25.6	04:32:36.5
Retro (left) No. 1	04:32:55.6	04:33:10.3
Retro (bottom) No. 2	04:33:00.6	04:33:15.3
Retro (right) No. 3	04:33:05.6	04:33:20.5
Retro assembly jettison	04:33:55.6	04:34:10.8
0.05 g relay	04:43:55.6	04:44:44
Drogue parachute deployment	04:50:00.6	04:50:54
Main parachute deployment	04:50:37.6	04:51:48.2
Water impact	04:55:22.6	04:55:57
Main parachute jettison	04:55:22.6	04:56:04.8

Orbital Flight Phase

After separation of the spacecraft from the launch vehicle, the astronaut was given all pertinent data involved with orbit parameters and the necessary retrofire times were transmitted. A remoting facility for transmitting air-to-ground voice for the Mercury Control Center through the Bermuda site transmitters was implemented for the MA–7 mission. This facility enabled the Mercury Control Center Capsule Communicator (Cap Com) to transmit spacecraft systems data and orbital information to the astronaut in real time; therefore, much of the requirement for relaying information between the Canaveral and Bermuda Flight Controllers was eliminated. From the summary messages received from the African sites, it became readily apparent that the suit cooling system was not correctly adjusted and that the astronaut was uncomfortable. However, the

suit temperature began to decrease when the astronaut increased the water flow in the suit cooling circuit. By the end of the first orbit it had reduced to a satisfactory value. Other than the slight discomfort due to the high suit temperature, the astronaut was obviously in good condition and performing satisfactorily throughout the first orbit. The Canary Island site transmitted radar data to the Goddard computers, and these data confirmed the orbital insertion parameters and an extremely good orital definition was obtained. Over the Woomera station, the astronaut reported that he took four swallows of water and that his bite-sized food tablets had crumbled in the container and some particles of food were floating free in the cabin. He was able to eat some of the crumbled food.

Toward the end of this pass, a slight increase in body temperature was noted. The Canton Island site then reported a body temperature of 102°. However, the Mercury Control Center surgeon felt such a rapid increase was not probable and that the transducer had either failed or had been affected by the telemetry calibrate command transmitted from the Muchea site. The only other problem was the large amount of automatic control system fuel being used by the astronaut during the first orbit. He was cautioned against further excessive usage of this fuel during the orbital pass over the United States. The air-to-ground transmissions relayed via the Goddard voice loop during the first orbit were of good quality and provided the Mercury Control Center with information available from the air-ground voice communications of the astronaut. The network air-ground voice quality, although not as good as the previous MA–6 mission, continued to be usable throughout the remaining orbits and provided one of the best tools for maintaining surveillance of the flight. The spacecraft clock performed satisfactorily throughout the entire mission. The initial clock error of −1 second remained constant throughout the mission and was compensated for in the retrosequence settings that were transmitted to the astronaut. During the first orbit, the network radar systems were able to obtain excellent tracking data and these data, together with the data obtained at cutoff, provided very adequate information on the spacecraft position and orbit. As an example, the retrosequence time computed at insertion was changed only 11 seconds by the Bermuda data, and thereafter, the time varied within only ±1 second throughout the mission. The balloon was deployed during contact with Cape Canaveral 1 hour 38 minutes after lift-off. During the first portion of the second orbit, the suit temperature indicated a rise from 70° at Cape Canaveral to approximately 90° during contact with the Indian Ocean Ship, but again showed a decrease in trend before acquisition by the Muchea and Woomera stations. It was obvious throughout the flight that the pilot was having difficulty in achieving the proper water-flow setting for the suit cooling system. There is about a 30-minute lag in the cooling system in response to a change in the valve setting and as a result it was difficult to determine an adequate setting. However, when the loss of signal (LOS) occurred at Woomera, the suit temperature had decreased to approximately 82° and during the remaining one and one-half orbits the suit temperature indicated a steady decrease to a value between 64° and 67°. Cabin-air-temperature readings were slightly higher with the MA–6 flight. A maximum temperature of 108° was monitored by the Hawaii station near the end of the second orbit. This temperature decreased and tended to stabilize at about 100° during the remainder of this orbit and the first portion of the third orbit.

Over the Woomera site, the astronaut reported that he could temporarily change the spacecraft attitude by moving his arms and body. The mission continued normally throughout the remainder of the second orbit. The astronaut was behind the flight-plan schedule by several items, and it was noted at California acquisition that the astronaut had used rather large amounts of manual fuel and was down to approximately 42 percent as he began the third orbit. The low automatic and manual fuel quantities caused considerable concern on the ground and resulted in a further request to the astronaut to conserve his fuel in both the automatic and manual systems. Site evaluation of telemetry recordings during the first and second orbits indicated considerable high thruster activity. These indications generally occurred while the astronaut was in the fly-by-wire mode, and it appeared that he was employ-

ing high thrusters excessively during attitude changes.

Throughout the flight, the astronaut made a number of voice reports regarding visual observations and discussed various experiments carried out in the flight. These reports are explained in more detail in paper 7.

The Mercury Control Center made a go decision for the beginning of the third orbit at 2 hours 55 minutes g.e.t. The astronaut was cautioned to conserve his fuel and it was suggested that he increase his water flow to the inverter cold plates. The inverters had indicated an increase in temperature similar to the previous MA–6 flight. This caused no major concern; however, the increased water flow reduced the rate of this temperature increase to an acceptable level. As a result of the request to conserve fuel, the astronaut entered a period of drifting flight at 3 hours 9 minutes g.e.t. while he was in contact with Cape Canaveral. Over Mercury Control Center during the third orbit, 45 percent of the fuel in the automatic system and 42 percent of the fuel in the manual system remained. Over the Indian Ocean Ship, the astronaut attempted to jettison the balloon manually and reported that he was unable to accomplish this although the switch was cycled several times.

During the third orbit, all systems appeared to be normal. The clock was reset to 04:32:34, the retrofire time for the end of the third orbit, by the astronaut while in contact with the Muchea station.

Reentry Phase

Upon contact with Hawaii at the end of the third orbit, the astronaut was instructed to begin his preretrosequence check list and to revert from his present manual control mode to the automatic mode in preparation for retrosequence. The retrosequence check list was started but when the astronaut returned to automatic control, he reported having trouble with this system and, as a result, was unable to complete the list. The capsule communicator at Hawaii continued transmitting the remainder of the preretrosequence check list after loss of telemetry contact, and most of the transmission was received by the astronaut. However, the ground was unable to confirm that it had been received because of the limited UHF range of the spacecraft.

From both astronaut reports and telemetry readouts during the periods in which the astronaut was using automatic control over remote sites during the mission, it appeared that no major difficulty was experienced while using this system. The astronaut reported the automatic stabilization and control system (ASCS) to be performing satisfactorily on several occasions. Although some differences between horizon scanner outputs and spacecraft attitudes had been noted, they were not considered to be any reason for concern because of the control configuration at the time. Therefore, the failure of the ASCS system to maintain proper attitudes when engaged by the astronaut over Hawaii was unexpected. When voice communications were established with the California station, the astronaut continued to have problems on ASCS and, with advice from the capsule communicator, elected to perform the retrofire maneuver using manual control. During this period the astronaut used a combination of window reference, periscope, and attitude displays.

The astronaut was directed to initiate retrofire manually and to bypass the attitude permission circuit. The coundown was transmitted from California, but it was apparent that the retrofire had taken place several seconds late. Initial reports from the astronaut indicated that the attitudes had been held fairly well during retrofire. The California station reported that the velocity change indicated by the integrating accelerometer was normal. The radar data from California indicated an overshoot but the indication was suspected to be in error because of previous reports. However, as additional radar data became available from other sites, it was obvious that the California radar data were correct and that the landing point would be approximately 250 nautical miles beyond the planned position. Because of the small amount of automatic fuel remaining following retrofire and the complete depletion of manual fuel, the astronaut was instructed to use as little fuel as possible in returning the spacecraft to reentry attitude and to conserve the fuel for use during reentry. He was also instructed to use the ASCS auxiliary damping

mode during the atmospheric reentry portion of the flight.

Upon contact with Cape Canaveral just previous to the loss of communications as a result of ionization blackout, the astronaut was queried as to his face-plate position. He indicated that it was still open, and proceeded to close it. The communication blackout occurred about 40 seconds late, an occurrence which lent further evidence to the longer reentry range predicted by the radar. The astronaut was told that his landing point would be long and would occur at approximately 19°23′ N., 63°51′ W. From this point no voice communications were received from the astronaut; however a brief period of telemetry data was obtained after blackout. A number of communications were attempted with the command voice system and the normal UHF and HF voice system on the chance that he might receive this information. All operating C-band radars at Cape Canaveral and San Salvador tracked the C-band beacon until the spacecraft went below the local horizon indicating that the spacecraft had reentered satisfactorily, and these radar data continued to predict approximately the same landing point.

Recovery Operations

The operation of recovery forces for this mission was very similar to that for the MA–6 mission. Planned landing areas were established in the Atlantic as shown in figure 3–1 to cover aborts during powered flight and landing at the end of each orbital pass. The disposition of

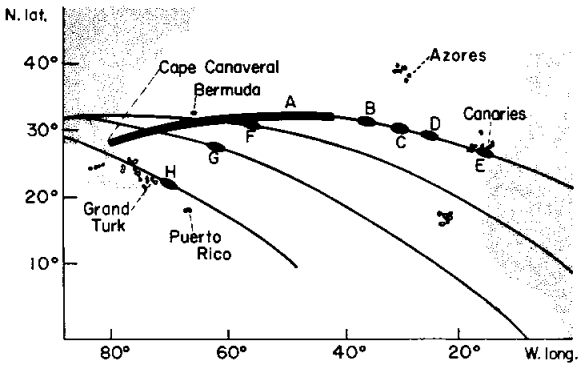

FIGURE 3–1.—Planned landing areas.

the recovery forces in the planned landing areas is shown in table 3–III. Area H is the planned landing area for the end of the third orbit, and recovery in this area could be effected within 3 hours of landing. Special aircraft were predeployed on a standby basis to locate the spacecraft and render pararescue assistance within 18 hours of landing at any point along the ground track.

During the entire mission, all recovery forces were informed of the flight progress by the Recovery Control Center. Shortly after the astronaut began the third pass, an Air Rescue Service SC–54 aircraft with a specially trained pararescue team aboard was dispatched as a precautionary measure from Roosevelt Roads, Puerto Rico, and assigned a position at the downrange end of landing area H. As soon as the calculated landing position was established about 250 nautical miles downrange of the center of area H, all units in area H were instructed

TABLE 3–III.—*Disposition of Recovery Forces in Planned Landing Areas*

Area	Search aircraft	Search and rescue aircraft	Helicopters	Ships	Maximum recovery time, hr
A[a]	4	2	0	9	3 to 6
B	1	0	0	1	6
C	1	0	0	1	3
D	1	0	0	1	6
E	1	0	0	1	6
F	0	0	3	2	3
G	1	0	3	2	3
H	2	1[b]	3	3	3
Total	11	3	9	20	----------

[a] Launch site recovery forces consisted of 3 helicopters, several amphibious vehicles, and small boats.
[b] Launched as a precautionary measure when the astronaut began the third orbital pass.

TABLE 3–IV.—*Chronological Summary of Post-Landing Events*

e.s.t., hr: min	Elapsed time from landing, hr: min	Event
11:18 a.m.	----------	As a precautionary measure, Air Rescue Service SC–54 was launched from Roosevelt Roads, Puerto Rico, to take station on downrange end of Area H. The SC–54 had specially trained pararescue team aboard.
12:22 p.m.	----------	Retrorockets were ignited.
12:33 p.m.	----------	Calculated landing position was reported as being 19°24′ N. latitude, 63°53′ W. longitude. Air Rescue Service SA–16 (amphibian) was launched and instructed to proceed to this point.
12:35 p.m.	----------	All units in area H were proceeding to calculated landing position.
12:41 p.m.	00:00	Spacecraft landed.
12:44 p.m.	00:03	Contingency recovery situation was established at Recovery Control Center. Recovery commander in area H (embarked on U.S.S. *Intrepid*) was designated mission coordinator. Positions of vessels in vicinity of landing point were requested from Coast Guard and other Naval commands (see fig. 3–2).
12:47 p.m.	00:06	Search aircraft reported possible UHF/DF contact with spacecraft at 04:54 g.e.t.
12:58 p.m.	00:17	Destroyer U.S.S. *Farragut* was proceeding to calculated landing position.
12:59 p.m.	00:18	All search aircraft were executing search plan. Had positive UHF/DF contact with spacecraft.
1:20 p.m.	00:39	Search aircraft reported visual contact with green dye at 19°29′ N. 64°05′ W. (Spacecraft employs flourescein sea-marker.)
1:21 p.m.	00:40	Search aircraft reported astronaut in liferaft attached to spacecraft.
1:27 p.m.	00:46	Search aircraft reported that astronaut appeared to be comfortable.
1:34 p.m.	00:53	The SC–54 descended to deploy pararescue team and auxiliary flotation collar.
1:40 p.m.	00:59	Pararescue team was deployed.
1:40 p.m.	00:59	Two HSS–2 helicopters were launched from U.S.S. *Intrepid* with Mercury Project doctor and specially equipped swimmers aboard.
1:50 p.m.	01:09	The SA–16 arrived on-scene.
1:56 p.m.	01:15	The SA–16 descended to evaluate sea-state condition for possible landing.
2:15 p.m.	01:34	The SA–16 reported sea condition satisfactory for landing and take-off.
2:21 p.m.	01:40	Astronaut appeared normal, and waved to aircraft. Pararescue team was in water. Helicopters were enroute to spacecraft. The SA–16 was instructed not to land unless helicopter retrieval could not be made.
2:39 p.m.	01:58	Auxiliary flotation collar was attached to spacecraft and inflated.
2:52 p.m.	02:11	Astronaut and pararescue team were in water. There was no direct communication with astronaut. Astronaut appeared to be in good condition.
3:30 p.m.	02:49	Helicopter arrived over spacecraft.
3:40 p.m.	02:59	Astronaut was in helicopter. Doctor reported astronaut in good condition.
3:42 p.m.	03:01	Helicopter retrieved pararescue team. Astronaut Carpenter reported, "Feel fine." Destroyer U.S.S. *Farragut* was 18 miles from spacecraft.
4:05 p.m.	03:24	Helicopters returned to the U.S.S. *Intrepid* accompanied by SA–16 and search aircraft.
4:20 p.m.	03:39	U.S.S. *Farragut* had spacecraft in sight.
4:52 p.m.	04:11	Astronaut arrived aboard U.S.S. *Intrepid.*
6:16 p.m.	05:35	U.S.S. *John R. Pierce* had U.S.S. *Farragut* in sight.
6:52 p.m.	06:11	U.S.S. *Pierce* had spacecraft onboard.
7:15 p.m.	06:34	Initial medical examination and debriefing of astronaut was completed onboard U.S.S. *Intrepid.* Astronaut departed for Grand Turk Island.

to proceed to this point. (See table 3–IV for a chronological summary of post-landing events.) An Air Rescue Service SA–16 amphibian aircraft was also dispatched from Roosevelt Roads and instructed to proceed directly to the calculated landing position.

Since the landing was outside of a planned landing area, recovery procedures set up for such an eventuality were followed in the Recovery Control Center. The recovery commander in area H aboard the aircraft carrier, U.S.S. *Intrepid*, was designated as mission coordinator. Various United States Naval Commands and the Coast Guard were interrogated as to the location of merchant and naval ships, other than those assigned to recovery forces, to establish their availability for possible assistance in the recovery operations. The location of units available to assist in recovery operations at the time of spacecraft landing is shown in figure 3–2.

Search aircraft from area H quickly obtained a bearing on the spacecraft UHF/DF electronic location aids and proceeded to establish visual contact with the spacecraft about 40 minutes after landing. The astronaut was reported as seated comfortably in his liferaft beside the floating spacecraft. The SC–54 aircraft arrived shortly thereafter and deployed the pararescue team with a spacecraft auxiliary flotation collar and other survival equipment to render any necessary assistance to the astronaut and to provide for the continued flotation of the spacecraft. A photograph of the spacecraft in the flotation collar is presented in figure 3–3.

Information received from the Coast Guard and Navy indicated a Coast Guard cutter at Saint Thomas, Virgin Islands; a destroyer, the U.S.S. *Farragut*, located about 90 nautical miles

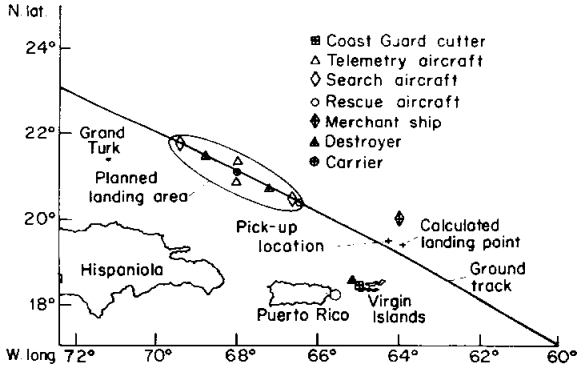

FIGURE 3–2.—Landing area details.

FIGURE 3–3.—Spacecraft in flotation collar.

southwest of the calculated landing position; and a merchant ship located about 31 nautical miles north of the calculated landing position. It was determined that the *Farragut* could arrive at the spacecraft first, and it was directed to proceed at best speed. Two twin-turbine HSS–2 helicopters were launched from the carrier *Intrepid* to retrieve the astronaut. The first helicopter carried a doctor from the special Mercury medical team assigned to the *Intrepid* for postflight examination and debriefing of the astronaut. The recovery helicopters also contained two specially trained divers equipped with a second spacecraft auxiliary flotation collar. The SA–16 then arrived at the spacecraft and prepared for landing in the event such action would be required before the arrival of the helicopters. Although the landing point was outside the planned landing area, the astronaut was retrieved by helicopter, as shown in figure 3–4, in slightly less than 3 hours after landing.

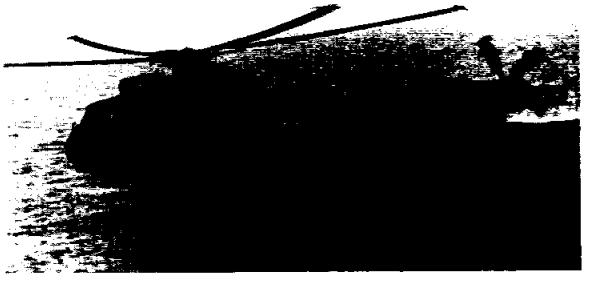

FIGURE 3–4.—Astronaut being retrieved by helicopter.

He was returned to the U.S.S. *Intrepid* for medical examination and debriefing and was later flown to Grand Turk Island.

The destroyer U.S.S. *Farragut* arrived at the spacecraft and kept it under close surveillance until the destroyer, U.S.S. *John R. Pierce*, arrived with special retrieval equipment to make the pickup as shown in figure 3–5. The spacecraft was delivered to Roosevelt Roads by the destroyer, with a subsequent return to Cape Canaveral by airplane.

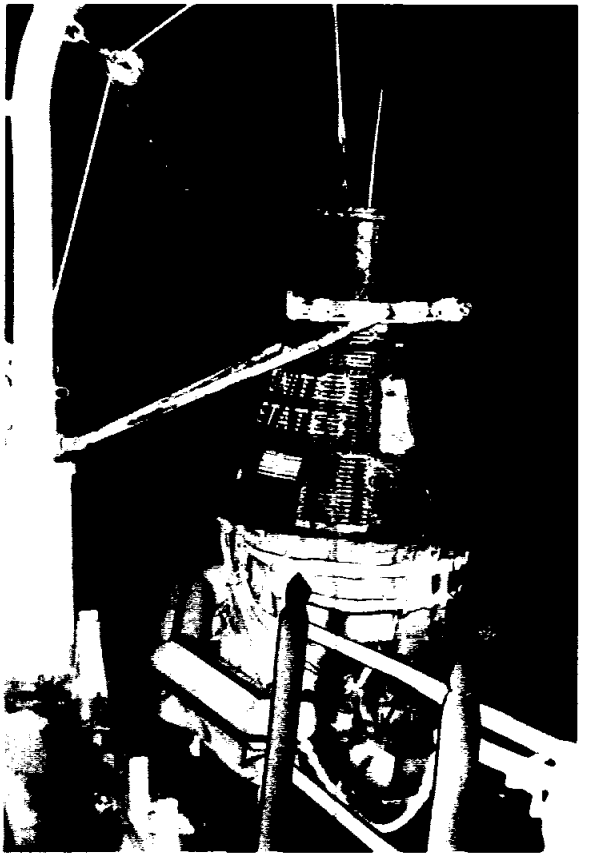

FIGURE 3–5.—Spacecraft retrieval by destroyer.

Reference

1. ANON.: *Results of the First United States Manned Orbital Space Flight, February 20, 1962.* NASA Manned Spacecraft Center.

4. SPACE SCIENCE REPORT

By JOHN A. O'KEEFE, PH. D., *Asst. Chief, Theoretical Division, NASA Goddard Space Flight Center; and* WINIFRED SAWTELL CAMERON, *Theoretical Division, NASA Goddard Space Flight Center*

Summary

The principal results in the field of space science obtained from the MA–7 mission are:

1. The luminous band around the horizon is attributed to airglow; a large part of the light is in the 5,577-angstrom (Å) line, where maximum intensity is at about 84 kilometers.
2. Space particles, similar in some ways to those reported by Astronaut Glenn, were shown to emanate from the spacecraft. They are probably ice crystals.
3. New photographs showing the flattened solar image at sunset were made.

Introduction

A discussion is presented in this paper of the observations regarding terrestrial space phenomena made by Astronaut M. Scott Carpenter during the MA–7 flight and reported in paper 7. Some of these observations are compared with those made by Astronaut John H. Glenn, Jr., in the first manned Mercury orbital flight and described in reference 1. The principal subjects considered in the field of space science are:

1. The airglow layer at the horizon.
2. The space particles reported by Astronaut Glenn.
3. The flattened solar image at sunset.

An analysis of these and other observations of the astronauts is continuing.

Airglow Layer

Toward the end of the MA–7 flight, between 4 hours 2 minutes g.e.t. (16 hr and 47 min Greenwich mean time) and 4 hours 18 minutes g.e.t., May 24, 1962, Astronaut M. Scott Carpenter made a series of observations of a luminous band visible around the horizon, known as the "airglow" layer. The airglow is a faint general illumination of the sky visible from the ground on a clear, moonless night. The glow is brightest about 10° or 15° above the horizon and becomes fainter toward the zenith. The height of the airglow layer has been investigated by Heppner and Meridith (ref. 2) of the Goddard Space Flight Center using an Aerobee sounding rocket. This rocket, which carried a filter that transmitted only the 5,577-angstrom (Å) line, have indicated that the height of the layer extends from 90 to 118 kilometers above the earth. Their studies were also concerned with the characteristics of other layers of specific wavelengths, such as the sodium layer. The light emitted from the luminous layer is attributed to a forbidden transition, or transition from a metastable state, of the oxygen in the upper atmosphere. A forbidden transition is very difficult to produce in the laboratory because the atoms lose the energy corresponding to the transition through the collision with another atom or with the walls of the container. This effect can be minimized only if the laboratory apparatus is very large and the enclosure is at an extremely high vacuum. Thus a forbidden transition is much more common in space.

The astronaut's observations of this luminous layer permit investigation and identification of three of its physical characteristics. The wavelength of the emitted light is discussed initially, and this is followed by an analysis of the brightness of the airglow layer. Finally, an examination of the height of the luminous band above the earth's surface is presented.

Wavelength

The most significant observation was made with a specially developed filter supplied by the NASA Goddard Space Flight Center. The filter transmits a narrow band of wavelengths, approximately 11 Å wide at the half-power point and centered at the wavelength of the

strongest radiation of the night airglow, namely 5,577 Å.

During the flight the astronaut noticed that the filter passed the light of the luminous band with but little attenuation; however, it rejected the light of the moonlit earth. Therefore, the band was identified as the 5577 layer.

Brightness of the Layer

Astronaut Carpenter noted that the airglow layer was relatively bright. An indication of this brightness was derived from a comparison of the brightness of the layer with that of the moonlit horizon.

Astronaut Carpenter also noted that the layer was about as bright as the horizon, which was at that time illuminated by the moon at last quarter. Assuming that the atmosphere at the horizon acts like a perfect diffusing reflector, and noting that the illumination of the moon at last quarter is approximately 2×10^{-2} lux, it is found that the surface brightness is 6×10^{-3} lux per steradian.

Height of the Layer

The astronaut provided evidence on the height of the layer through five separate observations:

1. By making a direct estimate which was from 8° to 10°.
2. By noting that it is approximately twice the height of the twilight layer. Astronaut Carpenter estimated the height of the twilight layer as 5 sun diameters or 2½°; hence, the height of 5577 layer would be 5°.
3. By observing the star Phecda as it passed the middle of the luminous band.
4. By noting the time when Phecda was halfway from the luminous band to the horizon.
5. By noting the fact that when the crossbar of the reticle is scribed on the window set diagonally, the horizontal bar just covers the distance from the band to the horizon.

In method 3, the time of passage of the star below the brightest part of the luminous layer was used. Through careful timing of the spacecraft tape and conversation with the astronaut, the time has been fixed at approximately 04:05:25 ground elapsed time (g.e.t.) or 16 hours 50 minutes 41 seconds G.m.t. To find the true height at that time, a special set of computations was made at Goddard Space Flight Center, starting from the spacecraft latitude

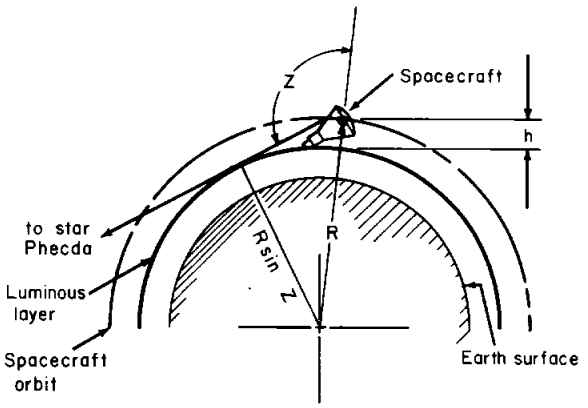

FIGURE 4–1.—Parameters used to calculate height of layer.

and longitude for each minute of ground elapsed time. By using the standard formulas of spherical astronomy, the angular zenith distance Z, schematically shown in figure 4–1, of Phecda was calculated. The ray from Phecda was considered to be tangent at each moment to an imaginary sphere which is concentric with the earth, and which is situated at a distance h below the observer. The usual formula for the dip of the horizon is $h=R(1\text{-}\sin Z)$, where R is the radius from the center of the earth to the spacecraft. Since only 3-figure accuracy is needed in h, it is not necessary to enter into refinements in the calculation of R; a mean radius of the earth of 6,371 kilometers plus the spacecraft elevation gives more than sufficient precision. Subtracting h from the spacecraft elevation gives the elevation of the layer. By using the above-mentioned time, the lower boundary of the layer is found to be at 73 kilometers. Other points are less definite; it appears that at 04:03:33 g.e.t. or 16 hours 48 minutes 49 seconds (110 kilometers) G.m.t. Phecda had not yet entered the layer, and that at 04:04:52 g.e.t. or 16 hours 50 minutes 8 seconds (84 kilometers) G.m.t. it was approaching the middle of the layer.

These heights are some 10 to 15 kilometers lower than those which result from rocket measurements (ref. 2). The discrepancy may be due in part to geometrical effects; for instance, a very thin layer has some intensity at all zenith distances greater than that of the tangent to the layer. Hence the determination of the bottom of the layer is intrinsically uncertain. In a thick layer, these methods are

slightly biased toward the lower portions. On the other hand, it appears to be physically possible, especially if account is taken of turbulence that the maximum of the oxygen (O) is really lower than 90 kilometers.

The observation of the luminous layer through the filter was made at 04:16:50 g.e.t. Sunrise was witnessed about 1 minute later while the observation was being conducted. It follows that the airglow is visible even when the twilight band is very strong. An attempt to observe it in the day appears to be desirable. In this connection, it should be noted that Astronaut Virgil I. Grissom reported a grayish band at the top of the blue sky layer (see ref. 4). He remembers this layer as narrow and grayish in color, representing an actual increase in intensity. He pointed out the approximate position of the layer on one of the photographs taken by Carpenter at the height of 1.7° above the horizon. Astronaut Grissom may have in fact observed the luminous layer during the daytime.

Astronaut Carpenter did not note any vertical or horizontal structures in this layer. He did not attempt a continuous survey around the horizon; however, he did note the layer at several points along the horizon and believes it to be continuous all the way. It does not appear possible that this layer can actually absorb starlight. Any layer at this level capable of absorbing a noticeable fraction of the light (25 percent or more) would also significantly scatter light; it would therefore be a very prominent object on the daylight side. However, it is not definitely visible on the photographs of the day side. That the decreased visibility of stars passing through the layer was a contrast effect is entirely in agreement with Astronaut Carpenter's impression. This layer is thus assumed to be luminous.

An interesting feature of this observation is the discrepancy between the eye estimates of 8° to 10° for the altitudes above the horizon, on the one hand, and the results of timed observations on the other. The latter indicates altitudes of 2° to 3°, which are clearly correct. For example, Astronaut Carpenter noted that when one arm of his reticle was at an angle of 45°, it covered the space between the horizon and the bright band. The crossarm is 1.21 centimeters in length and is 26.2 centimeters from the astronaut's eye. At an angle of 45°, it subtends a vertical angle of about 2.6°.

It thus appears that the well-known illusion which exaggerates angles near the horizon, may also be experienced in orbital flight. It was evidently present during the MA–6 mission, since Astronaut Glenn also reports 7° to 8° as the height of the luminous band.

A summary of the results derived from the five methods of calculating the height of the airglow layer is presented as table 4–I.

Space Particles

Astronaut Carpenter also noticed and photographed white objects resembling snowflakes, or reflecting particles, at sunrise on all three orbits. (See fig. 4–2.) However, he also saw these objects 7 minutes after the first sunrise and again 43 minutes after sunrise and 2, 11, 23, 26, 36, and 45 minutes after the second sunrise. It is thus quite clear that they are not related to sunrise, except perhaps in the sense of being most easily visible then.

In the photographs some of the particles were considerably brighter than the moon, which was then very near the first quarter. At this time, the moon is about −10; the particles may have been between −12.6 magnitude (10 times brighter than the moon) and −15 magnitude (100 times brighter than the moon). The second is considered more likely, in view of the appearance of the full moon (−12.6) as shown on photographs taken on the MA–6 mission. At −15 magnitude, the particle brightness is consistent with centimeter-size snowflakes. The particles were verbally described by the pilot as having been between 1 millimeter and 1 centi-

FIGURE 4–2.—Space particle photographed by Astronaut Carpenter.

meter in size and having a strong visual resemblance to snowflakes.

Shortly before reentry just at sunrise, Carpenter improvised the decisive experiment of hitting the walls of the spacecraft with his hand. The blows promptly resulted in the liberation of large numbers of particles. It is thus clear that at least those particles observed in the MA–7 flight emanated from the spacecraft.

The possibility that the particles might be dye marker or shark repellant, both of which are green and both of which are exposed to the vacuum, was considered. Tests were conducted which demonstrated that neither material tended to escape from the package in a vacuum. The possibility that they might be small particles from the fiber glass insulator was also considered; in view of the smallness of the fibers, it appears likely that they would have been blown away at once, like the confetti of the balloon experiment. The dynamic pressure of 1 dyne per square centimeter is sufficient to remove at once anything weighing less than about 10 to 100 milligrams per square centimeter, which corresponds to a thickness of the order of 0.3 to 1 millimeter for most ordinary substances.

As mentioned in reference 1, there are two plausible sources within the spacecraft for these particles:

1. Snow formed by condensation of steam from the life support system.
2. Small particles of dust, waste, bits of insulation, and other sweepings.

The latter are very conspicuous in a zero g environment when there is nothing to keep them down, and it is extraordinarily difficult to free the interior of the spacecraft of such material. Undoubtedly, the exterior parts of the spacecraft which are exposed to the environment will contain these particles, and they undoubtedly provide a source for the space particles. In particular, a corkscrew-shaped piece observed by Astronaut Carpenter could possibly have been a bit of metal shaving or perhaps a raveled piece of insulation.

On the other hand, there is considerable evidence which points to snow as the source of the majority of the material. In the first place, water is exhausted from the spacecraft in far larger quantities than any other substance. In the second place, the material looked like snowflakes both to Glenn and to Carpenter. In the third place, the frequency with which the particles are reported by Carpenter appears to be correlated with the temperature of the exterior of the spacecraft as recorded by thermocouples in the shingles. The temperature was always lowest at night, falling to temperatures of $-35°$ C just before sunrise, and rising to 10° C just after sunrise.

The condensation probably occurred in the space between the heat shield and the large pressure bulkhead of the spacecraft, rather than outside the spacecraft, because even at the lowest recorded shingle temperature, around $-50°$ C, the vapor pressure over ice amounts to about 0.039 millibar. Although this pressure is very low, it greatly exceeds the ambient pressure at the lowest spacecraft altitudes. Accordingly, it is not possible that snowflakes should form under these circumstances, even though it is true that the spacecraft must be surrounded by an expanding atmosphere of water vapor.

If the water vapor is assumed to expand freely, then the pressure at a distance of 1 meter from a hole 1 centimeter in diameter will be of the order of 1/10,000 of the pressure at the hole. Hence it is fairly clear that the pressure between the heat shield and bulkhead of the spacecraft will be far higher than the outside pressure, in spite of the presence of 18 one-centimeter apertures. Therefore, condensation behind the heat shield is more likely than outside. It is noteworthy that no formation of rime was noticed either on the window or on the balloon string. It is considered most likely that the luminous particles are snowflakes formed in the spacecraft between the cabin bulkhead and the heat shield by the steam exhaust from the life support system. It is suggested that they may have escaped into space through the ports, being driven outward by the expanding vapor. Note that at 2 hours 52 minutes 47 seconds g.e.t., Carpenter noticed a particle moving faster than he. At 2 hours 50 minutes g.e.t., he had planned to observe sunrise and was facing forward. This particle was therefore probably seen at a point east of him. Most of the particles were seen behind him and falling back. This supports the idea that the particles prob-

ably are pushed outward by the expanding steam from the spacecraft before they begin to stream backward. It is probable that many of the particles lodge on the outside of the spacecraft, since Carpenter is quite sure, from the direction in which the particles streamed across the window, that they came from near the point where he had knocked.

The Flattened Sun

New information regarding the refraction by the earth's atmosphere of celestial objects as seen from space has recently been provided by the Mercury manned orbital flights. Theory predicts that the sun's image near the horizon should be highly flattened. Astronauts Glenn and Carpenter obtained photographs of the setting sun that illustrate this effect rather strikingly. Carpenter recognized the phenomenon visually, but John Glenn did not.

A general procedure for the computation of refraction, in order to construct a theoretical solar profile for comparison with the actual photographs, is presented. The quantities determined are the apparent and true zenith distances as seen from the spacecraft denoted by Z_{app} and Z_{true}, respectively.

To find these quantities, a ray through the atmosphere to the spacecraft is idealized. The phenomenon takes place effectively only for rays whose perigees are lower than 20 kilometers above the surface of the earth. Figure 4–3 illustrates the geometry employed.

The ray from the sun is traced backward from the spacecraft, C. The first section, from

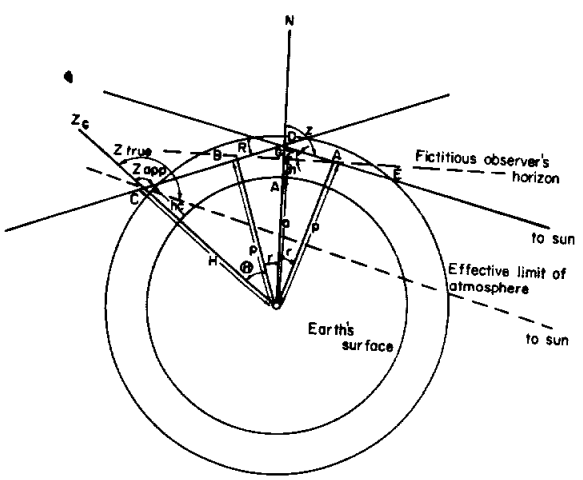

FIGURE 4–3.—Geometry employed in computation of refraction.

the spacecraft to the atmosphere, X, is straight. If the ray continued in this direction toward the sun, there would be a point, B, of nearest approach to the center of the earth, O. That distance is denoted by p, and the angle at the center of the earth from the spacecraft to B is denoted as Ⓗ. If B and p are known, the apparent height of any point on the sun as seen from the spacecraft could be calculated.

To make the calculation, the curving optical ray is followed forward until it is refracted so as to be parallel to the surface of the earth. This point is called the perigee of the ray, and is denoted by G. The line OG makes an angle Ⓗ$+r$ with OC, where r is the refraction angle for the sun when an observer at G sees it 90° from the zenith.

If the straight portion of the ray is prolonged, it will intersect OG at some point A. Then, the height of D above G is called the refraction height, s. For any given height G, the refraction angle r at the horizon and the refraction height s, which depends on the true height and r, can be calculated. Then the right triangle OBD for the distance p can be solved. The length p is denoted by analogy with the similar dynamic problem, such as the impact parameter.

Given p and the spacecraft height, the apparent angles at the spacecraft can be calculated as a function of Ⓗ. The refraction angle $2r=R$ is added to form the true zenith distances.

The computation of the refraction $r=z-z'$, where z is the true zenith distance and z' the apparent zenith distance, for a fictitious observer stationed at perigee, was based on the rather detailed theory given in reference 5. The pertinent formulas are:

$$r=T^{1/2}\sum_{i=0}^{5}B_i W^{i+1}$$

and

$$W=\frac{P}{T^2}$$

where

T = the absolute temperature divided by 273.0° at height h

P = pressure at height h divided by the ground pressure of 1.013×10^6 dynes/cm²

B = coefficient involving the index of refraction μ and the polytropic index n.

The temperature, pressure, and density δ of the atmosphere at altitude h were taken from reference 6. More recent data on these parameters are available from reference 7.

The parameter s, here called the refractive height, is a refraction correction commonly applied in calculations of times of contact in eclipses. The derivation of s is found on page 515 of reference 4, which gives its relation to the index of refraction as $1+s/a=\mu \sin z'/\sin z$. Here is mean radius of the earth (6,371,020 meters). The index of refraction μ is computed using $\mu=1+2k\delta$, where k is a constant, and δ is the density at h divided by the density at the surface (1.172×10^{-3} g/cm^3).

Once μ, r, and s have been obtained, then R follows immediately from the simple relation $R=2r$ (a ray is doubly refracted at the spacecraft) and p is obtained from the equation $p=(a+h+s)\cos r$. Then Ⓗ is determined from the relation cost Ⓗ$=p/H$, where $H=a+h_c$ ($h_c=257{,}000$ meters as determined by the MA–7 orbit). Finally, Z_{app} and Z_{true} are related to Ⓗ and R by the equations $Z_{app}=90°+$Ⓗ and $Z_{true}=90°+$(Ⓗ$+R$). Table 4–II summarizes the computed results.

The flattening of the image of the setting sun is best illustrated in the plot of Z_{app} versus Z_{true}. An image representing the sun to scale may be placed at any Z_{true}, and points around the limb extended to the curve may be located on the Z_{app} axis. This procedure yields the apparent zenith distance of those points. Since the horizontal axis is not affected by refraction, parallels of altitude may be laid off on the unrefracted image of the sun and similarly on the apparent image of the sun. The apparent image may be rectified for easy comparison. The theoretical profiles of four phases of a setting sun are illustrated in figure 4–4, which is a plot of Z_{true} vs. Z_{app} for four true zenith distances of the sun's center. These distances are $Z_{true}=105.460°$, $Z_{true}=106.236°$, $Z_{true}=106.918°$ (sun's lower limb on the horizon), and $Z_{true}=107.180°$ (sun's center on horizon). The ratios in percent of the vertical to horizontal diameters are approximately 0.63, 0.46, 0.17, and 0.11, respectively. Considering the spacecraft angular velocity of 4°/ min, it is seen that the entire refraction effect took place in the relatively short interval of about 20 seconds.

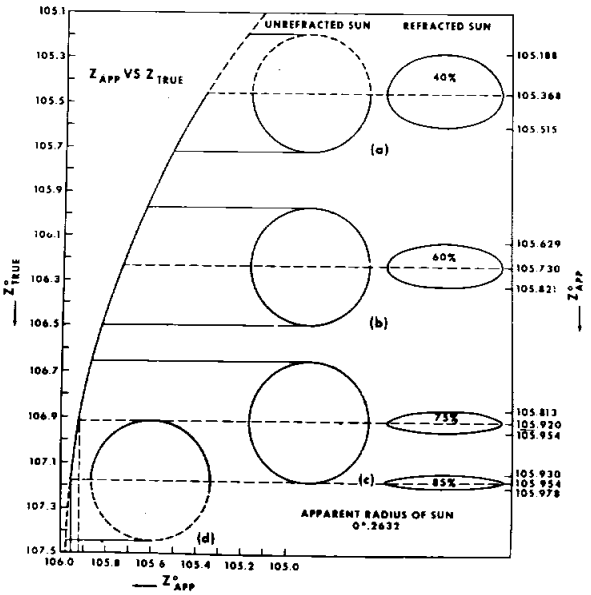

FIGURE 4–4.—Stages of the setting sun.

The uncertainty in photography times precludes an exact comparison of theory and observations. However, figure 4–4(c) most nearly simulates the photographs in figures 4–5 and 4–6 which show the effects of the spacecraft motion and still demonstrate the arresting effect. Figure 4–5 was photographed by Astronaut Glenn on February 20, 1962. He specifically states that he did not see the sun as a narrow, flat object. He observed it as spreading out about 10° on either side and merging with the twilight band.

FIGURE 4–5.—Flattening of sun photographed by Astronaut Glenn.

Figure 4–6 was photographed by Astronaut Carpenter on the MA–7 flight of May 24, 1962. He stated that the sun definitely appeared somewhat flattened during sunrise and sunset.

FIGURE 4–6.—Flattening of sun photographed by Astronaut Carpenter.

Therefore, the flattening effect produced by atmospheric refraction of a celestial body as seen from space has been demonstrated by direct observation. However, it is hoped that future missions will yield photographs with more precise times of observation and perhaps measures of the horizontal and apparent vertical diameters by the astronaut using a sextant might be feasible. At any rate, the observations by astronauts of future flights will be carefully analyzed and further compared with the theory stated herein to explain refraction phenomena more fully.

Acknowledgments.—Thanks are due to Mr. Lawrence Dunkelman of Goddard Space Flight Center for providing the 5,577 filter; to Professor Joseph W. Chamberlain, University of Chicago, for assistance and advice in the interpretation of the airglow information; to James J. Donegan of Data Operations Division of Goddard Space Flight Center for the provision of the final orbital elements; and to Frederick B. Shaffer of the Theoretical Division of Goddard Space Flight Center for programing and obtaining the orbit on the 7090 computer.

TABLE 4–I.—*Observations of the Height of the 5577 Layer*

Method	Results	Significance
1. Eye estimate at angular height.	8° to 10° above horizon	Apparently the moon illusion exists even in the absence of a gravitational field; objects look larger near the horizon.
2. Comparison with twilight layer.	5° above horizon	Same as above.
3. Observation of star in the middle of the layer.	101°54′ from Zenith	Height about 83 kilometers.
4. Observation of star halfway from haze layer to horizon.	Zenith distance is 103°10′	Apparent horizon 1° above geometrical horizon, whose Zenith distance is 106°.
5. Observation of angular height with reticle.	2.6° above horizon	Confirms methods 3 and 4; i.e. apparent horizon is more than 1° above geometrical horizon.

TABLE 4–II.—*Summary of Refraction Computations*

h, meters	T	P, dynes/cm²	δ, g/cm³	r, minutes	μ	s, meters	p, meters	Ⓡ, deg	Z_{app}, deg	Z_{true}, deg
00000	1. 0000	1. 0000	1. 0000	36. 765	1. 0002944	2, 238. 5	6, 368, 612	15. 954	105. 954	107. 180
2,000	1. 0330	0. 7933	0. 8474	27. 083	1. 0002495	1, 785. 9	6, 370, 327	15. 900	105. 900	106. 803
4,000	0. 9985	0. 6214	0. 6856	22. 072	1. 0002018	1, 416. 0	6, 372, 023	15. 846	105. 846	106. 582
6,000	0. 9524	0. 4813	0. 5573	18. 193	1. 0001641	1, 133. 9	6, 373, 783	15. 790	105. 790	106. 396
8,000	0. 8974	0. 3676	0. 4520	15. 092	1. 0001331	909. 2	6, 375, 585	15. 733	105. 733	106. 236
10,000	0. 8454	0. 2757	0. 3598	12. 300	1. 0001059	715. 0	6, 377, 412	15. 675	105. 675	106. 085
12,000	0. 8040	0. 2038	0. 2799	9. 740	1. 0000824	550. 1	6, 379, 262	15. 615	105. 615	105. 940
14,000	0. 7751	0. 1488	0. 2113	7. 468	1. 0000622	410. 7	6, 381, 134	15. 555	105. 555	105. 804
16,000	0. 7619	0. 1075	0. 1556	5. 508	1. 0000458	299. 9	6, 383, 030	15. 494	105. 494	105. 678
18,000	0. 7656	0. 0775	0. 1118	3. 923	1. 0000329	213. 3	6, 384, 947	15. 431	105. 431	105. 562
20,000	0. 7795	0. 0562	0. 0796	2. 758	1. 0000234	150. 9	6, 386, 887	15. 368	105. 368	105. 460

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5. AEROMEDICAL STUDIES

A. CLINICAL AEROMEDICAL OBSERVATIONS

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Summary

A review of the detailed medical examinations accomplished on two astronauts who each experienced approximately 4½ hours of weightless space flight reveals neither physical nor biochemical evidence of any detrimental effect. Such flights appear to be no more physiologically demanding than other nonspace-oriented test flights. Specifically, no pulmonary atelectasis has been found, no cosmic-ray damage has occurred, and no psychiatric abnormalities have been produced. In spite of directed efforts to stimulate the pilot's orientation and balancing mechanisms during weightless flight, no abnormal vestibular nor related gastrointestinal symptoms have occurred. Postflight special labyrinthine tests have confirmed an unchanged integrity of the pilots' vestibular system. Although events occurring during the MA–7 mission permitted only a qualitative verification of gastrointestinal absorption of xylose, such absorption was normal during MA–6. Biochemical analyses after Astronaut M. Scott Carpenter's flight confirmed the occurrence of a moderate diuresis.

Water survival is an emergent situation requiring the optimum in crew training and procedure discipline. Furthermore, if heat stress continues to be a part of space flight, adequate fluid intake during the mission is necessary for crew performance and safety.

Introduction

The experience gained in the MA–6 flight altered the medical planning for the MA–7 flight in two important respects. A comprehensive medical evaluation of the astronaut was conducted at the earliest opportunity after landing when his impressions were freshest and any acute medical alterations would have been greatest. The flexibility of the procedure at the debriefing site was increased to take greater advantage of any medical symptoms which might appear. The MA–7 pilot was aeromedically prepared for flight in a manner similar to that of the MA–6 pilot with allowance made for individual variations, for example, dietary preferences and the mode of physical conditioning. Prior to the mission, clinical observations were obtained during several medical examinations and before most of the preflight activities listed in table 5–I. The medical examinations are logically divided into a clinical history followed by physical examination. This latter division consists of standard medical procedures, including repeated and numerous observations by physicians, routine and special laboratory tests, X-rays, retinal photography, electrocardiography, electroencephalography, and special tests of the body's balancing mechanism.

Purpose

The threefold purpose of the clinical observations was (1) to determine the fitness of the astronaut for flight, (2) to provide baseline information for the Aeromedical Flight Controllers, and (3) to measure any changes which might have occurred between preflight and postflight conditions.

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TABLE 5–I.—*Significant Activities of MA–7 Astronaut*

[All times are eastern standard]

Date 1962	Activity
April 30	Arrived at Cape Canaveral; simulated flight, suited.
May	
2	Procedures trainer, suited
5	Began special diet, aeromedical feeding facility.
7	Procedures trainer, suited
9	Procedures trainer, not suited
10	Simulated launch, suited
15	Simulated flight 3, suited
17	Comprehensive medical examinations, Patrick Air Force Base Hospital, Fla.
21	Preflight low-residue diet began for third time.
23	MA–7 meetings; asleep at 8:00 p.m.
24	Awakened at 1:15 a.m.; began aeromedical countdown; launch 7:45 a.m.; recovery physician's examination 3:30 p.m. and 5:15 p.m.; brief examination, Grand Turk Island 11:00 p.m.
25	Asleep 2:30 a.m.; awoke 9:15 a.m.; aeromedical debriefing; engineering debriefing.
26	Asleep 12:45 a.m.; awoke 6:45 a.m.; aeromedical and engineering debriefing; skin diving for 3 hours.
27	Asleep 2:30 a.m.; awoke 9:15 a.m.; arrived Patrick Air Force Base 2:00 p.m.
28	Departed Cape Canaveral 2:15 p.m.

Aeromedical History

For purposes of these observations, the aeromedical history of the MA–7 mission began on April 30, 1962, with Astronaut M. Scott Carpenter's arrival at Cape Canaveral, Fla., for preflight preparations. A summary of his significant activities from this date until his return to Cape Canaveral following the flight is presented in table 5–I. Throughout this period, his physical and mental health remained excellent. A special diet which insured good nutrition and hygiene was used for 19 days before the flight. Mission rescheduling caused two starts on the low-residue diet before the third and final 3-day low-residue diet began on May 21, 1962. The pilot maintained his physical condition through frequent exercise on a trampoline (fig. 5–1) and distance running.

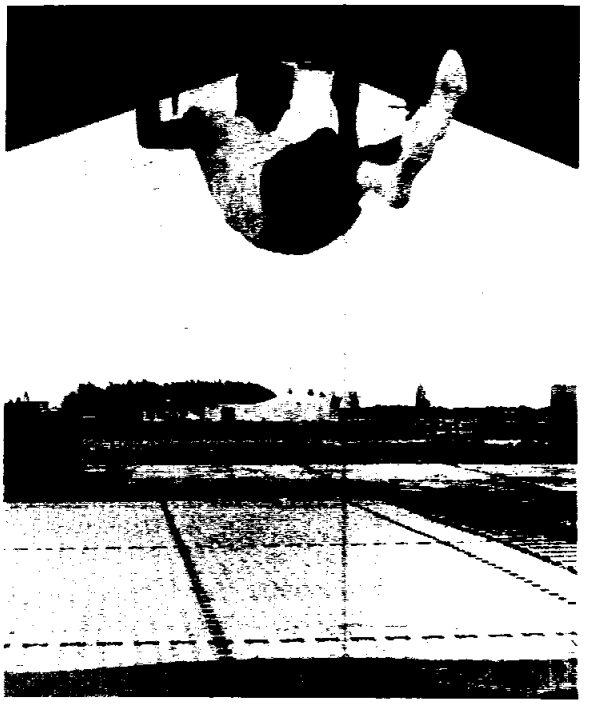

FIGURE 5–1.—Astronaut Carpenter during physical training.

On the morning of the flight, Astronaut Carpenter was free of medical complaints, mentally composed, and ready for the mission. Breakfast consisted of filet mignon, poached eggs, strained orange juice, toast, and coffee. The preflight fluid intake consisted of 1,050 cc of water, juice, coffee, and sweetened iced tea. He voided three times into the urine collection device before launch. The events of the aeromedical countdown are listed in table 5–II. Astronaut Carpenter was awakened 65 minutes earlier than the MA–6 pilot had been and the MA–7 launch was 122 minutes earlier than the MA–6 launch.

After the flight, Astronaut Carpenter stated. "My status is very good, but I am tired." His fatigue at landing is attributable to the heat load accompanying an elevated suit temperature (see paper 1) and the associated high humidity, the activity required to carry out the flight plan, and the expected emotional stress associated with such a flight. The following postlanding sequence of events contributed further to his fatigue: after entering the raft, he recognized that it was upside down. He left the raft, held to the spacecraft, righted the raft, and once

TABLE 5–II.—*MA–7 Aeromedical Countdown Events*

[May 24, 1962]

Time, a.m. e.s.t.	Activity
1:15 [1]	Awakened the pilot
1:46	Breakfast
2:05	Preflight physical examination
2:41	Biosensor placement
3:04	Don Mercury pressure suit
3:25	Pressure suit and biosensor checkout
3:40	Entered transfer van
4:03	Arrived at launch pad
4:36	Ascended gantry
4:43	Insertion into spacecraft
7:45 [1]	Lift-off

[1] MA–6 times: Awakened, 2:20 a.m. (e.s.t.); lift-off, 9:47 a.m. (e.s.t.).

again climbed aboard. His neck dam was still stowed, and, after several fatiguing attempts, he was able to deploy it some 30 minutes after his second entry into the raft. An undetermined but moderate quantity of water had entered the pressure suit. Obviously, these events represent survival hazards. Astronaut Carpenter drank water and ate food from his survival kit during the 3-hour period awaiting helicopter pickup.

Throughout the debriefing period, he talked logically about his space flight and remained alert. A detailed review of the pilot's in-flight aeromedical observations is presented in another section of this paper.

Physical Examinations

Abbreviated physical examinations were accomplished by the Astronaut Flight Surgeons prior to most of the planned activities in the prelaunch period. These examinations revealed no significant variations from previous examinations. The aeromedical debriefing team, representing the specialties of internal medicine, neurology, ophthalmology, aviation medicine, psychiatry, radiology, and clinical laboratory conducted a comprehensive medical examination 7 days before the mission. This examination included special labyrinthine studies (modified caloric test and balance test on successively more narrow rails), electrocardiogram (ECG), electroencephalogram (EEG), and audiogram. Astronaut Carpenter was in excellent health and showed no significant change from previous examinations.

On the night prior to the flight, the pilot obtained approximately 3 hours of sound sleep. No sedative was required. He was given the final cursory preflight examination by the same specialists in aviation medicine, internal medicine, and neuropsychiatry who carried out the earlier extensive medical checks. His physical and mental status was normal.

After a 3-hour period in the liferaft, Astronaut Carpenter was examined in the helicopter. The physician reported as follows: "He pulled the tight rubber collar [neck dam] from his neck and cut a hole in his [left] rubber pressure-suit sock to drain out sea water. He was anxious to talk and to discuss his experiences in a cooperative and well-controlled manner. He talked with the helicopter pilot, paced about a bit, and finally relaxed as one normally would after an extended mental and physical exercise." The physical examination aboard the aircraft carrier revealed that he was without injury and in good health. He did show a mild reaction to the adhesive tape used at the four ECG sensor sites and the blood-pressure microphone location.

Upon Astronaut Carpenter's arrival at Grand Turk Island (10 hours after the landing), the internist member of the debriefing team noted: "He entered the dispensary with the air and the greeting of a man who had been away from his friends for a long time. He was alert, desiring to tell of his adventure, and seemed very fit . . . his appearance and movement suggested strength and excellent neuromuscular coordination." A brief medical examination was undertaken an hour after the pilot's arrival. The following morning, a comprehensive examination was made by the same group of specialists who had examined Astronaut Carpenter 7 days prior to space flight. This extensive examination revealed no physical changes from the pilot's preflight condition. Specifically, an audiogram, EEG, ECG, chest X-rays, balance, neuromuscular coordination, and mental status were all normal. No evidence of cosmic-ray damage was found during the ophthalmologic examination, which included slit lamp biomicroscopy. The aeromedical debriefing was completed on the second morning following the flight. The results of these examinations

are presented in tables 5–III to 5–V. A mild asymptomatic urethritis was present in both preflight and postflight examinations. Treatment was withheld until after the flight.

TABLE 5–III.—*Preflight and Postflight Medical Findings*

	Preflight				Postflight			
	May 17, 1962 (Patrick Air Force Base)		May 24, 1962 (Cape Canaveral, 2:05 a.m.)		May 24, 1962 (Recovery Vessel, 5:15 p.m.)		May 25 and 26, 1962 (Grand Turk Island)	
Temperature (oral), °F	97. 9		97. 4		97. 6		97. 5	
Pulse rate, beats/min	60		60		76 to 80		----------	
Blood pressure (sitting), mm Hg.	126/84 (right arm)		120/78 (left arm)		116/78 (left arm)		124/80 (left arm)	
Respiration, breaths/min.	14		12		----------		----------	
Weight (nude), lb [1]	151½		154		148		151¾	
Extremity measurements,[2] in.:	Left	Right	Left	Right	Left	Right	Left	Right
Forearm	9	8¾	10⅞	11	10¾	10¾	10¼	10⅝
Wrist	7	6⅞	6¾	6⅝	6⅝	6½	6¾	6¾
Calf	12⅞	13¼	13¾	13	13	13¼	13⅜	13¾
Ankle	8	8¾	8	7⅞	7¾	7¾	8⅛	8
Comments	Complete examination negative; skin clear except for two clusters of inclusion cysts at left axilliary ECG site; chest X-ray normal; ECG normal.		Fit for flight; alert with appropriate mental status.		Moderate erythema at left chest ECG and bloodpressure cuff site; normal mental status; chest X-ray normal; no atelectasis; ECG normal, specifically, no arrythmia.		Minimal erythema as at postflight sites; examination unchanged from May 17 findings, including ECG, EEG, audiogram, and chest X-ray.	

[1] All body weights on different scales; weights comparable ±1 pound.

[2] Extremity measurements by same individual on May 17, May 24 (preflight) and May 25 and 26, 1962. On May 17, 1962, measurements made 6 and 10 inches below olecranon on forearms; 6 and 14 inches below patella on legs. All other measurements are maximums and minimums.

TABLE 5–IV.—*Astronaut Peripheral Blood Values*

Determination	Preflight		Postflight	
	−7 days	−2 days	May 25, 1962 12:15 a.m.	May 26, 1962 12:00 m
Hemoglobin (Cyanmethemoglobin method), grams/100 ml	15. 0	13. 8	16. 0	14. 8
Hematocrit, percent	47	42	50	46
White blood cells/mm³	12, 700	11, 600	12, 500	11, 900
Red blood cells, millions[6]/mm³	5. 2	----------	5. 6	5. 2
Differential blood count:				
Lymphocytes, percent	25	19	27	37
Neutrophiles, percent	71	79	65	58
Monocytes, percent	2	1	3	2
Eosinophiles, percent	2	1	4	2
Basophiles, percent	0	0	1	1

TABLE 5–V.—*Urine Summary*

	Preflight		In flight	Postflight (postlanding times)								
	−7 days	−2 days		+4½ hr	+17½ hr	+20½ hr	+26 hr	+30 hr	+35 hr	+37½ hr	+41½ hr	+45 hr
Volume, cc	250	---------	2, 360	155	770	140	215	305	890	310	550	310
Specific gravity	1. 024	1. 015	1. 003	1. 013	1. 002	1. 016	1. 024	1. 021	1. 005	1. 019	1. 009	1. 014
Osmolarity, milliosmoles	179	---------	313	295	148	600	848	860	314	729	527	684
Albumin, mg	Trace	Neg.	Trace	30	Trace	Trace	Trace	Trace	Trace	Trace	Neg.	Neg.
Glucose	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Ketones	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
Bile	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.	Neg.
pH	5. 0	6. 0	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0	5. 0	6. 0	5. 0	5. 0
Na, mEq/L	20. 1	---------	85. 6	45	18	71	141	183	39	90	76	187
K, mEq/L	4. 9	---------	16. 7	21	4	28	67	59	11	47	11	35
Cl, mEq/L	13	---------	88	51	13	80	189	200	29	96	72	216
Ca, mEq/L	1. 0	---------	3. 9	3. 7	1. 3	6. 5	8. 9	8. 8	2. 2	3. 2	9. 8	7. 8

NOTE.—The microscopic examination revealed the presence of 20–30 WBC/HPF which suggested a lower urinary infection. This was confirmed by a 3-glass test. No RBC were noted in the collections. By the end of the test period only an occasional WBC was to be found.

Aside from moderate tiredness based upon long hours of work and few hours of sleep, Astronaut Carpenter remained in excellent health throughout the debriefing period. He returned to Cape Canaveral on May 27, 1962, ready to "do it again."

Chemistries

The blood and urine chemistries studied were similar to those examined in previous manned space flights (see bibliography). The results of the MA-7 blood chemistry studies are summarized in table 5-VI. The level of the blood chloride and alkali metals remained stable throughout the period of observation. There was a slight lowering of blood calcium on the second day after the MA-7 mission.

The urinary output of calcium (table 5-VII) for this period showed a total of 10.67 milliequivalents (mEq) of calcium excreted during the 17½-hour period which included the flight and the immediate postflight period. In the subsequent 28 hours, 16.25 mEq of calcium were excreted. The fact that the potassium excretion was also elevated in the same period of time suggests that this increased calcium output is a result of a variation in kidney activity rather than just calcium mobilization alone. The stability of the blood potassium values, moreover, indicates that the loss of potassium was well compensated. During this period, Astronaut Carpenter's urine was consistently acidic with a pH near 5.0.

A comparison of similar data obtained from Astronaut Glenn during the MA-6 mission is also shown in table 5-VII. The MA-6 pilot eliminated 9.11 mEq of calcium during the initial 18-hour period (table 5-VII) and 18.32 mEq during the subsequent 28 hours. However, his blood calcium did not change significantly, with values of 4.3, 4.2, and 4.4 mEq/l corresponding approximately in time to similar samples taken on Astronaut Carpenter (table 5-VI). Study in future space flights should help to determine if the difference in blood value for calcium is an individual variable or a truly significant difference.

TABLE 5-VI.—*Blood Chemistry Summary*

Determination [1]	Preflight	Postflight	
	−2 days	+10½ hr	+45 hr
Sodium, mEq/l	141	137	139
Potassium, mEq/l	4. 0	4. 4	4. 3
Calcium, mEq/l	4. 8	4. 1	3. 5
Chloride, mEq/l	107	105	102
Protein (total), g/100 ml	6. 9	6. 4	6. 6
Albumin, g/100 ml	3. 6	3. 2	3. 4
Albumin-Globulin ratio	1. 1	1. 0	1. 1
Epinephrine, micrograms per liter (μg/l)	0. 2	0. 2	0. 2
Norepinephrine, micrograms per liter (μg/l)	(2)	6. 3	6. 3

[1] All blood chemistry determinations were done on plasma.
[2] Value too low to measure accurately on sample furnished for preflight examination.

TABLE 5–VII.—*Urinary Electrolyte Excretion*

(Times are postlanding)

Time, hour	Volume, liter	Na, mEq/l	K, mEq/l	Cl, mEq/l	Ca, mEq/l
MA–7 Pilot					
In flight	2. 36	201	39. 4	208	9. 2
+4½	. 155	6. 97	3. 25	7. 9	. 47
+17½	. 770	13. 85	3. 08	10	1. 0
Subtotal	3. 285	221. 82	45. 73	225. 9	10. 67
+20½	0. 140	9. 95	3. 92	11. 2	0. 91
+26	. 215	30. 3	14. 4	40. 6	1. 89
+30	. 305	55. 8	18. 0	61. 0	2. 69
+35	. 890	34. 7	9. 8	24. 8	1. 96
+37½	. 310	27. 8	14. 5	29. 6	. 98
+41½	. 550	41. 8	6. 05	39. 6	5. 4
+45	. 310	58. 0	10. 9	67. 0	2. 42
Subtotal	2. 720	258. 35	77. 47	273. 8	16. 25
MA–6 Pilot					
In flight	0. 8	126	21. 6	121	1. 51
+8	. 295	30	17. 4	29	6. 2
+10	. 076	6. 8	5. 1	2. 3	1. 03
+18	. 182	17. 5	6. 8	3. 6	. 37
Subtotal	1. 353	180. 3	50. 9	155. 9	9. 11
+24	0. 210	18. 5	7. 35	16. 4	5. 05
+27	. 250	15. 2	4. 25	11. 3	2. 05
+34	. 720	52. 5	10. 8	48. 2	5. 95
+41	. 365	17. 9	8. 4	14. 2	2. 15
+46	. 405	50. 5	16. 6	56. 5	3. 12
Subtotal	1. 95	154. 6	47. 40	146. 6	18. 32

Fluid and Electrolyte Balance

An attempt was made to control fluid and electrolyte balance through adequate hydration during the MA–7 mission. However, this balance was complicated by problems of high suit-inlet temperature and the associated sweating plus the increased fluid intake used to compensate for this.

A summary of Astronaut Carpenter's fluid intake and urine output is presented in table 5–VIII. In spite of the excess of intake over output, the pilot lost 6±1 pounds (table 5–III). This fact, combined with slight hemoconcentration after flight, the low specific gravity of the 2,360 cc "in-flight" urine specimen and the urinary electrolyte values, leads to the opinion that a moderate diuresis occurred. Such a diuresis can be explained through the suppression of antidiuretic hormone (ADH) secondary to such factors as the relative water loading both before and during the mission and the normal supine position of the astronaut when in the earth's gravity.

TABLE 5–VIII.—*Fluid Intake and Output* [a]

[May 24, 1962]

	Fluid intake, cc		Time, e.s.t.	Urine output, cc	Time, e.s.t.
Countdown				Bladder empty	1:15 a.m.
Breakfast	Orange juice, coffee	200	1:45 a.m.		
Transfer van	Water	600	4:03 a.m. to 4:36 a.m.	0	
	Tea	250			
Spacecraft				[b] 1,000	5:00 a.m. to 7:30 a.m.
In flight and before recovery.	Water	1, 213	7:45 a.m. to 3:40 p.m.	[b] 1,360	([c])
Subtotal		2, 263	1:45 a.m. to 3:40 p.m.	2,360	5:00 a.m. to 3:40 p.m.
After recovery	Tea	100	5:35 p.m.	155	5:00 p.m.
	Tea	150	5:50 p.m.		
	Coffee	180	7:35 p.m. to 8:15 p.m.		
	Tea	200			
	Soup	150			
	Water	≈ 500	9:12 p.m.		
Total		3, 543	1:45 a.m. to 9:12 p.m.	2,515	5:00 a.m. to 5:00 p.m.

[a] 30 cc of blood drawn at 5:20 p.m.
[b] Total of 2,360 cc in urine collection device; division into preflight and in-flight aliquots is estimated.
[c] Time unknown, approximately 7:45 a.m. to 3:40 p.m.

Special Studies

For both the MA–6 and MA–7 missions, a questionnaire and two special tests were utilized to elicit or measure any effect of space flight and its attendant weightlessness upon the human vestibular apparatus. The first of these tests was a modified caloric test (see fig. 5–2) which is considered to be a valid and finely discriminating index of semicircular canal function. The subject's ear was irrigated for 45 seconds with water below body temperature which could be warmed or cooled under precise control. The times of onset and duration of nystagmus (fine eye jerk) were noted. The highest water temperature which caused nystagmus was regarded as the threshold value. Usually this is 3° to 5° centigrade below body temperature. In patients with clinical vestibular disease, the threshold temperature is usually lower than normal, and, during the course of the disease, it exhibits moderate variation in magnitude.

Astronaut Glenn exhibited no significant change in threshold temperatures before and after his orbital space flight. Astronaut Carpenter likewise did not show a significant change between tests carried out 6 months prior to flight and the two tests conducted after the flight. Slightly higher threshold temperatures for both left and right ears were obtained at the time of the preflight evaluation (7 days prior to the flight). However, in this instance, these high threshold values were the result of a technical error.

The other labyrinthine tests measured the subject's ability to balance himself on successively more narrow rails, similar to the rails of a railroad track. In this test, the astronaut was required both to stand and to walk heel-to-toe and to keep arms folded on the chest. The standing tests were carried out first with the

FIGURE 5–2.—Modified calorie test.

eyes open, then with the eyes closed. In addition to the influence of fatigue and motivation, the results of this test are affected by several dynamic systems other than the vestibular apparatus, particularly general neuromuscular coordination and position sense. Normal baseline scores on this test for Astronauts Carpenter and Glenn indicate somewhat higher performance than was found in a group of military flight personnel. Both astronauts showed a small increase in their postflight versus preflight scores on this test. These increments were small and within the expected range of physiological variation. This test represents a relatively quantitative method for evaluating the integrity of a number of neuromuscular mechanisms related to balance. It is not, however, as precise nor as specific a test as is the modified caloric test.

In both United States manned orbital space flights, a xylose tolerance test was performed to measure intestinal absorption while the astronaut was weightless. This test requires the astronaut to ingest a 5.0-gram xylose tablet while weightless, followed by urination just prior to return to 1*g*. Unfortunately the urine collected during weightlessness from that collection device does not separate the urine passed before and after the flight; therefore, it was not possible to determine the absorption of xylose during weightlessness as was done in the MA–6 mission. Control studies on both the MA–6 and MA–7 were set up to simulate, in time, programed in-flight times for xylose ingestion and subsequent urination. However, the xylose-tolerance test accomplished during the MA–7 mission differed significantly from the same test which was successfully accomplished during the MA–6 mission. In accordance with the flight plan, the 5-gram xylose tablet was ingested at 2 hours 41 minutes 35 seconds g.e.t. in the MA–7 mission instead of at 23 minutes 11 seconds g.e.t. as was done in the MA–6 mission. Through a later in-flight xylose ingestion time, it was hoped that any gastrointestinal changes would be more pronounced after a slightly longer (138 minutes) exposure to weightlessness. Also, the weightless absorption and excretion of xylose would then take place, if it followed the curve of normal xylose urinary excretion, during the period of maximum anticipated absorption and excretion. The other significant variable was the marked increase in fluid intake by Astronaut Carpenter over that of Astronaut Glenn. Both astronauts had demonstrated a normal response in the preflight period when compared to five control subjects. Astronaut Glenn produced only 800 cc of urine and excreted 34.9 percent of the test xylose dose during his 4½-hour period of weightlessness. When compared with his control excretion of 38.2 percent in the preflight period, this in-flight result is normal. Astronaut Carpenter produced 2,360 cc of urine during the flight collection period and excreted 22.5 percent of the xylose (figure 5–3). When the single urine specimen passed aboard ship at 5 p.m. e.s.t. is included in the test period, a total

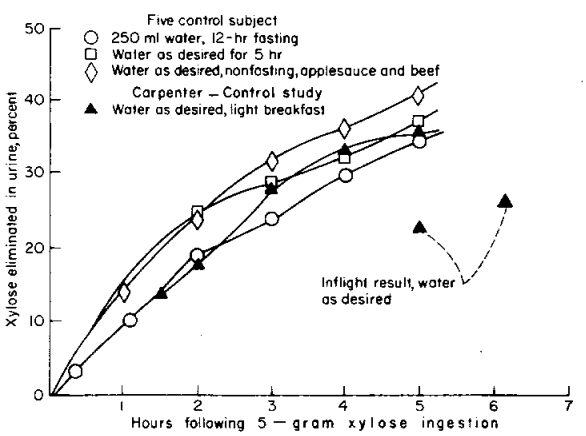

FIGURE 5–3.—Xylose Absorption. Astronaut flight sample, volume 2, 360 ml. (Exact time of final collection not known, but estimated at 2 hours postflight.) Additional specimen aboard carrier increased output to 25.7 percent for total elapsed time of 6 hours, 40 minutes.

of 25.7 percent of the xylose was excreted. The latter specimen extends the elapsed time following the in-flight xylose ingestion to 6 hours and 10 minutes. The excretion of only 25.7 percent is significantly less than the 35 percent recovered after 5 hours in the preflight control study period. This decreased xylose excretion is difficult to interpret because of the following circumstances: (1) the pilot is not certain when he urinated during the mission, (2) another specimen was passed approximately 2 hours after landing while he awaited recovery, and (3) normal control studies of xylose absorption allowing for such large volumes of fluid intake and urinary output were not obtained prior to flight. There is a remote possibility that the recovered xylose was absorbed and excreted after landing. However, in the MA–6 flight, normal xylose absorption did occur during weightlessness. The normalcy of such absorption during the MA–7 flight cannot be verified. If this test is to be used on future flights, the accurate timing of xylose ingestion and urination must be known. Ideally, urine specimens passed while the subject is under the influence of gravity should be separated from those specimens voided while he is weightless. The current urine collection device does not provide for such a separation. Nevertheless, in general terms, both the MA–6 and MA–7 pilots reported no abnormal gastrointestinal symptoms during their missions. Likewise, they related that bladder sensation and function were normal.

Enzymes

In previous flights, a number of enzymes have been studied to evaluate variations of muscle or liver activity resulting from acceleration followed by a weightlessness period or from the prolonged semi-immobilization of the astronaut. Neither the MR–3, MR–4, nor MA–6 pilot showed significant change in transaminase or aldolase activity. No increases in acetylcholine activity have been demonstrated. The dehydrogenases examined have included glutamic, alpha-ketoglutaric, isocitric, malic and lactic dehydrogenases. Of these, only lactic acid dehydrogenase has shown any appreciable change and this has been consistent in each flight. In the MA–6 flight, the lactic acid level was increased. Increases have also been noted in leucylamino peptidase activity and in phosphohexose isomerase. Since these were consistent findings in all previous flights, an effort was made in the MA–7 flight (table 5–IX) to study only those enzyme systems reflecting change. These evaluations will be elaborated further to study heat stability of the enzyme systems and to determine the Michaelis-Menton constants (K_M) for the enzyme reactions. These additional determinations may allow an evaluation of the tissue of origin.

Acknowledgments.—The authors greatly appreciate the assistance rendered by the follow-

TABLE 5–IX.—*Plasma Enzymes Summary MA–7*

	Normal values	MA–7 flight		
		Preflight	Postflight	
		−2 days	+10½ hr	+45 hr
Lactic acid, mg	25 to 35	35	28	44
Phosphohexose isomerase	10 to 20	7	20	28
Leucylamino peptidase	100 to 310	270	300	270
Lactic dehydrogenase	150 to 250	-------	-------	-------
Incubated, 30° C	----------	334	367	434
Incubated, 20° to 25° C	----------	250	525	500
Heat stable	----------	167	183	220
Heat stable, percent	14 to 15	50	50	51
Urea stable	----------	165	250	375
Urea stable, percent	----------	49	68	86

ing individuals: Paul W. Myers, M.D., and Charles C. Watts, Jr., M.D., Lackland Air Force Hospital, San Antonio, Tex.; George Ruff, M.D., University of Pennsylvania; W. Bruce Clark, M.D., USAF School of Aerospace Medicine, San Antonio, Tex.; Carlton L. Stewart, Lackland Air Force Hospital, San Antonio, Tex.; Evan W. Schear, M.D., USAF Hospital, Wright-Patterson Air Force Base, Ohio; Richard A. Rink, M.D., Brooke General Hospital, Fort Sam Houston, Tex.; Rita M. Rapp, NASA Manned Spacecraft Center; Walter Frajola, Ph. D., Ohio State University; Kristen B. Eik-Nes, M.D., University of Utah; and Hans Weil-Malherbe, M.D., St. Elizabeths Hospital, Washington, D.C.; Beatrice Finklestein, Aeromedical Laboratory, Wright-Patterson Air Force Base, Ohio.

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B. PHYSIOLOGICAL RESPONSES OF THE ASTRONAUT

By Ernest P. McCutcheon, M.D., *Aerospace Medical Operations Office, NASA Manned Spacecraft Center;* Charles A. Berry, M.D., *Chief, Aerospace Medical Operations Office, NASA Manned Spacecraft Center;* G. Fred Kelly, M.D., *U.S. Naval Air Station, Cecil Field, Jacksonville, Florida;* Rita M. Rapp, *Life Systems Division, NASA Manned Spacecraft Center; and* Robie Hackworth, *Aerospace Medical Operations Office, NASA Manned Spacecraft Center*

Summary

The MA–7 mission provided an appreciable extension to the observation of man's physiological responses to space flight. The stresses of space flight appeared to have been well tolerated. All flight responses are considered to be within acceptable physiological ranges. Specifically, the heart-rate response to nominal exercise demonstrated a reactive cardiovascular system. An aberrant ECG tracing was recorded during reentry and is believed to have resulted from the increased respiratory effort associated with continued speech during maximum acceleration. No disturbing body sensations were reported as a result of weightless flight. Astronaut Carpenter felt that all body functions were normal. Solid foods can be successfully consumed in flight, but precautions must be taken to prevent crumbling. The biosensors provided useful ECG data, with minimal artifact. The respiration rate sensor provided good prelaunch but minimal in-flight coverage. Because of erratic amplifier behavior, the rectal temperature thermister gave invalid values for approximately one-third of the flight. At the present time, the in-flight blood pressure cannot be interpreted.

Introduction

The three-pass mission of Astronaut M. Scott Carpenter has added a second 4½-hour increment to the time that man's responses to orbital flight have been observed as a part of Project Mercury. There were a number of aeromedical objectives continued from the MA–6 flight including additional study of man's physiological and psychological responses to space flight, i.e., exit and reentry accelerations, weightlessness, weightless transition periods, and an artificial environment.

Although the general objectives for each flight are similar, there are many specific differences. One of the most important medical variables from flight to flight is the normal physiological differences between pilots. Preflight, in-flight, and postflight comparisons for a particular individual can be made in some detail, but only general comparisons with results from previous flights with other subjects are possible. Projections of the flight responses of a new astronaut must include considerations of this important variable.

Data were obtained from clinical examinations, bioinstrumentation, and subjective in-flight observations. The data and analysis from subjective in-flight observations and bioinstrumentation are contained in this part of the Aeromedical Studies paper. Since the pilot's physiological responses cannot be completely separated from his environment, the discussion in paper 1 regarding the environmental control system complements the following analysis.

Mission

The astronaut's activities during the countdown have been discussed in section A of this paper. The transfer van arrived at the launch pad at 4:11 a.m. e.s.t., where the astronaut waited 19 minutes until it was time to ascend the gantry. Insertion into the spacecraft occurred at 4:44 a.m. e.s.t. and physiological monitoring began. The astronaut, wearing the Mercury full-pressure suit, was positioned in his contour couch in the semisupine position and secured by shoulder and lap harnesses. His position, in relation to the spacecraft, re-

mained stationary throughout the flight. For both launch and reentry, the spacecraft is oriented such that the contoured couch is in a plane 90° from the direction of acceleration, which results in the astronaut's being exposed to acceleration transversely, or through the back.

The spacecraft cabin and suit environments were maintained at nearly 100-percent oxygen throughout the flight until the air inlet and outflow valves were opened after reentry. Opening these valves permits the introduction of ambient air. Spacecraft cabin and suit pressures were at ambient levels until launch and then declined to the nominal regulated pressure of 5.1 psia. They remained essentially constant until the pressure relief valve opened at an altitude of 27,000 feet.

The astronaut's total time in the spacecraft while on the launch pad was 3 hours and 1 minute. During this period, spacecraft preparation and final preflight checks were completed, and the astronaut performed frequent deep-breathing and muscle-tensing exercises.

After a 45-minute hold, the spacecraft was launched at approximately 7:45 a.m. e.s.t. and the flight proceeded as planned. The accelerations of powered flight occurred in two phases. The first phase occurred in the first 129 seconds from lift-off to booster engine cutoff (BECO) and varied progressively from $1g$ to $6.5g$. The second phase occurred at the time interval from 130 to 181 seconds which is from BECO to sustainer engine cutoff (SECO). In this phase the accelerations varied smoothly from $1.3g$ at 130 seconds to $7.8g$ at 181 seconds. The period of weightlessness began at 5 minutes and 10 seconds after launch and lasted for 4 hours and 39 minutes.

Reentry acceleration began 4 hours and 44 minutes after launch and increased gradually to a value of $7.5g$, which occurred at 4 hours and 48 minutes ground elapsed time. The buildup from $1g$ and return to $1g$ occurred over a period of 3 minutes and 30 seconds. The spacecraft landed on the water at 12:41 p.m. e.s.t., 4 hours and 56 minutes after launch.

Monitoring and Data Sources

Physiological data for the MA–7 mission were acquired by utilizing methods and sources similar to those used in previous Mercury manned flights. (See refs. 1 to 3.) Data from the Mercury-Atlas three-orbit centrifuge simulation, conducted in September 1961, provide a dynamic experience to compare with the flight data. Recent data for establishing baseline responses were obtained from Astronaut Carpenter's simulated launch for the MA–6 mission and from launch-pad simulated flights in the last weeks before the MA–7 launch. Flight data included the range medical monitor reports, pilot's reports of special tests performed, biosensor data, and voice transmissions. The biosensor data were recorded continuously from 6 minutes before lift-off until bioplug disconnect at 3 minutes prior to landing. The astronaut's voice was recorded from 6 minutes before lift-off until landing. The pilot-observer camera film and the postflight debriefing were additional data sources.

Bioinstrumentation

The biosensor system consists of two sets of electrocardiographic leads, ECG 1 (axillary) and ECG 2 (sternal); a rectal temperature thermistor; a respiration-rate thermistor; and the blood-pressure measuring system (BPMS). The only change from MA–6 flight was the replacement of the manual BPMS with a semiautomatic system as discussed in paper 1.

All sensors operated normally during the countdown except the BPMS. Some 34 minutes prior to lift-off, 3 cycles of the BPMS demonstrated intermittent contact in the microphone cable, but later cycles near lift-off were normal. Twenty-four blood-pressure cycles were obtained in flight. At the present time these records cannot be interpreted. The BPMS and procedures in its use are being extensively investigated in an effort to obtain accurate in-flight blood pressure values.

Figure 5–4 shows a blood-pressure trace from the blockhouse record at 5:52 a.m. e.s.t. 68 minutes prior to launch. A summary of blood-pressure data is presented in table 5–X.

During the flight, body movements and profuse perspiration caused a large number of ECG artifacts, but the record was interpretable throughout the mission.

The respiration rate sensor provided useful preflight information but in-flight coverage was minimal.

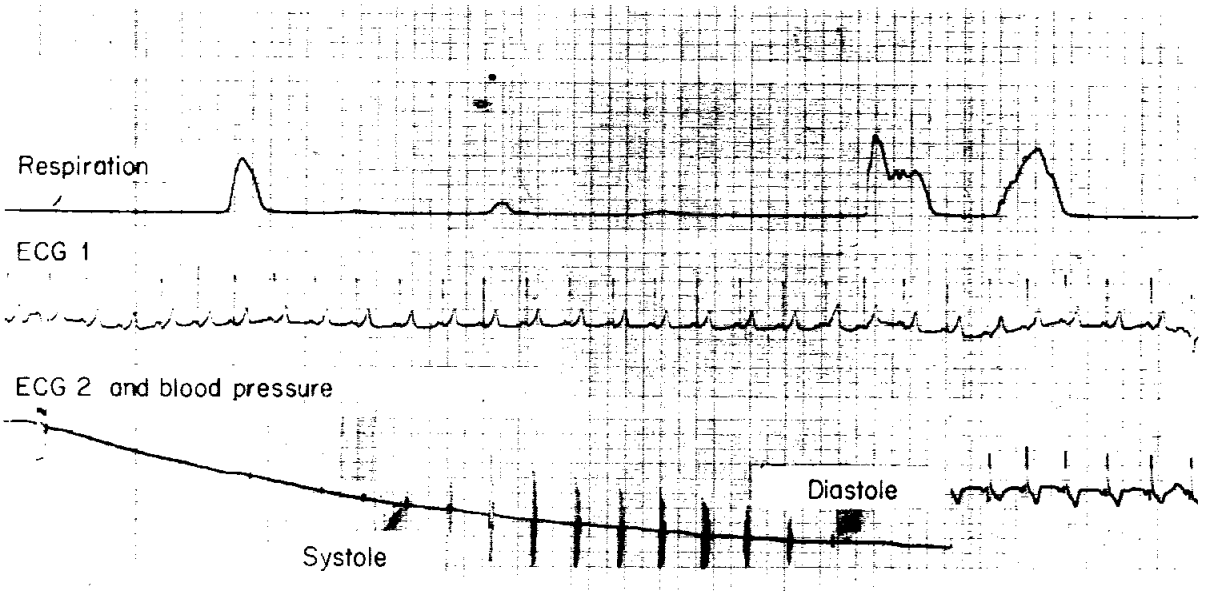

FIGURE 5-4.—Bioinstrumentation from blockhouse records (T-68 minutes).
Speed of the tape-recorder was 10 mm/sec

TABLE 5-X.—*Summary of Blood-Pressure Data*

Data source	Number of values	Mean blood pressure, mm Hg	Standard deviation, 2σ		Systolic range, mm Hg	Diastolic range, mm Hg	Mean pulse pressure, mm Hg
			Systolic	Diastolic			
Preflight physical exams	18	119/73	14	15	98 to 128	58 to 84	46
3-orbit Mercury-Atlas centrifuge simulation	30	130/83	22	15	104 to 155	72 to 106	47
Launch-pad tests	45	127/64	31	18	101 to 149	44 to 84	63
MA-7 countdown	13	116/63	18	12	105 to 139	56 to 70	53
Preflight totals	106	125/71	24	14	98 to 155	44 to 106	54
Postflight physical exams	3	115/76	2	9	114 to 116	70 to 80	39

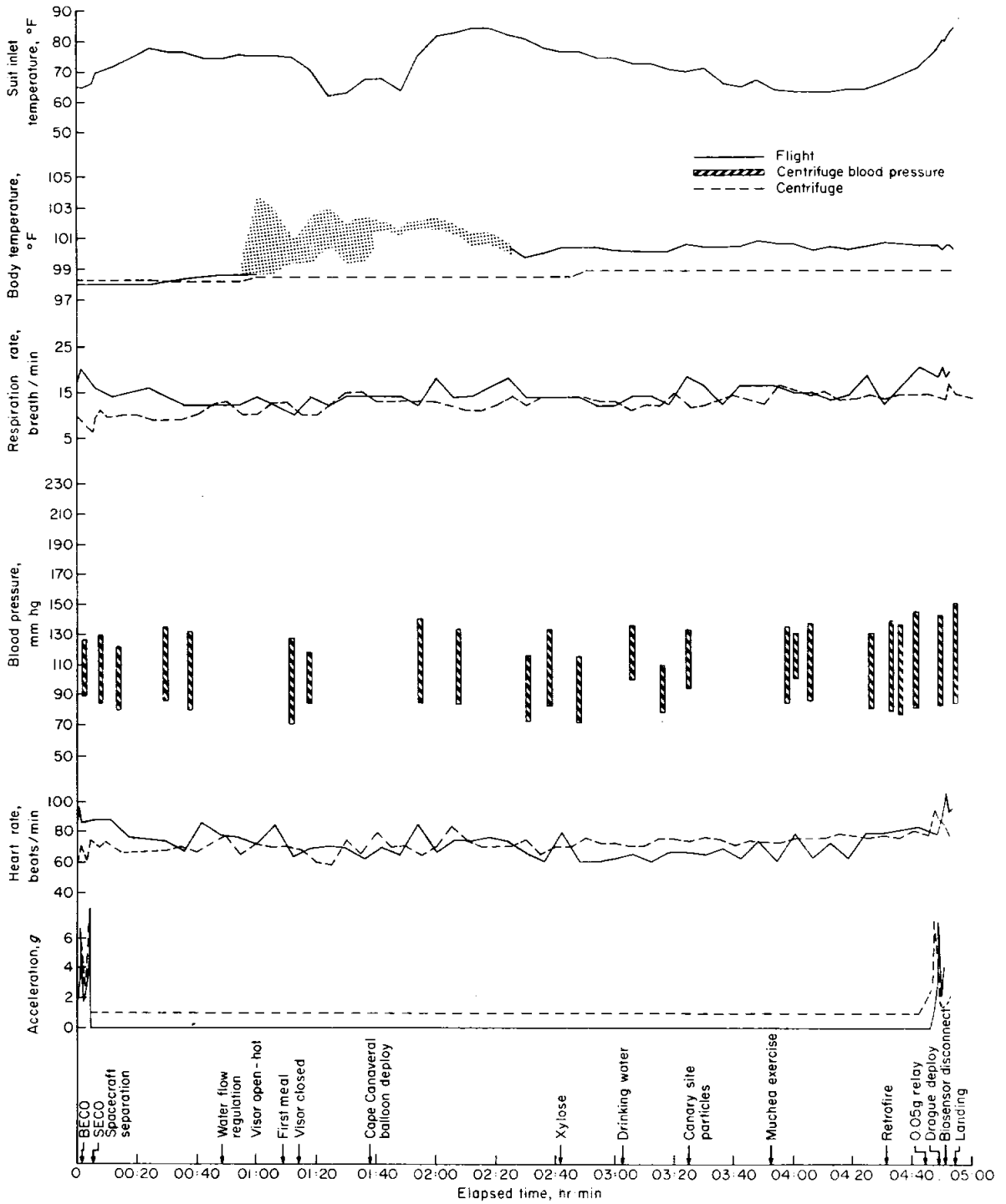

FIGURE 5-5.—Bioinstrumentation in flight.

The instability of the body temperature readout is believed to have been the result of erratic behavior of the amplifier from 59 minutes to 2½ hours after launch, approximately one-third of the flight. This erratic period is shown as a shaded area in figure 5–5. The values at all other times are considered valid.

The pilot-observer camera film, as a result of postlanding immersion in sea water, was of poor technical quality and limited usefulness.

Preflight

In order to obtain pertinent physiological baseline data on Astronaut Carpenter, certain preflight activities were monitored by the medical personnel. Table 5–XI lists these activities and their duration.

TABLE 5–XI.—*Launch-Pad Test Monitoring*

Event	Duration, hr:min
Simulated launch, MA–6, Jan. 17, 1962	5:12
Simulated flight 2, MA–7, Apr. 30, 1962	4:00
Simulated launch, MA–7, May 10, 1962	3:15
Simulated flight 3, MA–7, May 15, 1962	4:50
Launch countdown, MA–7, May 24, 1962	3:01
Total	20:18

Figure 5–6 depicts the heart rate, blood pressure, respiration rate, body temperature, and suit-inlet temperature recorded during the MA–7 countdown. The values for the same physiological functions from the astronaut's MA–6 and MA–7 simulated launches are also shown and the occurrence of significant events is indicated. Heart and respiration rates were determined by counting for 30 seconds every 3 minutes until 10 minutes prior to lift-off, at which time 30-second-duration counts were made each minute. The minute-long counts were continued until orbital insertion.

During the simulated launches of January 17, 1962, and May 10, 1962, the heart rate varied from 48 to 78 beats/minute with a mean of 57 beats/minute. The respiration rate varied from 8 to 32 breaths/minute with a mean of 16 breaths/minute. The blood-pressure values, recorded in millimeters of mercury, showed a systolic range of 101 to 149 and a diastolic range of 44 to 84, with a mean of 135/62. These values were essentially the same as those observed during the MA–7 countdown and are all within an accepted physiological range.

Examination of the ECG wave form from all preflight data revealed sinus arrhythmia, occasional premature atrial contractions (PAC), and rare premature ventricular contractions (PVC). These are normal physiological variations.

During approximately 50 minutes in the transfer van on launch day, the astronaut's heart rate varied from 56 to 70 beats/minutes with a mean of 65. Respiration rate varied from 8 to 20 breaths/minute with a mean of 14. The ECG was normal. Other physiological values were not obtained.

Flight Responses

A summary of the in-flight physiological data is presented in table 5–XII.

The maximum heart rate observed during launch was 96 beats/minute. The increase from 84 to 96 beats/minute occurred within the first 30 seconds of flight and was not, therefore, associated with maximum acceleration. The heart rate during the weightless period remained relatively stable with a mean of 70 beats/minute. The maximum heart rate of 104 beats/minute was found at drogue parachute deployment, which occurred at the time of maximum spacecraft oscillation. The mean rate during reentry was 84 beats/minute. All observed heart rates are well within accepted ranges.

The pilot's in-flight statement that he was comfortable and could not believe the telemetered body temperature readings of 102° F was helpful in the determination of the significance of these readings. The values in question are shown as a shaded area in figure 5–5 but are not included in table 5–XII. This increase in the astronaut's body temperature from 98° to 100.6° F during flight is physiologically acceptable and is believed to have resulted in part from an increased suit inlet temperature. A mild trend of gradually increasing body tempera-

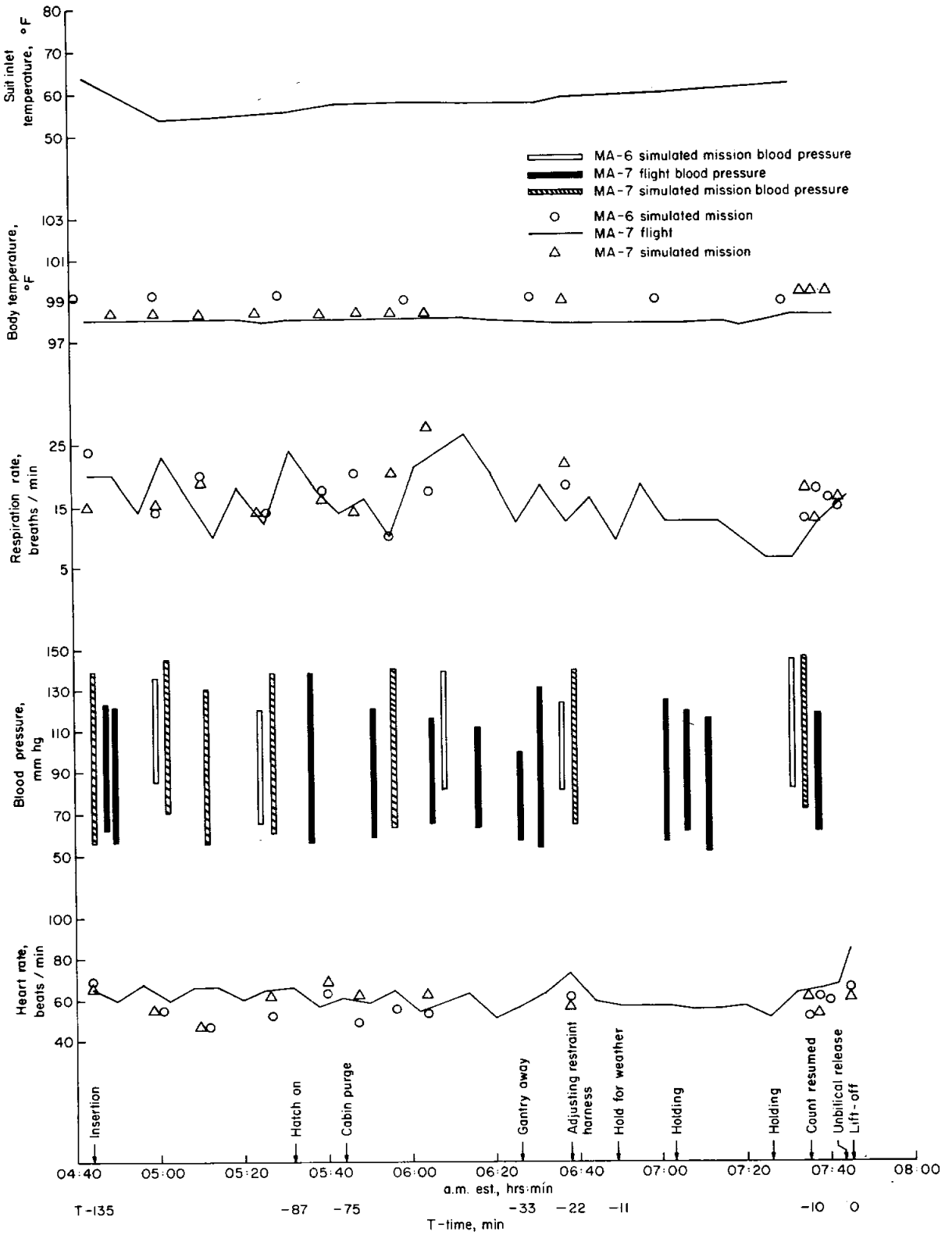

FIGURE 5-6.—Bioinstrumentation in countdown and launch.

TABLE 5-XII.—*Summary of Heart Rate, Respiration Rate, and Body Temperature Data*

Data sources	Heart rate, beats/minute			Respiration rate, breaths/minute			Body temperature, °F		
	Number of values	Mean	Range	Number of values	Mean	Range	Number of values	Mean	Range
All preflight data	408	57	42 to 84	354	15	5 to 32	128	99.3	98.3 to 101.5
Countdown	92	62	50 to 84	75	15	6 to 26	57	97.8	96.8 to 98.2
Flight:									
Launch	7	87	82 to 96	5	16	10 to 20	4	98	98
Orbital	94	70	60 to 94	[a] 83	14	10 to 18	60	99.9	98 to 100.6
Reentry	15	84	72 to 104	[a] 9	19	16 to 24	15	100.4	100.2 to 100.5

[a] Values were obtained from the variation in the height of the ECG R-wave and are approximate only.

ture has been observed in previous manned flights.

The respiration sensor did not provide useful information during most of the flight. Approximate respiratory rates per minute were estimated by using variation in the height of the ECG R-wave and were within normal ranges.

Examination of the ECG wave form recorded during the flight showed an entirely normal record except for the following variations: There was a single premature atrial contraction (PAC) 13 seconds after SECO, followed by a beat showing suppression of the sinus pacemaker. A second PAC occurred 1 minute and 15 seconds before retrofire. At 04:48:19 g.e.t., 21 seconds prior to maximum reentry acceleration, a 43-second period contained a number of cardiac pattern variations. These variations included premature atrial contractions with aberrant QRS complexes, atrial fusion beats, and short runs of four and five nodal beats. A sample of the nodal beats obtained during reentry is shown in figure 5-7. The remainder of the record was entirely normal. During the period of maximum reentry acceleration, Astronaut Carpenter made a special effort to continue talking. The increased respiratory effort associated with continued speech during increasing acceleration is believed to have produced these changes. These irregularities did not compromise the pilot's performance.

Subjective Observations

Astronaut Carpenter stated that the flight was not physically stressful. He was subjectively hot and perspiring during the second orbital pass and the first half of the third pass but was never extremely uncomfortable.

During the acceleration-weightlessness transition phase, there was no tumbling sensation. The pilot was impressed by the silence after separation and adapted quickly to the new environment. He described the weightless state as "a blessing—nothing more, nothing less." He compared the weightless state to that of being submerged in water. The Mercury full-pressure suit was comfortable in the weightless state. The pilot reported that there were no pressure points and that mobility was good. After the retrorockets ignited, the sensation was one of having stopped, rather than that of traveling in an opposite direction from flight as was reported in the MA-6 flight.

The astronaut was always oriented with respect to the spacecraft, but at times lost orientation with respect to the earth. When the horizon was not in view, it was difficult to distinguish up and down positions, but this was never of immediate concern to the astronaut. The only illusory phenomenon occurred just after orbital attitude was attained and involved the position of the special equipment storage kit. At this time, the pilot had rotated from the horizontal to the vertical and was in a seated position relative to the earth's surface. He was surprised to find that the equipment kit had also rotated to this position and was very accessible. Tactile approximation with the eyes closed was the same as that on the ground. There was no tendency to overshoot or underreach control switches on the spacecraft instrument panel.

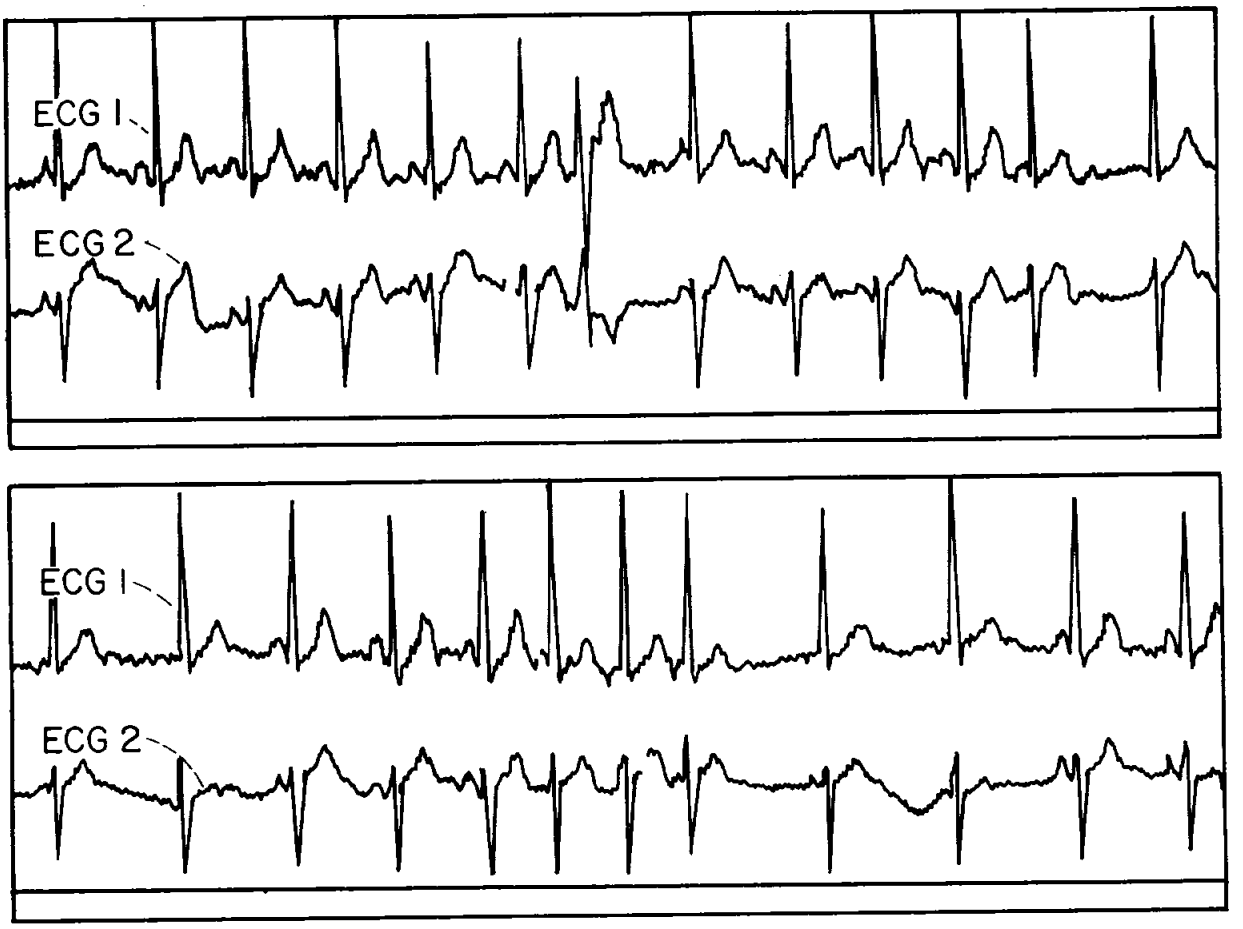

FIGURE 5–7.—Onboard physiological reentry data.

No disturbing sensory inputs were reported during weightless flight. Violent head maneuvers within the limited mobility of the helmet were performed several times in every direction without symptoms of disorientation or vertigo. Vision was normal throughout the flight, and colors and brightness of objects were clear and easily discernible. Distances were estimated by the relative size of objects. There was no detectable change in hearing. Somatic sensations were normal and no gastrointestinal symptoms were apparent.

During flight, Astronaut Carpenter consumed solid food, water, and a xylose tablet without difficulty. The solid food was in the form of bite size, ¾-inch cubes with a special coating, packed loosely in a plastic bag and stored in the equipment kit. Since the crumbling was reported when he first attempted to eat, it is believed that the food was inadvertently crushed during final spacecraft preparation on the launch pad. The special coating having been broken, the food continued to crumble during flight. The pilot stated that the floating particles within the spacecraft were a potential inhalation hazard. Finally, the elevated cabin temperature caused the candy to melt. He reported the only difficulty was in getting the crumbled food particles to his mouth. Once in the mouth, chewing and swallowing of both solids and liquids were normal. Taste and smell were also normal.

A total of 1,213 cc of water was consumed from the mission water supply. An estimated 60 percent was consumed in flight and the remainder after landing.

Calibrated exercise was performed without difficulty at 03:59:29 g.e.t. Because of the overheated condition of the pilot, earlier scheduled exercises were omitted. A hand-held bungee cord with a 16-pound pull through a distance of 6 inches was used. Use of this device for a

short period caused an increase of 12 beats per minute in heart rate with return to previous values within 1 minute. The heart-rate response to this nominal exercise demonstrated a reactive cardiovascular system.

Attempts to produce autokinesis (illusion of vision due to involuntary eye muscle movements) were made on two occasions. Autokinesis was not produced but the tests were inconclusive.

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6. PILOT PERFORMANCE

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Summary

The results of the MA–7 orbital flight further indicate that man can function effectively in a space environment for periods up to 4½ hours. In general, the pilot can orient the spacecraft to a given attitude by using external reference provided sufficient time is available for determining yaw alinement. As with the MA–6 flight the results of this flight provide evidence that the man can serve as a backup to the automatic spacecraft systems. The pilot has demonstrated his ability to operate scientific apparatus successfully in a space environment and to obtain useful data for the analysis of scientific problems associated with a terrestrial space environment. The results of the MA–7 flight provide additional evidence that man is ready for a more extended mission in a weightless environment. Flight difficulties occurring during this mission, however, have served to emphasize that the primary attention of the pilot should be devoted to management of spacecraft systems and detailed attention to operational functions.

Introduction

The pilot's primary role during the MA–7 mission, as in the MA–6 mission, was to report and monitor systems operations and, if necessary, to take corrective action in order to achieve the mission objectives. The pilot's secondary responsibility during both of these missions was to conduct scientific experiments and to make observations that would further evaluate the spacecraft systems' performance. The purpose of this paper will be to discuss the pilot's performance in accomplishing the primary mission objectives. Only a few of the pilot's secondary tasks, such as scientific experiments and observations, are discussed here, since many of these are discussed in papers 1, 4, and 7 of this report.

Preflight Performance

A flight plan was formulated for the MA–7 flight to guide the pilot in carrying out the operational and experimental objectives of the mission. This plan defined the mission activities and established the sequence in which these activities were to be attempted. In preparation for the flight, the pilot participated in extensive preflight checkout activities and training sessions. In general, his preflight activities were similar to those accomplished by the MA–6 pilot as shown in table 6–I; however, the MA–7 pilot generally did acquire more time on the trainers and in the spacecraft than did the

TABLE 6–I.—*Pilot Training Summary*

Flight	ALFA and Mercury procedures trainers				Time spent on spacecraft systems checks, hr:min
	Time hr:min	Number of simulated failures	Number of simulated missions	Number of simulated control maneuvers	
MA–6 (Glenn)	59:45	189	70	162	25:55
MA–7 (Carpenter)	70:45	143	73	255	45:00

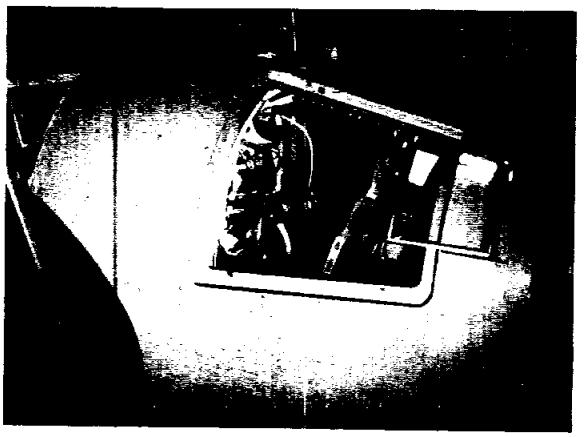

FIGURE 6–1.—Astronaut Carpenter in the Langley procedures trainer.

MA–6 pilot. It should be pointed out that this table summarizes only the pilots' specific preparation for their particular flight and does not include general training accomplished since their selection as astronauts.

It should be noted that Astronaut Carpenter had an opportunity to become familiar with the spacecraft and launch-vehicle operations during his period as backup pilot for the MA–6 flight. Thus, in addition to the experience indicated in table 6–I, he spent approximately 80 hours in the MA–6 spacecraft during its checkout period at the launch site. This period of familiarization provided him with an opportunity to increase his knowledge of the spacecraft systems and gave him a good background for his own MA–7 mission preparation activities. The training activities, which were conducted in the Langley (see fig. 6–1) and Cape Canaveral procedures trainer and the air-lubricated free-attitude (ALFA) trainer, included a large number of attitude control maneuvers and simulated system failures. These trainers have been described in references 1 and 2. The pilot was also thoroughly rehearsed on egress and recovery procedures. (See fig. 6–2.) In addition to the above-mentioned training activities, the MA–7 pilot participated in several launch abort and network simulations during which the mission rules and the flight plan were rehearsed and discussed. Although the training as described above was extensive, it should be recognized that limitations in the Mercury procedures trainer precluded practice of certain activities, such as controlling attitude by using external references.

FIGURE 6–2.—Astronaut Carpenter practicing egress procedures.

Control Tasks

Several control tasks and in-flight maneuvers were programed for the MA–7 flight to obtain information on orientation problems in space and the ability of the pilot to perform attitude control tasks. These control tasks included turnaround, tracking, maneuvering, drifting flight, and retrofire. It should be pointed out that the pilot's performance could not be quantitatively analyzed because:

1. The pitch horizon scanner circuit appeared to have malfunctioned.
2. The pilot deviated somewhat from planned procedures established prior to the mission.
3. The gyros were caged during much of the flight.
4. The spacecraft attitudes exceeded the viewing limits of the horizon scanners on a number of occasions.

With these limitations in mind, the attitude control tasks are discussed in the following paragraphs.

Turnaround Maneuver

The primary purpose in scheduling a manual turnaround after spacecraft separation was to conserve reaction control system fuel.

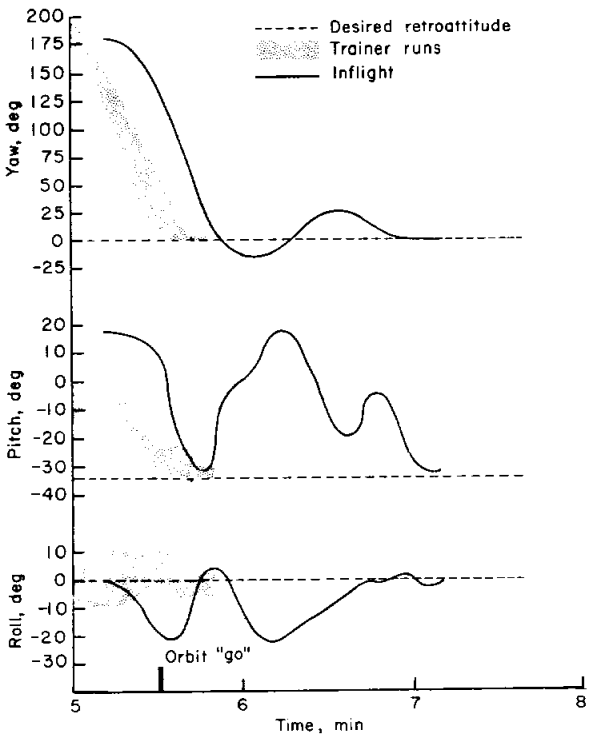

FIGURE 6–3.—Turnaround maneuver.

The pilot used only 1.6 pounds of control fuel for the MA–7 turnaround, whereas past flight experience has shown that the automatic control system employs over 4 pounds of control fuel for this maneuver.

The shaded area of figure 6–3 displays the pilot's performance during turnaround training sessions, and the uncorrected gyro attitudes indicated during the actual flight maneuver are represented by the solid curves. The flight maneuver was performed in yaw approximately as planned, and the correct spacecraft orientation was achieved shortly after separation from the launch vehicle.

Although indicated roll attitude deviated to a greater extent during the in-flight turnaround maneuver than in training sessions, the pilot successfully brought roll attitude to zero by the end of the maneuver.

The pitch attitude indication initially varied from that of the trainer because of the malfunction in the pitch horizon scanner circuit described in paper 1. Therefore, the pilot was required to perform a correction in pitch which was considerably larger than planned, and as figure 6–3 shows, he accomplished this correction in approximately the same time exhibited during training exercises. Then the pilot allowed the spacecraft attitude to diverge for a considerable period of time before stabilizing as planned at retroattitude, as shown in figure 6–3. However, it should be noted that an insertion "go" condition had been received from ground control during the turnaround, and it was not essential for the pilot to hold orbit attitude.

Sustainer Stage Tracking

The purpose of tracking the sustainer stage was to investigate the ability of the pilot to observe an object in space and to determine his capability to perform pursuit tracking of an object in a slightly different trajectory. The pilot readily sighted the sustainer stage through the spacecraft window after completion of spacecraft turnaround at a calculated distance of approximately 300 yards. He continued to observe and photograph the sustainer for 8½ minutes at which time the sustainer stage was calculated to be at a range of 3 miles behind and below the spacecraft. During this period, the pilot noted a very slow tumbling motion of the sustainer and also observed small crystalline particles emanating from the sustainer nozzle.

Sufficient data were not obtained to permit a quantitative analysis of the pilot's tracking capability. However, the pilot stated that he believed precision tracking would not be a difficult task while using the low thrusters for control.

Use of External Reference for Maneuvering

This flight has further shown that manual control of spacecraft attitudes through the use of external references can be adequately accomplished under daylight and moonlit night conditions. Furthermore, the MA–7 flight provided evidence that spacecraft orientation about the pitch and roll axes could be accomplished manually on the dark side of the earth without moonlight by using the airglow layer as a horizon reference.

Manual control of the spacecraft yaw attitude using external references has proven to be more difficult and time consuming than pitch and roll alinement, particularly as external lighting diminishes. Although no precision

maneuvers were accomplished on the flight which could be quantitatively analyzed, the pilot did confirm that ground terrain drift provided the best daylight reference in yaw. However, a terrestrial reference at night was useful in controlling yaw attitudes only when sufficiently illuminated by moonlight. In the absence of moonlight, the pilot reported that the only satisfactory yaw reference was a known star complex near the orbital plane.

Drifting Flight

During the final portion of the MA–7 flight, the spacecraft was allowed to drift free to conserve fuel and to evaluate the behavior of the astronaut and vehicle during drifting flight. The spacecraft drifted for a total of 1 hour and 17 minutes during the mission, 1 hour and 6 minutes of which was continuous during the third orbital pass. Rates of 0.5 degree/second or less were generally typical of this period when the spacecraft was allowed to drift completely free of all control inputs. The pilot commented that on one occasion during drifting flight, he observed the moon for a significantly long period in or near the center of the window, indicating that attitude rates were near zero. Data showed that spacecraft attitude rates were less than 0.5 degree/second during this particular period. The pilot also reported that drifting flight was not disturbing and that he was not concerned when external references were temporarily unavailable. It would appear, then, that drifting flight, in addition to conserving fuel, affords a period when the pilot can be relatively free to accomplish many useful activities and experiments without devoting attention to spacecraft orientation.

Retrofire Maneuver

It was intended to have the automatic control system maintain spacecraft attitude during the firing of the retrorocket; however, the malfunction of the pitch horizon scanner circuit dictated that the pilot manually control the spacecraft attitudes during this event. Except for the late ignition of the retrorockets, the pilot reported that he believed the maneuver had proceeded without serious misalinement of the spacecraft attitude. However, the spacecraft overshot the intended landing point by approximately 250 miles.

The pilot backed up the automatic retrofire system by pushing the manual retrofire button when the event did not occur at the commanded time. Retrofire occurred 3 to 4 seconds late which accounted for approximately 15 to 20 miles of the total overshoot error.

In an effort to explain the major cause of the overshoot error, a review of the events just prior to and during the retrofire is presented. At approximately 11 minutes prior to retrofire, the pilot observed a possible source of the luminous particles previously reported by Astronaut Glenn during the MA–6 mission. This event followed by photographing of these particles delayed his completing the stowage of the onboard equipment as well as the accomplishment of the preretrosequence checklist.

At approximately 6 minutes prior to retrofire the pilot enabled the manual proportional (MP) control system as a backup to the automatic stabilization and control system (ASCS), as specified for an automatic retrofire maneuver. The pilot then engaged his automatic control system and almost immediately reported a discrepancy between the instruments and the external window references. In the 5 minutes prior to retrosequence (T–30 sec), he attempted to analyze the automatic control system problem, and rechecked his manual control systems in preparation for this event.

At 30 seconds before retrofire, the pilot again checked his ASCS orientation mode upon ground request. While the pilot was making this check, the spacecraft attained excessive pitch-down attitude; therefore, the pilot quickly switched from ASCS to FBW modes and repositioned the spacecraft to retrofie attitude using his earth-through-window reference. It was during this period that gyro outputs indicated a significant excursion in yaw attitude. As a result of switching to the FBW mode without cutting off the MP mode, the pilot inadvertently used double authority control. Because of the horizon scanner malfunction the pilot cross referenced between the gyro indications and the external references for attitude information during the firing of the retrorockets.

Figure 6–4 presents the gyro output attitude indications as well as the desired attitudes to be held during retrofire. Because of the horizon scanner malfunction, the gyro indications do

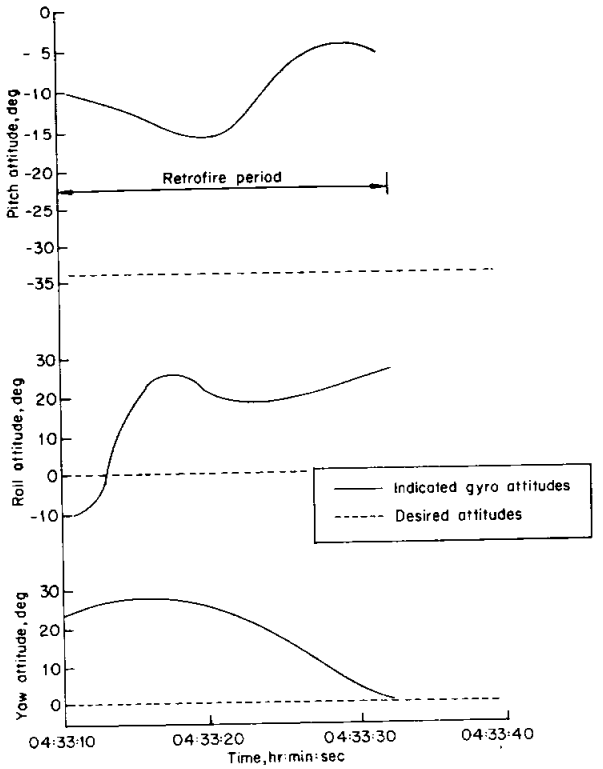

FIGURE 6–4.—Indicated spacecraft attitudes during retrofire. Not corrected, gyros free.

not necessarily represent the true spacecraft attitudes particularly; however, they do illustrate the trends in attitude as a function of elapsed time during retrofire. However, these are the indicated attitudes displayed to the pilot.

Radar tracking data have indicated that the mean spacecraft pitch attitude during the retrofire period was essentially correct. Thus the deviation in pitch attitude shown in this figure did not contribute to the overshoot error in landing. Some deviations are also shown in spacecraft roll attitude during retrofire; however, roll errors of this magnitude have a negligible effect on landing point dispersion. Thus, the error in landing position resulted primarily from a misalinement in spacecraft yaw attitude (indicated in fig. 6–4). Radar tracking data have shown that the spacecraft had an average yaw error of 27° during retrofire. It should be noted, however, that the error in yaw was essentially corrected by the end of the retrofire event.

In review, the pilot, by manually controlling the spacecraft during retrofire, demonstrated an ability to orient the vehicle so as to effect a successful reentry, thereby providing evidence that he can serve as a backup to malfunctioning automatic systems of the spacecraft. The extensive review of this maneuver further serves to illustrate the desirability of assigning priority to flight requirements so that sufficient time will be available to perform the more critical operational activities.

Fuel Management

The fact that the fuel usage rate was greater than expected was an area of major concern during this flight. This primarily resulted from the extensive use of high thruster control for orbit maneuvering, inadvertent actuation of two control systems simultaneously, and frequent engagement of the automatic system orientation control mode which generally uses high thrusters to reorient the spacecraft to orbit attitude.

As pointed out in paper 1, a systems modification has been incorporated on future spacecraft to preclude recurrence of high thruster usage for manual maneuvering in orbit. Further training emphasizing a more strict adherence to optimal operation of the control system, as well as simplified attitude maneuvering requirements and reduced control mode switching should also help reduce excessive fuel consumption for future Mercury flights.

Scientific Experiments

In addition to controlling the spacecraft and monitoring systems operations during the flight, the pilot also assumed a dominant role in accomplishing a number of in-flight experiments. One of these experiments consisted of deploying a multicolored inflatable balloon from the spacecraft while in orbit. The balloon was tethered to the spacecraft by means of a 100-foot braided nylon line. It was intended that the pilot should observe balloon motions and the various color patterns on the balloon to determine which appeared best suited for visual detection in space. Drag measurements were also to be taken at periodic intervals throughout the flight.

The balloon was deployed as programed. The pilot was readily able to observe the balloon and attachment line as well as the balsa inserts used to hold the package prior to deployment. The pilot noted that both the orange and aluminum segments were visible and photographs confirmed this report. The pilot was also able to discern the irregular shape assumed by the balloon when it failed to inflate properly. The random motion of the balloon noted by the pilot was probably a result of large attitude maneuvers of the spacecraft and unsteady aerodynamic loading because of the irregular balloon shape. The pilot was able to maintain visual balloon contact throughout the orbital daylight phases and on several occasions at night. Effective evaluation of the colors and meaningful measurements of the balloon drag were, of course, compromised by failure of the balloon to inflate fully.

Another experiment was conducted which was intended to define the earth's limb by photographing the daylight horizon with a blue and red split filter over the film plane. The pilot was able to maneuver the spacecraft into the correct attitude during the proper phase of the daylight pass and to expose a number of frames of film for microdensitometer evaluation by scientists of MIT. Of the 26 frames analyzed, 20 have yielded good data and 6 are questionable. Figure 6–5 is an example of one of the photographs taken during this experiment. The densitometer analysis has indicated that the earth's limb definition in the blue is very regular and this can be seen from the sample photograph; however, the definition in the red is variable due partly to the distorting effect of the clouds. It is hoped that a complete analysis of these results will yield information on the height of the earth's limb; however, at the present results are still incomplete.

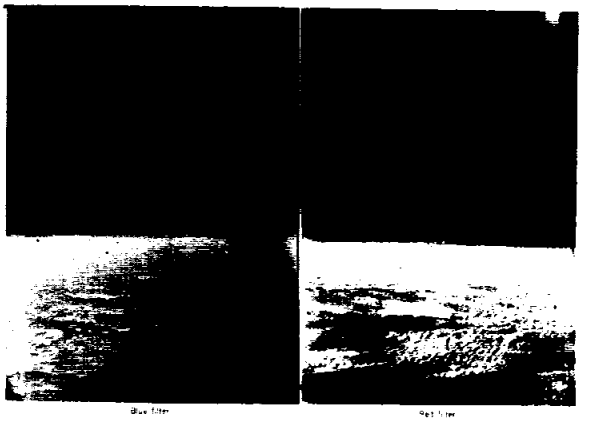

FIGURE 6–5.—Representative photograph of horizon definition.

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7. PILOT'S FLIGHT REPORT

By M. Scott Carpenter, *Astronaut, NASA Manned Spacecraft Center*

Summary

An account of the major events and personal observations of the MA–7 flight is reviewed by the pilot. Prior to and during powered flight, launch-vehicle noise and vibration were less than expected. As in the MA–6 mission, the astronaut quickly adapted to weightless flight and remarked that it was more comfortable and provided greater mobility than under normal gravity. Astronaut Carpenter also observed the space particles and the bright horizon band, previously reported by Astronaut John H. Glenn, Jr., and secured new information on both phenomena. The final phases of the flight, including retrosequence, reentry, landing, and egress, are covered in detail.

Introduction

The previous papers in this report have considered the engineering and operational aspects of the MA–7 mission, including a scientific analysis of some of my flight observations. In this presentation, I shall attempt to give a narrative account of my impressions during the flight.

A period of more than 2 months, most of which was spent at Cape Canaveral, was consumed in preparing me for the orbital flight. My activities during this period were very similar to those which I, as the backup pilot, described in a paper on Astronaut Preparation for the MA–6 report. The experience gained as the backup pilot to John Glenn was valuable practice for my own preparation period prior to the MA–7 flight. In the discussion which follows, I will report my observations, sensations, and experiences.

Launch Phase

Insertion into the spacecraft was accomplished without incident, except for a minor problem with the tiedown of the visor seal bottle hose to the helmet. The countdown went perfectly until the 45-minute weather hold. At T–10 minutes it was picked up again and proceeded perfectly once more until lift-off. During the prelaunch period I had no problems. The couch was comfortable, and I had no pressure points. The length of the prelaunch period was not a problem. I believe I could have gone at least twice as long. Throughout this period, the launch vehicle was much more dormant than I had expected it to be. I did not hear the clatter that John Glenn had reported. Once I felt the engines gimbaling. I do not recall hearing the lox venting.

When the ignition signal was given, everything became quiet. I had expected to feel the launch vehicle shake, some machinery start, the vernier engines light off, or to hear the lox valve make some noise, but I did not. Nothing happened until main engine ignition; then I began to feel the vibration. There was a little bit of shaking. Lift-off was unmistakable.

About a minute and a half after lift-off, the sky changed in brightness rather suddenly. It was not black, but it was no longer a light blue. The noise and vibration increased so little during maximum dynamic pressure that it would not be noticed unless you were looking for it. The booster engine cutoff (BECO) was very gentle. Three seconds later, staging occurred. There was no mistaking staging. Two very definite noise cues could be heard: one was the decrease in noise level that accompanied the drop in acceleration; the other was associated with staging. At staging there was a change in the light outside the window and I saw a wisp of smoke.

At tower jettison, I felt a bigger jolt than at staging, and it was gone in a second. Out the window, the tower could be seen way off in the distance, heading straight for the horizon. It was rotating slowly, with smoke still trailing

out of the three nozzles. Just prior to BECO, I noticed a low-frequency oscillation in yaw. This picked up again after BECO and increased very gradually until sustainer engine cutoff (SECO).

At SECO, the dropoff in acceleration was not disturbing. Two separate bangs could be heard: first, the clamp ring explosive bolts, and then, the louder noise of the posigrade rockets. The best cues to the end of powered flight were weightlessness and absolute silence.

Orbital Flight Phase

General Flight Observations

I began the turnaround and wondered why I felt nothing. At this time, the angular accelerations of the spacecraft were not perceptible, and only the blackness of space could be seen through the window. The instruments provided the only reference. The turnaround proceeded just as in the trainer except that I was somewhat distracted initially by the new sensation of weightlessness. I followed the needles around and soon there was the horizon.

Following the turnaround, I watched the expended launch vehicle through the window as it fell behind me, tumbling slowly. It was bright and easily visible. I could see what looked like little ice crystals emanating from the sustainer engine nozzle. They seemed to extend for two or three times the length of the lannch vehicle, in a gradually broadening fan pattern.

After the initial sensation of weightlessness, it was exactly what I had expected from my brief experience with it in training. It was very pleasant, a great freedom, and I adapted to it quickly. Movement in the pressure suit was easier and the couch was more comfortable. Later, when I tried to eat the solid food provided for the flight, I found it crumbled in its plastic bag. Every time I opened the bag, some crumbs would come floating out; but once a bite sized piece of food was in my mouth, there was no problem. It was just like eating here on earth.

Orientation

My only cues to motion were the instruments and the view through the window and periscope. At times during the flight, the spacecraft angular rates were greater than 6° per second, but aside from vision, I had no sense of movement.

I was never disoriented. I always knew where the controls and other objects within the cabin were relative to myself. I could reach anything I needed. I did have one unusual experience. After looking out the window for some time, I noticed that when I turned my head to the right to look at the special equipment storage kit, I would get the impression that it was oriented vertically, or 90° from where I felt it should be. This impression was because of my training in the procedures trainer and lasted only temporarily.

At times when the gyros were caged and nothing was visible out the window, I had no idea where the earth was in relation to the spacecraft. However, it did not seem important to me. I knew at all times that I had only to wait and the earth would again appear in the window. The periscope was particularly useful in this respect, because it had such a wide field of view. Even without it, however, the window would have been adequate.

Unusual Flight Attitudes

During the flight I had an opportunity to investigate a number of unusual flight attitudes. One of these was forward inverted flight. When I was pitched down close to −90°, I think I could pick out the nadir point, that is, the ground directly below me, very easily without reference to the horizon. I could determine whether I was looking straight down or off at an angle. During portions of the second and third orbits, I allowed the spacecraft to drift. Drifting flight was effortless and created no problems.

Alining the gyros consumed fuel or time. The horizon provided a good roll and pitch reference as long as it was visible in the window. On the dark side of the earth, the horizon or the airglow layer is visible at all times, even before moonrise. Yaw reference was a problem. The best yaw reference was obtained by pitching down −50° to −70° and looking through the window. The periscope provided another good

yaw reference at nearly any attitude. The zero-pitch mark on the periscope was also a valuable reference for alining the gyros since at zero pitch, the horizon could not be seen through the window. Yaw attitude is difficult to determine at night, and the periscope is of little help in determining yaw on the night side. The best reference is a known star.

Control System Operation

For normal maneuvering in orbit, fly-by-wire, low thrusters only, was the best system. However, I believe for a tracking task, manual proportional control might be more desirable, although I did not actually try it for this purpose. The fly-by-wire high thrusters and the rate command and auxiliary damping systems were not needed for the tasks that I had to perform in orbit prior to preparing for retrofire.

In orbit, the operation of the solenoids of both the high and low thrusters of the fly-by-wire system could be heard. I could hear and feel the rate command system, both the solenoids and the thruster. When using the manual proportional mode, I did not hear the control linkages, but again I heard the thrusters. Through the window, the exhaust from the pitch-down thrusters could be seen. There was no movement, just a little "V" of white steam in front of the window. It was visible even at night.

Balloon Observations

At balloon deployment, I saw the confetti as it was jettisoned, but it disappeared rapidly. I saw one of the balsa blocks and mistook it for the balloon. Finally, the balloon came into view; it looked to me like it was a wrinkled sphere about 8 to 10 inches thick. It had small protrusions coming out each side. The balloon motion following deployment was completely random.

Terrestrial Observations

There was no difference between the appearance and color of land, water areas, or clouds from orbit and the view from a high-flying aircraft. (See fig. 7–1.) The view looked to me exactly like the photographs from other Mercury flights. The South Atlantic was 90 percent covered with clouds, but all of western Africa was clear. I had a beautiful view of Lake Chad. Other parts of Africa were green, and it was easy to tell that these areas were jungle.

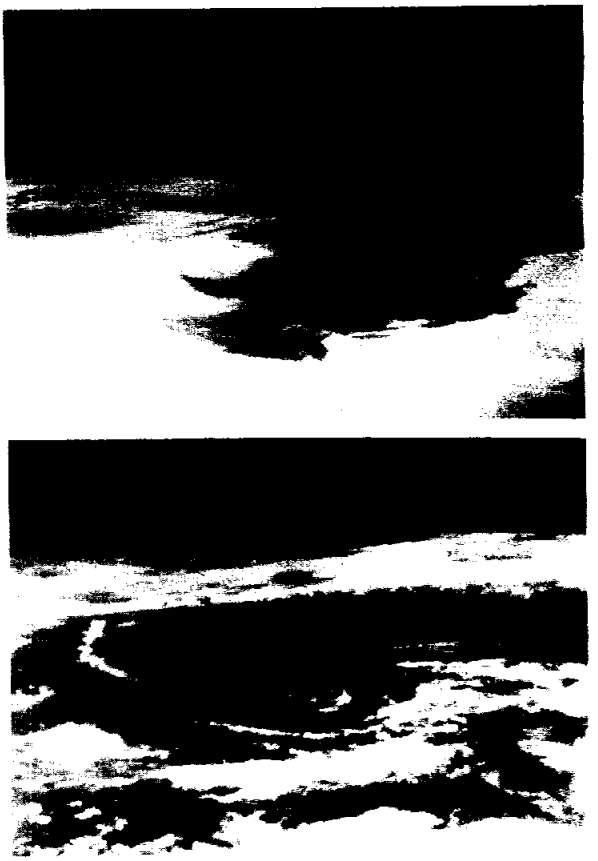

FIGURE 7–1.—Examples of interesting cloud formations photographed by Astronaut Carpenter.

There were clouds over the Indian Ocean. Farther west in the Pacific, it was not heavily clouded, but the western half of Baja California, Mexico, was covered with clouds along its entire length. The eastern half was clear. Over the United States on the second orbit, I noticed a good amount of cloudiness, but after retrofire I could see the area around El Centro, Calif., quite clearly. I saw a dirt road and had the impression that had there been a truck on it, I could have picked it out. I did not see Florida or the Cape Canaveral area.

Celestial Observations

Because of the small source of light around the time correlation clock, I was not fully dark adapted, nor was the cabin completely dark; therefore, I did not see any more stars than I could have seen from the earth. After having seen the star, Corvus, during the flight and later in the recovery airplane, I am convinced that a lot more stars can be seen from the ground than

FIGURE 7-2.—Sunset as viewed by Astronaut Carpenter in orbital flight.

I could see through the spacecraft window. I could, nevertheless, readily see and identify the major constellations and use them for heading information. I could not see stars on the daylight side if the earth was in the field of view of the window. However, I do remember seeing stars at the western horizon when the sun was just up in the east but the terminator had not yet reached the western horizon. The sunrises and sunsets were the most beautiful and spectacular events of the flight. Unlike those on earth, the sunrises and sunsets in orbit were all the same. The sharply defined bands of color at the horizon were brilliant. (See fig. 7-2.)

On the dark side of the earth, I saw the same bright band of light just above the horizon which John Glenn reported. I measured the width of this band in a number of ways, and I also observed it through a special "airglow" filter. A description and analysis of my observations are discussed in the Space Science report (paper 4).

A number of times during the flight, I observed the particles reported by John Glenn. They appeared to be like snowflakes. I believe that they reflected sunlight and were not truly luminous. The particles traveled at different speeds, but they did not move away from the vehicle as rapidly as the confetti that was deployed upon balloon release. At dawn on the third orbit as I reached for the densiometer, I inadvertently hit the spacecraft hatch and a cloud of particles flew by the window. Since I was yawed to the right, the particles traveled across the front of the window from the right to the left. I continued to knock on the hatch and on other portions of the spacecraft walls, and each time a cloud of particles came past the window. The particles varied in size, brightness, and color. Some were gray and others were white. The largest were 4 to 5 times the size of the smaller ones. One that I saw was a half inch long. It was shaped like a curlicue and looked like a lathe turning.

Retrograde and Reentry Phase

Retrosequence

I think that one reason that I got behind at retrofire was because, just at dawn during the third orbit, I discovered the source of the space particles. I felt that I had time to get that taken care of and still prepare properly for retrofire, but time slipped away. The Hawaii Cap Com was trying very hard to get me to do the preretrograde checklist. After observing the particles, I was busy trying to get alined in orbit attitude. Then I had to evaluate the problem in the automatic control system. I got behind and had to stow things haphazardly.

Just prior to retrofire, I had a problem in pitch attitude, and lost all confidence in the automatic control system. By this time, I had gone through the part of the preretro checklist which called for the manual fuel handle to be out as a backup for the automatic control system. When I selected the fly-by-wire mode, I did not shut off the manual system. As a result, attitude control during retrofire was accomplished on both the fly-by-wire and the manual control modes.

At the time, I felt that my control of spacecraft attitude during retrofire was good. My reference was divided between the periscope, the window, and the attitude indicators. When the retroattitude of $-34°$ was properly indicated by the window and the periscope, the pitch attitude indicator read $-10°$. I tried to hold this attitude on the instruments throughout retrofire, but I cross-checked attitude in the window and the periscope. I have commented many times that on the trainer you cannot divide your attention between one attitude reference system and another and still do a good job in retrofire. But that was the way I controlled attitude during retrofire on this flight.

Although retrosequence came on time, the initiation of retrofire was slightly late. After

receiving a countdown to retrofire from the California Cap Com, I waited 2 seconds and then punched the manual retrofire button. About 1 second after that I felt the first retrorocket fire.

If the California Cap Com had not mentioned the retroattitude bypass switch, I would have forgotten it, and retrofire would have been delayed considerably longer. Later, he also mentioned an auxiliary damping reentry which I think I would have chosen in any case, but it was a good suggestion to have.

I had expected a big "boot" from the retrorockets. But the deceleration was just a very gentle nudge. The ignition of the rockets was just audible. Retrofire gave me a sensation, not of being pushed back toward Hawaii as John Glenn had reported, but of being slowed down in three increments. By the time the retrofire was over, I felt that there had been just enough deceleration to bring the spacecraft to a stop; but of course, it had not stopped.

Reentry

Retropack jettison and the retraction of the periscope occurred on time. At this time, I noticed my appalling fuel state and realized that I had controlled retrofire on both the manual and fly-by-wire systems. I tried both the manual and the rate-command control modes and got no response. The fuel gage was reading about 6 percent, but the fuel tank was empty. This left me with 15 percent on the automatic system to last out the 10 minutes to 0.05g and to control the reentry. I used it sparingly, trying to keep the horizon in the window so that I would have a correct attitude reference. I stayed on fly-by-wire until 0.05g. At 0.05g I think I still had a reading of about 15 percent on the automatic fuel gage. I used the window for attitude reference during reentry because of the difficulty I had experienced with the attitude displays prior to retrofire.

I began to hear the hissing outside the spacecraft that John Glenn had described. The spacecraft was alined within 3° or 4° in pitch and yaw at the start of the reentry period. I feel that it would have reentered properly without any attitude control. The gradual increase of aerodynamic forces during the reentry appeared to be sufficient to aline the spacecraft properly. Very shortly after 0.05 g, I began to pick up oscillations on the pitch and yaw rate needles. These oscillations seemed about the same as those experienced in some of the trainer runs. From this I decided that the spacecraft was in a good reentry attitude, and I selected the auxiliary damping control mode.

I watched both the rate indicator and the window during this period, because I was beginning to see the reentry glow. I could see a few flaming pieces falling off the spacecraft. I also saw a long rectangular strap going off in the distance. The window did not light up to the extent that John Glenn reported. I did not see a fiery glow prior to peak acceleration.

I noticed one unexpected thing during the heat pulse. I was looking for the orange glow and noticed instead a light green glow that seemed to be coming from the cylindrical section of the spacecraft. It made me feel that the trim angle was not right and that some of the surface of the recovery compartment might be overheating. However, the fact that the rates were oscillating evenly strengthened my conviction that the spacecraft was at a good trim angle. The green glow was brighter than the orange glow around the window.

I heard the Cape Cap Com up to the blackout. He told me that blackout was expected momentarily. I listened at first for his command transmission, but it did not get through. So I just talked the rest of the way down.

At peak acceleration, oscillations in rate were nearly imperceptible, since the auxiliary damping was doing very well. The period of peak acceleration was much longer than I had expected. I noticed that I had to breath a little more forcefully in order to say normal sentences.

Landing

At around 70,000 feet, I may have run out of automatic fuel. I do not remember looking at the fuel gage, but the rates began to oscillate pretty badly, although the rate needles were still on scale. My best indication of the oscillation amplitude was to watch the sun cross the window and try to determine the angle through which the spacecraft was oscillating. I could feel the change in deceleration as the spacecraft went to one side in yaw or pitch. I switched the drogue parachute fuse switch on at

about 45,000 feet. At about 40,000 feet, spacecraft oscillations were increasing. At about 25,000 feet, I deployed the drogue parachute manually when the oscillations became severe. I could see the drogue parachute pulsing and vibrating more than I had expected. It was visible against a cloudy sky. After the drogue parachute was deployed, I operated the snorkel manually.

I switched the main parachute fuse switch on at 15,000 feet and waited for the main parachute to deploy. At about 9,500 feet, I manually activated the main parachute deployment switch without waiting for automatic deployment. It came out and was reefed for a little while. I could see the parachute working as the material was stretched taut and then as it undulated after the peak load. The parachute disreefed and it was beautiful. I could see no damage whatsoever, and rate of descent was right on 30 feet per second.

I was convinced that the main parachute was good, selected the automatic position on the landing bag switch, and the bag went out immediately. I went through the postreentry and 10,000-foot checklists and got everything pretty well taken care of.

The landing was much less severe than I had expected. It was more noticeable by the noise than by the *g*-load, and I thought I had a recontact problem of some kind. I was somewhat dismayed to see water splashed on the face of the tape recorder box immediately after impact. My fears that there might be a leak in the spacecraft appeared to be confirmed by the fact that the spacecraft did not immediately right itself.

Egress

The spacecraft listed halfway between pitch down and yaw left. I got the proper items disconnected and waited for the spacecraft to right itself. However, the list angle did not appreciably change.

I knew that I was way beyond my intended landing point, because I had heard earlier the Cape Cap Com transmitting blind that there would be about an hour for recovery. I decided to get out at that time and went about egressing from the spacecraft.

Egress is a tough job. The space is tight, and the small pressure bulkhead stuck slightly. I easily pushed out the canister, and I had the raft and the camera with me. I disconnected the hose after I had the canister nearly out.

I forgot to seal the suit and deploy the neck dam. I think one of the reasons was that it was so hot. After landing I read 105° on the cabin temperature gage. I felt much hotter in orbit than after landing; and although it was humid, I still felt fine.

I climbed out through the small pressure bulkhead with the raft attached to me. I placed the camera up on top of the recovery compartment so that I could get it in case the spacecraft sank. I left the spacecraft, pulled the raft out after me, and inflated it, still holding onto the spacecraft. I climbed aboard and assessed the situation. Then I realized that the raft was upside down! I climbed back onto the spacecraft, turned the raft over, and got back in.

Recovery

The sea was quite calm except for periodic swells, but it was not choppy. The time on the ocean was very pleasant. I drank a lot of water from my survival kit while I was in the raft, but as far as temperature was concerned I was comfortable.

The first thing I saw in the water was some seaweed. Then a black fish appeared, and he was quite friendly. Later, I heard some planes. The first one I saw was a P2V, so I took out the signaling mirror from my survival kit. Since it was hazy, I had some difficulty in aiming the mirror, which is done by centering the small bright spot produced by the sun in the center of the mirror. However, I knew the planes had spotted me because they kept circling the area. Another aid to the planes in locating me was the dye marker which was automatically ejected by the spacecraft. There must have been a stream of dye in the water 10 miles long.

Soon there were a lot of airplanes around, but I just sat there minding my own business. Suddenly, I heard a voice calling from behind me. I turned around and there was someone swimming up to me. I did not even know that he had been parachuted into the water. He inflated his raft, climbed in, and attached his raft to mine. He told me he had parachuted from 1,100 feet and had to swim quite a way to reach me. Later, another swimmer joined us. I broke

out the food and asked them if they wanted any; but they had finished lunch recently, and they did not take any.

More aircraft kept circling over us. From time to time, one would drop a smoke bomb marker. A 20-man liferaft was dropped, but the chute failed to open and it hit the water with a tremendous impact. Attached to the raft was another package, containing the Stullken collar, a flotation device much like a life preserver which can be wrapped around the spacecraft to keep it floating. It also hit with a terrific force which, as we learned later, broke one of the CO_2 bottles used to inflate the collar. The divers started out to get the collar and it took them some time to bring it back. They finally got back, wrapped the collar around the spacecraft, and inflated it.

When the HSS-2 helicopter appeared, it made a beautiful approach. One of the divers helped me put on the sling, and I picked up my camera which I had previously placed in the recovery compartment. I motioned to the helicopter pilot to take up the slack in the line, and I let go of the spacecraft expecting to be lifted up. Instead, I went down! The helicopter must have settled slightly, because I am sure that there was a moment when nobody saw anything of me but a hand holding a camera clear of the water.

A moment later, however, I began to rise. It was a lift of some 50 to 60 feet. I got into the helicopter with no difficulty and took off my gloves and boots. I poked a hole in the toe of my left sock and stuck my leg out the window to let the water drain out of the suit. When the helicopter landed aboard the carrier, I was in good shape. (See fig. 7-3.) Although I had already had a long day, I was not excessively tired and I was looking forward to describing my experiences to those at the debriefing site.

FIGURE 7-3.—Astronaut Carpenter coming aboard the carrier *Intrepid* from the recovery helicopter.

Concluding Remarks

Overall, I believe the MA-7 flight can be considered another successful step on the road to the development of a useful and reliable manned spacecraft system. The good performance of most of the spacecraft systems gave me confidence in the vehicle itself, while the spectacular novelty of the view from space challenged me to make the most of my opportunity, and lured me into an unwise expenditure of fuel early in the flight. As a result, it became necessary to go to extended drifting flight, and I was able to demonstrate that there was no problem associated with prolonged drifting flight, a procedure we shall have to make use of on the longer duration Mercury flights. I was able to detect and overcome the one significant systems malfunction that might have affected the flight: the malfunction of the pitch horizon scanner circuit. I understand that many were concerned while waiting without word from me during reentry and after landing. However, from my position, there was no major cause for concern. The spacecraft was stable during the critical portions of reentry and the parachute worked perfectly. For me, this flight was a wonderful experience, and I anxiously await another space mission.

APPENDIX

MA-7 AIR-GROUND VOICE COMMUNICATIONS

The following is a transcript of the MA-7 flight communications taken from the spacecraft onboard tape recording. This is, therefore, a transcription of the communication received and transmitted, as well as some in-flight comments made while in a record-only mode, by the pilot, Scott Carpenter.

The first column shows the ground elapsed time (g.e.t.) from liftoff in hours, minutes, and seconds when the communique was initiated. The communicator is identified, as follows:

CC—Capsule (spacecraft) Communicator at the range station

CT—Communications Technician at the range station

F—Flight Director at Bermuda range station

P—Pilot

S—Surgeon or Medical Monitor at the range station

Stony—Blockhouse Communicator

All temperatures are given as °F; all pressures are in pounds per square inch, absolute (psia); fuel, oxygen, and coolant quantities are expressed in remaining percent of total nominal capacities; retrosequence times are expressed in g.e.t. (hours, minutes, and seconds).

Within the text, a series of three dots is used to designate times when communiques could not be deciphered. One dash indicates a time pause during a communique. The station in prime contact with the astronaut is designated at the initiation of communications.

CAPE CANAVERAL (FIRST PASS)

	Stony	5, 4, 3, 2, 1, 0.
00 00 01	P	I feel the lift-off. The clock has started.
00 00 04	CC	Roger. [Cape Canaveral]
00 00 06	P	Loud and clear, Gus.
00 00 07. 5	CC	Roger, Aurora seven, stand by for—the time hack.
00 00 11	P	Roger.
00 00 12. 5	P	Little bit of shaking, pretty smooth.
00 00 16. 5	CC	3, 2, 1, mark.
00 00 21	P	Roger, the backup clock has started.
00 00 24. 5	CC	Roger, Aurora Seven.
00 00 29	P	Clear blue sky; 32 seconds; 9,000 [feet], fuel and oxygen steady; cabin pressure 15.1 [psia]; and dropping. A little rough through max q, and 1 minute.
00 00 46	CC	Roger. You're looking good from here.
00 00 47	P	Okay, 25 amps and the power is good.
00 00 50. 5	CC	Roger. You're looking good.
00 00 59. 5	P	Mark, 1 minute. Cabin pressure is on schedule; fuel and oxygen are steady, 24 amps; all the power is good.
00 01 10. 5	CC	Roger. Pitch is 56 [degrees]. You look—
00 01 13	P	Roger. My pitch looks good, it's smoothing down a little bit now. I feel the pitch program starting over.
00 01 22. 5	CC	Roger.
00 01 26. 5	P	The sky is getting quite black at 01 30—elapsed. Fuel and oxygen is steady, cabin pressure is leveling off at 6.2 [psia], 22 amps and the power is still good, one cps sway in yaw.
00 01 44	CC	Roger. Understand. Pitch is 37 [degree]. You look real good.
00 01 59	CC	Stand by.
00 02 08.5	P	Roger. There is BECO on time, and—
00 02 14.5	CC	Ah, Roger. Understand BECO.

00 02 16	P	Roger, I felt staging. Do you confirm?
00 02 19	CC	Staging?
00 02 20	P	Do you confirm staging?
00 02 22	CC	Aurora Seven, we confirm staging.
00 02 24	P	Roger, g peaked at 6.3.
00 02 32	P	The tower is way out. It's gone. The light is green. Going over the BECO check now.
00 02 41.5	CC	Roger, Aurora Seven.
00 02 49	P	BECO check is complete
00 02 54.5	CC	Roger. Understand complete. Is that correct?
00 02 57.5	P	That is. Roger.
00 03 01.5	P	At 3 minutes. Fuel and oxygen are still steady; cabin is holding 5.8 [psia]. Power still looks good; my status is good.
00 03 14	CC	Roger. Pitch minus, minus 2½ [degrees], and you're right on; you're good.
00 03 19	P	Roger. Reading you loud and clear, Gus.
00 03 29	CC	Aurora Seven, . . ., you are good.
00 03 33.5	P	Roger. Still reading you. Broken a little bit. At 30, my status is good. Fuel and oxygen are steady. Cabin is holding 5.8 [psia]; Cabin is holding 5.8 [psia]. Power is good, 25 amps.
00 03 47.5	CC	Roger.
00 04 01	P	Four minutes. Aurora Seven is Go. Fuel and oxygen steady; cabin holding, 25 amps; power is good.
00 04 12	CC	Roger, Aurora Seven. Pitch minus 3½ [degrees]. You're good.
00 04 15.5	P	Roger, Reading you on Bermuda antennas now, much louder.
00 04 19	CC	Roger.
00 04 30	P	4 plus 30 my clock. Fuel and oxygen steady, 3½ g's. Cabin holding 5.8 [psia]; 25 amps power is good.
00 04 42	CC	Roger, Aurora Seven. You're through 0.8, V over V_R of 0.8.
00 04 46	P	Roger. 0.8.
00 05 09	P	Okay, there is SECO. The posigrades fired. I am weightless and starting the fly-by-wire turnaround. Aux Damp is good.
00 05 25.5	CC	Roger. You look good down here.
00 05 27	P	Periscope is out, and . . . .
00 05 32	CC	We have a Go, with a 7-orbit capability.
00 05 36	P	Roger. Sweet words.
00 05 38.5	CC	Roger.
00 05 52	P	Okay, turnaround has stopped. I'm pitching down. I have the moon in the center of the window, and the booster off to the right slightly.
00 06 07.5	CC	Roger. Understand.
00 06 09.5	P	Fly-by-wire is good in all axes; my pitch attitude is high; coming down now.
00 06 51	CC	Roger. Understand.
00 06 38	P	Roger. The control system on fly-by-wire is very good. I have the booster in the center of the window now, tumbling very slowly.
00 06 50.5	CC	Roger, Aurora Seven. Understand. You sound real good.
00 06 59.5	P	It's very quiet.
00 07 04.5	P	A steady stream of gas, white gas, out of the sustainer engine. Going to ASCS now.
00 07 15	CC	Roger. Understand.
00 07 17	P	ASCS seems to be holding very well. I have a small island just below me.
00 07 26.5	CC	Aurora Seven, standby for retrosequence times.
00 07 29.5	P	Standing by.
00 07 31.5	CC	Area 1 B is 17 17.
00 07 38.5	P	17 17 Roger.
00 07 41.5	CC	Roger, standby for later times. That's all I have right now.
00 07 50	CC	Roger, Sequence time for end of orbit.
00 07 53.5	P	Send your message.
00 07 55	CC	Aurora Seven, retrosequence time for end of orbit—28 26.
00 08 00	P	01 28 26, Roger.
00 08 04	CC	End of mission, 04 32 39.
00 08 09	P	04 32 39, Roger.
00 08 12	CC	Negative 04 3, 04 32 39.
00 08 17.5	P	Roger, Understand, 04 32 39.

00 08 21	CC	Roger.
00 08 22.5	P	Roger, I have copied.
00 08 27	P	ASCS looks good, all fly-by-wire thrusters appear to be good in all axes. Going to—beginning to unstow the equipment.
00 08 41	CC	Aurora Seven.
00 08 43	P	Roger, and the SECO checklist is complete. She peaked at 6.3[g's].
00 08 51.5	CC	Cap Com. Over.
00 08 53.5	P	Go ahead, Gus. Loud and clear. How me?
00 09 01.5	CC	Aurora Seven, Cap Com.
00 09 03	P	Roger, loud and clear. How me?
00 09 07	CC	Aurora Seven, Cape Cap Com. Over.
00 09 16	CC	Aurora Seven, Cape Cap Com. Over.
00 09 18.5	P	Loud and clear, Gus. How me?
00 09 25	CC	Aurora Seven, Cape Cap Com. If you read, retro delay to normal?
00 09 29	P	Retro delay normal. Roger.
00 09 32	CC	. . . igee 86 [nautical miles].
00 09 34.5	P	Roger. Copied perigee 86 [nautical miles]. Did not get apogee.
00 09 54.5	P	Mark. One picture of the booster. Going to transmit and record now. 2, 3, 4, 5, 6, . . . 10, 11, 12 pictures of the booster, traveling right down the center of the booster, right down the center of the window.
00 10 34	P	Going over the insertion checklist now. D-c volts is main. Retromanual fuse switch is off. Retromanual is off. All instruments are. All batteries okay. The a-c power is good. The, let's see, where's the booster? There's some beautiful cloud patterns down there. The booster is in front of a large cloud pattern. I seem to be, I seem to be much closer to the earth than I expected to be. The booster is approximately 2 miles away now.
00 11 40	P	I have some pictures of the booster, maybe 17 or 18, all together. Then going to the horizon, north sweeping south. There is the moon, just setting. Winding the camera at this time.
00 12 22	P	There are some rather large pieces floating around. The flight plan is now out. Gyros are going to free at 12 33, and I'm going to fly-by-wire to track the booster. I will—this is not a good tracking problem. Our speeds are too close to being the same. I will put it in the center of the right window, plus. I have it right in the center—I feel that—overshot there. Getting ahead of me in pitch.
00 13 29.5	P	The high thrusters work well, close tracking should be done on—on fly-by-wire low only. To follow the booster is a tough job with the highs. Gyros are staying within limits pretty well. Elapsed time is 13 56. I have lost sight of the booster at this time. I'll pick up a retroattitude at this time for Canary radar. Large piece of—
00 14 37.5	P	Going back to gyros free, or to gyros normal.

CANARY (FIRST PASS)

00 14 47	CC	Aurora Seven. This is Canary Cap Com. How do you read? Over.
00 14 51	P	Hello, Canary Cap Com. Aurora Seven. Reading you loud and clear. How me?
00 14 56.5	CC	Read you loud and clear also. We have radar track. Please remain in orbit attitude.
00 15 02	P	Roger. Understand. I, my control mode is fly-by-wire, gyros normal, maneuver off. I am picking up retroattitude and automatic control very shortly. Over.
00 15 18.5	CC	Roger. Will you verify that your retrodelay switch is in the normal position?
00 15 24	P	Retrodelay is normal. I say again, retrodelay is normal.
00 15 29.5	CC	Roger. Will you please proceed with the short report, fuel and oxygen readings.
00 15 38	P	Roger. Fuel 103–100 [percent]. Oxygen 89–100 [percent]. All the power is good. Aurora seven status is Go in all respects. Over.
00 15 53.5	CC	Roger. Say again fuel, please. Over.
00 15 56.5	P	Fuel 103–100 [percent]. Over.
00 16–01.5	CC	Roger. Have copied.
00 16 04.5	CC	Please send blood pressure. Over.
00 16 07	P	Roger. Blood pressure start now.
00 16 19	P	I have, west of your station, many whirls and vortices of cloud patterns. Pictures at this time—2, 3, 4, 5. Control mode is now automatic. I have the booster directly below me. I think my attitude is not in agreement with the instruments. It's probably because of that gyro free period. Outside of a minor difference in attitude indications, everything is proceeding normally.

00 17 14	CC	Can you confirm orientation, ASCS and fly-by-wire . . . operating normal?
00 17 21.5	P	Roger. Wait one.
00 17 53	P	Roger. Canary, TS plus 5 is verified. Manual is satisfactory in all axes. Fly-by-wire and auto is satisfactory, all axes. Aux Damp is okay also. Over.
00 18 08.5	CC	Roger. I have copied. I have new end of orbit, end of mission and 1 Bravo times for you. Are you prepared to copy?
00 18 15	P	Stand by one.
00 18 39.5	P	Send your message, Canary.
00 18 41.5	CC	Roger. End of orbit time 01 28 17. End of mission, 04 32 27. 1 Bravo 16 plus 56. Did you copy? Over.
00 19 05	P	Roger. End of orbit 01 28 17, Hotel 04 32 39, 1 Bravo 16 56. Over.
00 19 22	CC	Correction. Aurora Seven, correction 1 Bravo. Make that 16 plus 52. Over.
00 19 30	P	Roger. Understand. 16 52.
00 19 33	CC	Roger. Apogee altitude is 143 [nautical miles]. Perigee 86 [nautical miles]. Did you copy? Over.
00 19 43.5	P	Roger. 143 and 86 [nautical miles].
00 19 48	CC	Roger. Here are sunrise and sunset times. Sunrise orbit one: 1 plus 21 plus 00. Sunrise, orbit two: 2 plus 50 plus 00. Sunrise, orbit three: 4 plus 19 plus 00.
00 20 16.5	P	Roger, Canary. I'm going to have loss of signal before I get these. I want to get some pictures. Have Muchea, or, correction, have Kano send these to me in this order: Sunset, sunrise, sunset, sunrise, break, break. Did you copy?
00 20 36	CC	— plus 41 plus 20. Did you copy? Over.
00 20 40.5	P	That is negative. I'll have to wait awhile for those.
00 20 50	P	I'll get them from Kano. Thank you.
00 20 52.5	CC	Have a blood-pressure reading. Your first attempt was unreadable on the ground. Over.
00 20 58	P	Okay. It's on the air.

KANO (FIRST PASS)

00 23 49	CC	Aurora Seven. This is Kano on UHF/HF. Do you read? Over.
00 23 56	P	Roger, Kano Cap Com. Aurora Seven reads you loud and clear. How me?
00 24 02.5	CC	Roger, Aurora Seven. Kano Cap Com reads you loud and clear. Welcome back, Scott.
00 24 08	P	Roger.
00 24 09	CC	Blood-pressure check, please. Hold your button for 4 seconds and then go through the short report.
00 24 16	P	Roger. Blood-pressure start, now. My status is good. The capsule status is good. Fuel is 99–98 [percent]. Oxygen, 89–100 [percent]. Cabin is holding good. All d-c power is good. All a-c power is good, 22 amps. Everything is green and you should be reading blood pressure. Over.
00 24 41.5	CC	Roger. We are reading blood pressure. Do you want to check your UHF low? Over.
00 24 47	P	Roger. Going to UHF low now, stand by 15.
00 25 10.5	P	Hello, Kano. Hello, Kano Cap Com. Aurora Seven UHF low. How do you read?
00 25 17	CC	Aurora Seven. Kano Cap Com reads you loud and clear. Over.
00 25 20.5	P	Roger. Reading you the same. Going back to UHF high.
00 26 22	CC	Aurora Seven, Kano Cap Com. How do you read? Over.
00 26 28	P	Loud and clear, Kano. Send your message.
00 26 32	CC	Roger, Aurora Seven. Are you going to be doing your caging, uncaging procedure now? Over.
00 26 37.5	P	Roger. I—am a little behind in the flight plan at this moment. I have been unable at this time to install the MIT film. I finally have it. I'll go through the gyro uncaging procedure very shortly.
00 27 01	CC	Roger.
00 27 34	P	Okay, the MIT film is now in.
00 28 00	P	ASCS is operating okay.
00 28 12.5	CC	What mode are you on now?
00 28 14.5	P	Roger. My mode is auto, gyro normal, maneuver off.
00 28 21.5	CC	Aurora Seven, Kano Cap Com. Be sure you're on fly-by-wire before going through the procedures for uncaging.
00 28 27	P	Roger, Roger. Understand.
00 28 54.5	P	I'm going to be unable to complete the MIT pictures on this pass, I believe. Negative, negative, I can fix the problem. Too much film was out of the canister, that was the problem. Film is now in tight. The small back going on now.

00 29 43.5	P	At 00 29 43, the first time I was able to get horizon pictures with MIT film. Set at F8 and 125th. A picture to the south into the sun, directly down my flight path is number two. Number three, 15 degrees north at capsule elapse 00 30 17.
00 30 29.5	P	Stowing the camera at this time. Going to the gyro uncaging procedure at this time. Fly-by-wire, now. Gyros going to cage. Maneuver at this point is on.
00 31 02.5	P	Pitching down, yawing left.

INDIAN OCEAN SHIP (FIRST PASS)

00 31 36	CT	Aurora Seven, Aurora Seven, Aurora Seven. This is I.O.S. Com Tech on HF and UHF. How do you read? Over.
00 31 49	P	Roger, Indian Com Tech. Aurora Seven reading you weak but readable. Go ahead.
00 32 10	CT	Aurora Seven, Aurora Seven. This is I.O.S. Com Tech on HF and UHF. How do you read? Over.
00 32 19	P	Hello, Indian Ship Cap Com. Aurora Seven. Loud and clear. How me?
00 33 59	P	Hello, Indian Cap Com, Indian Cap Com, Aurora Seven. How do you read?
00 34 17	P	Hello, Indian Cap Com, Indian Cap Com, Aurora Seven. How do you read?
00 34 26.5	P	At 00 34 28, I'm increasing the cabin water valve and the suit valve to 6 [degrees]. Steam vent temperature now reads 65 and 75 [degrees].
00 34 47	P	Mark African coastal passage, about 20 seconds ago.
00 35 02.5	P	I'm using the airglow filter at this time. Visor is coming open for a better look at that. Hello, Indian Cap Com, Aurora Seven. Do you read?
00 35 39	P	Maneuver [switch] is going off at this time, and I'm going to aline manually to retroattitude.
00 38 04	P	Station calling Aurora Seven. Say again.
00 39 28	P	Okay. That took me some time to aline my attitudes properly. Three more pictures with MIT film: 2, 3, directly into the sun at an elapsed time of 00 39 42.
00 40 12.5	P	Okay, going through . . . .
00 42 30.5	P	The big back is going on the camera at this time. There was a period there when nothing was recorded because I was in VOX power off, instead of record. The big . . . .
00 43 02.5	P	At 00 43 02, I think my gyros are properly alined.
00 43 15.5	P	What in the world happened to the periscope?
00 43 25	P	Oh, its' dark, that's what happened. It's facing a dark earth. Sunset F16 to F, okay; we'll start with F16. Up north, coming south. Try some at 250.
00 44 12.5	P	It's getting darker. Let me see. Muchea contact, sometime. Oh, look at that sun.
00 44 31	P	F11.
00 44 45.5	P	F5.6 That was those last four, were F3.8. It's quite dark. I didn't begin to get time to dark-adapt.
00 45 15	P	Photo lights are off. Cabin lights are going to red at this time. Oh, man, a wide, a beautiful, beautiful red like in John's pictures. Going to fly-by-wire.
00 46 01	P	It is a reflection. It is a reflection in the window. That's too bad.
00 46 10	P	I see at this point; I'm not sure I am recording on VOX record. I will go to transmit. I have Venus, now approaching the horizon.
00 46 37	P	It's about 30 degrees up. It's just coming into view. Bright and unblinking. I cannot—I can see some other stars down below Venus. Going back to ASCS than at this time.
00 47 05	P	Bright, bright blue horizon band as the sun gets lower and lower—the horizon band still glows. It looks like five times the width of the—the diameter of the sun. I'm at—now at 00 47 34 elapsed.
00 47 46.5	P	It's now nearly dark, and I can't believe I'm where I am.
00 48 08	P	Oh, dear, I've used too much fuel.
00 48 22	P	Well, I'm going yo have to increase. Let's see, going to ASCS at this time.
00 48 38	P	My fuel reads 75–100 [percent] at this time. The window—is Venus occlude. No, that—that is not correct. Venus did not occlude. I'm getting out the equipment to measure Venus occlusion.
00 49 15	P	There is too much red light in the cockpit from the time correlation. Venus at above the—horizon.

MUCHEA (FIRST PASS)

00 49 28.5	CC	Aurora Seven. This is Muchea Cap Com. How do you read?
00 49 34	P	Hello, Muchea Cap Com, Aurora Seven. Loud and clear. How me, Deke?
00 49 39	CC	Rog. Coming in very good, dad. Sound very good. How's things going?

00 49 45.5	P	Roger. Things are going very well. My status is very good. The capsule status is very good. The control mode is normal. Automatic gyros normal and maneuver off. Fuel is 72–100 [percent]. Oxygen 88–100 [percent]. Everything is normal with the exception of—the fact that I am a tad behind in the flight plan. Over.
00 50 11.5	CC	Roger. Understand.
00 50 13	P	Blood pressure is starting now.
00 50 17	CC	Okay. Blood pressure starting. We suggest that you do not exercise during the blood pressure since your temp is up.
00 50 23.5	P	Roger. This is the story on the suit temp. I have increased two 10-degree marks since lift-off. And now about—well, 15 degrees above launch mark. My steam vent temperatures read 69 and 80 [degrees]. I'll take one more stab at increasing or decreasing temperature by increasing flow rate. If this doesn't work, I'll turn them off and start lower. Over.
00 50 59	CC	Rog. Understand. I'll give you some retrotimes while you're sending blood pressure. End of orbit is 01 28 18. End of mission is 04 32 28.
00 51 15.5	P	Roger. Understand. End of orbit 01 28 18 and 04 32 28 for end of orbit. Over. End of mission.
00 51 26	CC	That's affirmative. We indicate your clock is 1 second slow and this is compensated for.
00 51 31	P	Roger. Thank you.
00 51 34	CC	G.m.t. time hack at this time—we're coming up on 13 36 57. Mark.
00 51 41	P	Roger. My G.m.t.—my backup G.m.t. are right in synch. with G.m.t. Over.
00 51 49	CC	That's very good.
00 51 51.5	CC	Okay, if you're ready, I'll give you the emergency voice check. We will turn off UHF and HF transmitters for this so that you will not have to change volume.
00 51 59	P	Roger, standing by.
00 52 04.5	CC	Aurora Seven. Muchea Cap Com. 1, 2, 3, 4, 5, 5, 4, 3, 2, 1 command voice. How do you read?
00 52 12	P	Roger, Deke. Read you loud and clear, loud and clear emergency voice.
00 52 16.5	CC	Very good, Very good. Switching back to UHF.
00 52 20	P	Roger.
00 52 25.5	CC	Aurora Seven, Muchea Cap Com on UHF. How do you read?
00 52 28	P	Roger. Muchea Cap Com. Loud and clear. Tell Jerry and Gus and Lewis and—everybody else there, that I worked with "hello." John Whittler, if you see him, tell him to saddle Butch up. Break, break. Is your cloud cover such that I can expect [to] see light—or flares at Woomera? Over.
00 52 52.5	CC	Roger. The cloud coverage here is 3,000 [nautical miles] overcast stratus, and we think you'll probably see them through the clouds. Woomera is clear.
00 53 03.5	P	Roger.
00 53 18.5	CC	Seven from Muchea. Would you send us one more blood pressure?
00 53 21.5	P	Roger. Starting now.
00 53 28.5	CC	We're going to send you a Z cal at this time.
00 53 31	P	Roger. And—go ahead and send it. I'll—you'll be interested to know that I have no moon, now. The horizon is clearly visible from my present position; that's at 00 54 44 elapsed. I believe the horizon on the dark side with no moon is very good for pitch and roll. The stars are adequate for yaw in, maybe 2 minutes of tracking. Over.
00 54 01.5	CC	Roger, Understand. Sounds very good. Z cal off; R cal coming on. Mark.
00 54 12	CC	Suggest that you back the fuel control back to your first black mark.
00 54 18	P	Roger. I'll try that. Going all the way off and back up a little bit lower than where I was.
00 54 28.5	CC	Roger. Your suit temperature is down a bit at this point.
00 54 31.5	P	Say again, Deke.
00 54 33	CC	Your suit temperature is down, which is good.
00 54 36.5	P	Well, that's a result of an increase in flow lately. I would think that—I'll try increasing rather than decreasing.
00 54 55.5	P	Hello, Woomera Cap Com, Aurora Seven. Do you read?
00 55 00	CC	Roger. This is Woomera. This is Woomera Cap Com. Reading you loud and clear. How me?
	CC	This is Muchea Cap Com. They will not be contacting you for another 3 minutes.
00 55 08	P	Roger. Go ahead, Deke. Just trying to get the word on the flare.
00 55 12	CC	Roger. Understand. I'll give you the settings, correction, the attitudes for the first flare at this time. It would be plus 80 [degrees] yaw, minus 80 [degrees] in pitch.
00 55 28.5	P	Roger. Understand, Deke. Plus 80 [degrees] yaw, minus 80 [degrees] pitch.

00 55 37	CC	Roger. Okay. The Cape now advises to keep the suit setting where it was since it's coming down.
00 55 44.5	P	Roger. I—for your information, I have increased it just slightly. My readings now are 7 [psia] and 7 [psia] on suit and cabin. What are my inverter temperatures and thruster line temperatures, Deke? Are they okay?
00 56 04.5	CC	Rog. We are losing you. We are losing you on air-ground. Would you care to contact Woomera at this time?
00 56 11.5	P	Roger.

WOOMERA (FIRST PASS)

00 56 14.5	CC	Aurora Seven, Aurora Seven, this is Woomera. Read you loud and clear. How me?
00 56 18.5	P	Roger, Woomera. Reading you loud and clear, also. I'd like readout on my inverter temperatures—and mark on your flare. Over.
00 56 29	CC	Roger. We're going to have the flare in approximately 2 minutes. We'll give you a readout on your temperatures.
00 56 37	P	Roger. And for your information, Rate Command is also working in all axes. Over.
00 56 47.5	CC	Roger. Rate—rate Command in all axes.
00 56 52	P	That—that signifies that all control systems are operating satisfactorily. Over.
00 57 00	CC	Roger. Understand. All systems okay. We have your temperatures. Your 150 inverter, 152 [degrees]. Your 250 inverter, 167 [degrees]. Do you copy? Over.
00 57 13	P	Roger. Copied, thank you. Standing by.
00 57 16.5	CC	We're going to have the flares. All four of them go at approximately 00 [plus] 58 plus 30. We do have an eight by eight coverage.
00 57 24	P	Roger. I am at—plus 80 [degrees] yaw, minus 80 [degrees] pitch now.
00 57 35	CC	Roger. We'll give you a time hack when we come up to flare test.
00 57 41	P	Roger.
00 57 47	CC	This is Woomera Cap Com, Seven. Surgeon reports all systems look good down here. And Systems reports everything okay on his panel.
00 57 57	P	Roger. Thank you. It looks good to me, also.
00 58 00	CC	Roger. You are loud and clear. Coming up on the flare test—in approximately 25 seconds.
00 58 05.5	P	Roger.
00 58 09.5	CC	Good air-to-ground.
00 58 12	P	Roger. Going to fly-by-wire. It doesn't cost so much.
00 58 17.5	CC	Roger. Fly-by-wire, Manual on. Is that affirmative?
00 58 21.5	P	Manual is—no, I'm, my control mode is pure fly-by-wire now.
00 58 26	CC	Roger. Flare test coming up. Stand by. Mark 00 [plus] 58 plus 30. All four flares away.
00 58 52	CC	Aurora Seven, Aurora Seven, this is Woomera. How do you read? Over.
00 58 55	P	Roger. Reading you loud and clear. Searching for your flares. Stand by.
00 59 02	CC	Roger. We still have approximately 60 seconds left.
00 59 11	CC	You're up to minus 50 [degrees] on roll.
00 59 15	P	Roger. Backing off. Thank you, thank you. Backing off.
00 59 27.5	P	I do not have your flares. I'm sorry, Woomera.
00 59 31	CC	Say again, Seven.
00 59 33.5	P	No joy on your flares. I do not have your flares visible.
00 59 37.5	CC	Have copied. Evidently the cloud coverage is too tight.
00 59 43	P	At this time I have extensive cloud coverage—wait.
00 59 49.5	CC	Did you try Aux Damp when you're in fly-by-wire to see if you are holding attitudes?
00 59 54	P	Negative. I have verified that Aux Damp is operating satisfactorily. Over.
01 00 00	CC	Roger. Understand.
01 00 02	P	I have some lights on the ground underneath me. Stand by, I'll try to identify them.
01 00 12	CC	Roger. Wilco.
01 00 42	CC	Aurora Seven, Aurora Seven, this is Woomera Cap Com. Do you read? Over.
01 00 46	P	Loud and clear, Woomera. Go ahead.
01 00 49	CC	Roger. Could you give us a short report at this time?
01 00 52.5	P	Roger. My control mode is fly-by-wire, gyros are free, and the maneuver switch is off. Fuel reads 75–85 [percent], oxygen 88 and 100 [percent]. Wait till I pick a washer out of the air. And everything is very good. Over.
01 01 23	CC	Roger. You're intermittent. What is your suit temperature? Over.
01 01 29	P	Roger. Suit temperature is now 70 [degrees]. Suit temperature is 70 [degrees]. Steam exhaust is 70 [degrees]. The cabin exhaust is 80 [degrees].
01 01 43	CC	Roger. Do you confirm—do you have your—back down to the black scribe mark?

01 01 51	P	That is negative. I have then both set on seven at this time and—an increase in setting resulted in a decrease—in suit temperature. I think I'd like to try—try them at this setting a little while longer. Over.
01 02 11	CC	Roger. Understand. I believe at this time you're supposed to have your midnight snack.
01 02 18	P	Roger. I'll get to that shortly.
01 02 21.5	CC	Roger. You're starting to drift or fade slightly.
01 02 26.5	P	Roger.
01 02 31.5	CC	Are you prepared to go into drifting flight before too long?
01 02 34.5	P	Roger. I can do that at this time. At night yawed—
01 02 40	CC	. . . is that affirmative?
01 02 41.5	P	I am going to drifting flight at this time. Over.
01 02 46.5	CC	Roger.
01 02 53.5	P	Gyros are caged. I have about a 2-degree-per-second yaw rate. All gyros are zero. I have Corvus directly above me I'm yawing over the top. I feel that my attitude is—the line of sight is nearly—nearly vertical.
01 03 55	P	I am in VOX record only now. The time is 01 04 00 elapsed. I'm searching the star charts.
01 04 19	P	The finish on the star chart is so shiny that—it's impossible to read because of reflection.
01 04 44.5	P	I've got to turn white lights on, that's all.
01 05 03	P	At 01 05 00.
01 05 14.5	P	Attitudes are of no concern to me whatsoever. I know I'm drifting freely. The moon crossed the window not too long ago.
01 05 51.5	P	Let's see, now what can—I am at this moment rocking my arms back and forth and I can make this show up in the roll, yaw, and pitch needle. By moving my torso, I can make the pitch rate needle move up to 1 degree per second. Roll is, needle, rate needle is very sensitive to this. Yaw is also. Let's see, am going to open the visor at this time. Have a few crumbs of food floating around in the capsule.
01 06 58.5	P	At 01 06 106—at 1 minute, 1 hour and 7 minutes elapsed, I'm going above the scale to approximately 8 on cabin and suit.

CANTON (FIRST PASS)

01 07 16	P	Hello, hello, Canton Com Tech, Canton Com Tech, Aurora Seven. Weak but readable. Go ahead.
01 07 40.5	CT	Aurora Seven, Aurora Seven. This is Canton Com Tech, Canton Com Tech. Do you read? Over.
01 07 46.5	P	Hello, Canton Com Tech, Aurora Seven. Loud and clear. How me?
01 08 23.5	P	The food—hello, Canton Com Tech, Aurora Seven. How do you read?
01 08 33	P	Hello, Canton Com Tech, Aurora Seven. How do you read?
01 08 41	P	This food has crumbled badly.
01 08 50.5	P	First meal at 01 08 52.
01 09 21	P	Hello, Canton Com Tech, Canton Com Tech, Aurora Seven on HF. How do you read?
01 09 39.5	CT	Seven, this is Canton Com Tech. Do you read?
01 09 45	P	Canton Com Tech, Aurora Seven. Loud and clear. How do you read Aurora Seven on HF? Over.
01 10 07	CT	Aurora Seven, Aurora Seven. This is Canton Com Tech. Do you read? Over.
01 10 13	P	Roger, Canton Com Tech. Loud and clear. How me?
01 10 33.5	CT	Aurora Seven, Aurora Seven. This is Canton Com Tech. Do you read?
01 10 57	P	Hello, Canton Com Tech, Canton Com Tech, Aurora Seven. Loud and clear. How me?
01 11 04	CC	This is Canton. Loud and clear, Aurora Seven. Can you begin with the short report?
01 11 10	P	Roger. I've been reading you for some time. I've tried to contact you on HF with no success. My status is good; the capsule status is good; control mode is fly-by-wire; gyros caged; maneuver is off. The fuel reads 74–85 [percent]. Oxygen is 87–100 [percent]. The cabin temperature is a bit high at 104 [degrees]. The suit—steam vent temperature is 70 [degrees], and cabin is 80 [degrees], but I believe they're coming down. Over.
01 11 49	CC	Roger. Did you wish to check your attitude readings with our telemetry? Over.
01 11 56.5	P	Roger. My—my gyros are caged at this time. Stand by one.
01 12 05	CC	Standing by.
01 12 17	P	I am beginning to pick up what I believe is a—yeah, it's very definitely a cloud pattern equally low.

01 12 31.5	CC	Roger.
01 12 42	P	I am—let's see, Canton, do you have the exact sunrise time for the first orbit? Over.
01 12 55	CC	Say again, Aurora Seven.
01 12 57	P	Sunrise time for first orbit. Over.
01 13 03	CC	I have a sunrise time of 1 plus 21 plus 00.
01 13 10	P	1 plus 21 00. Roger. Thank you.
01 13 13.5	CC	Did you—could you comment on whether you are comfortable or not—would you . . . a 102 [degrees] on body temperature.
01 13 21	P	No, I don't believe that's correct. My visor was open; it is now closed. I can't imagine I'm that hot. I'm quite comfortable, but sweating some.
01 13 38	CC	Roger. Can you confirm then that the faceplate is closed, and will be closed for the pass over Guaymas.
01 13 44	P	That is correct, George. I'll leave the faceplate closed. I have had one piece of the inflight food. It's crumbling badly and I hate to get it all over, and I have had about four swallows of water at that time.
01 14 04.5	CC	Roger, four swallows of water.
01 14 11	CC	You wish to start your comment now on the haze layer—there was the . . . pitch, and at the same time confirm that the flight plan is on schedule.
01 14 16.5	P	Roger. I cannot confirm that the flight plan is completely on schedule. At sunset I was unable to see a separate haze layer—the same—height above the horizon that John reported. I'll watch closely at sunrise and see if I can pick it up. Over.
01 14 48	CC	Roger.
01 14 53.5	CC	All readings appear to be normal down here. The capsule looks good from down here.
01 15 01.5	P	Roger, the—
01 15 02.5	CC	. . . queries, you can continue on with your observations. Over.
01 15 05.5	P	Roger. Thanks, George, see you next time around.
01 15 10	CC	Okay, Scott. Good luck.

HAWAII (FIRST PASS)

01 15 30.5	CT	Aurora Seven, Hawaii Com Tech. How do you read me? Over.
01 15 40	P	I am in VOX record now. I heard Hawaii calling, ha ha, Hawaii calling. I will go to transmit directly, and see if we can pick up Hawaii.
01 15 54	P	Hello, Hawaii Com Tech, Aurora Seven on HF. Loud and clear. How me?
01 16 17.5	P	Hello, Hawaii Com Tech, Hawaii Com Tech, Aurora Seven. Loud and clear. How do you read HF? Over.
01 16 32.5	P	Going now to record only while I switch back to UHF.
01 17 30.5	P	Hello, Hawaii, hello, Hawaii Com Tech, Aurora Seven. Weak but readable. Go ahead.
01 18 00	CT	Aurora Seven, Aurora Seven, . . . on HF, UHF. How do you read? Over.
01 18 05	P	Roger. Hawaii Com Tech. Aurora Seven reading you loud and clear. How me?
01 18 30	CT	Aurora Seven. Hawaii Com Tech. How do you read?
01 18 51.5	P	All right. My—I am at 01 19 02. Have been several times completely disoriented.[1] There, I have Cassiopeia directly in the window and am yawing around for the sunrise—photographs. The sky is quite light in the east.
01 19 51	P	Excess cabin-water light came on at that time. I'll have to go back all the way down and off. Suit is—still high. The cabin-water gage is reading—plus 9, which is hard to believe.
01 20 15	P	My temperature, my body temperature doesn't feel . . . feel bad at all. My suit—yes, my suit temperature is down now, also.
01 20 32.5	P	But the steam vent temperature is—still about—70 [degrees].
01 22 03	P	I have the fireflies. Hello, Guaymas.
01 22 18	P	I have the particles. I was facing away from the sun at sunrise—and I did not see the particles—just—just yawing about—180 degrees, I was able to pick up—at this.—Stand by, I think I see more.
01 23 00	P	Yes, there was one, random motions—some even appeared to be going ahead. There's one outside. Almost like a light snowflake particle caught in an eddy. They are not glowing with their own light at this time.
01 23 32	P	It could be frost from a thruster.
01 24 01.5	P	Going to transmit to—record only, at this time.
01 24 11	P	The weightless condition is a blessing, nothing more, nothing less.
01 25 43	P	I am now photographing large cloud banks over the Pacific on a southerly direction.
01 26 08.5	P	I'm drifting slowly to retroattitude at this time.

[1] Astronaut Carpenter stated that the disorientation was with respect to the earth, and this occurred only when no visual reference was available. However, he remained oriented with respect to the spacecraft. See footnote 4.

01 27 22	P	Hello, Guaymas Com Tech. Aurora Seven. Loud and clear. How me?
01 27 29.5	CC	Roger. Aurora Seven, this is Guaymas Cap Com. How me? Over.
01 27 33.5	P	Roger, Guaymas, loud and clear. My control mode is now fly-by-wire; gyros are caged, I'm in— maneuver is off. I'll go to automatic mode directly. My status good; the capsule status is good. The fuel is 69–69 [percent], oxygen is 88–100 [percent]. The cabin steam vent has gone to plus 10, I believe that's a bad gage reading, and suit temperature steam vent is coming down slowly, now reading 68 [degrees]. Over.
01 28 16	CC	Roger. Understand 68 [degrees]. How is your temperature comfort? Over.
01 28 19	P	Roger. My body comfort is good. I am tracking now a very small particle, one isolated particle, about—there is another, very small, could be a light snowflake.
01 28 40	CC	Roger. We're reading—we're having a—a bad body temperature reading on you, 102.4 [degrees], probably erroneous.
01 28 48.5	P	I can't believe it. My suit temperature shows 60 [degrees] and I feel quite comfortable. I'm sure I would be sweating more than this if my temperature were 102 [degrees].
01 28 59.5	CC	Your suit-inlet temperature, near 61 [degrees], so it looks pretty good.
01 29 04	P	Roger.
01 29 06.5	CC	Roger. It looks like we have a go for the second orbit as everything appears all right for you.
01 29 13	P	Roger. I was hoping you'd say that, Gordo.
01 29 16	CC	You start to conserve your fuel a bit and maybe, perhaps, use a little more of your manual fuel.
01 29 22	P	Roger. Can do.
01 29 24.5	CC	Roger, are you ready for Z and R cal?
01 29 27	P	Roger, send them.
01 29 28.5	CC	Z cal coming on now.
01 29 31	P	And, mark, coastal passage.
01 29 35	CC	Say again.
01 29 36	P	Mark, coastal passage coming over the—Baja.
01 29 41	CC	Good.
01 29 43	CC	How does it look?
01 29 46	P	Half covered with clouds, and—and the other half is dry. Will you pass on—this message for me, Gordo, to all the troops at Guaymas?
01 30 05	P	Hola, amigos, felicitaciones a Mexico y especialmente a mi amigos de Guaymas. Desde el espacio exterior, su pais esta cubierto con numbes—and—es—also—se muy bello. Aqui el tiempo esta muy bueno. Buena suerte desde Auror Siete.[2]
01 30 33.5	CC	Roger, muchas gracias, amigo.
01 30 35.5	P	Ha ha, okay.
01 30. 37.5	CC	Give us a blood pressure.
01 30 39	P	Here you go.
01 30 50	CC	Roger, do you—I'd like to pass your 2 Alpha time on to you, Scotty.
01 30 54.5	P	Roger.
01 30 56	CC	Roger, 2 Alpha time is 01 36 13, with a G.M.T. of 14 21 30. That takes into account your clock error.
01 31 08.5	P	That's 02 36 13?
01 31 12.5	CC	Roger, 01 36 13.
01 31 15.5	P	Roger, 01 36 13 for 2 Alpha.
01 31 19.5	CC	For Golf, 03 00 31.
01 31 25	P	Roger, 03 00 31 for Golf.
01 31 28.	CC	There's a G.m.t. on that of 15 45 48.
01 31 33.55	P	Roger. Standing by for the . . . my mark on the radar test over White Sands.
	CC	. . .
01 31 46	P	Roger.
01 31 52.5	CC	Roger. Command roll now.
01 31 55	P	Roll now.
01 32 02	P	No, I'll have to get in a better attitude for you first, Gus. It'll mean nothing this way, I mean Coop.
01 32 10	CC	Roger.
01 32 58.5	CC	You still reading us, Scotty?
01 32 59.5	P	Roger. Loud and clear.

[2] Translation: Hello, friends, greetings to Mexico and especially to my friends of Guaymas. From outer space, your country is covered with clouds and is very beautiful. Here the weather is very good. Good luck from Aurora Seven.

01 33 02	CC	Hearing you also. Have you done your roll for the radar yet?
01 33 10.5	P	That's negative. I'm afraid I'm not going to make it, Gordo, unless I get the attitudes—down close.
01 33 21.5	CC	Roger. We're reading your attitudes all right at zero now.
01 33 26.5	P	Roger. The gyros are caged.

CAPE CANAVERAL (SECOND PASS)

01 33 41	CC	Aurora Seven, this is Cape Cap Com on emergency voice.
01 33 44	P	Roger, Cape. Loud and clear. How me?
01 33 48	CC	Loud and clear. I'm going back to HF/UHF.
01 33 52.5	P	Roger.
01 33 55	CC	Are you ready for your 2 Bravo time?
01 33 58	P	Roger. Send 2 Bravo.
01 34 00.5	CC	01 49 30.
01 34 07	P	Roger. 01 49 30.
01 34 12.5	CC	Roger. And 2 Charlie time is nominal.
01 34 15.5	P	Okay. Stand by one.
01 34 37.5	P	Okay, Gus, my status is good; my control mode is fly-by-wire; the gyros are still caged; maneuver is off. Fuel is 62 and 68 [percent]. A little ahead on fuel consumption; fuel quantity light is on; the excess cabin-water light is on. I'll try and get auto mode here directly.
01 35 04.5	CC	Roger. Can you give us a blood pressure?
01 35 07	P	Roger. Blood pressure coming now.
01 35 13.5	CC	And after the IOS voice has dropped, will use Zanzibar in that area.
01 35 20	P	Roger. I heard IOS calling, but I couldn't raise him.
01 35 24	CC	Roger.
01 35 30	CC	Aurora Seven, use a normal balloon release.
01 35 34	P	Roger.
01 35 41	P	And are you going to give me a mark for that?
01 35 47.5	CC	Roger. One at an elapsed time of 01 37.
01 35 51	P	01 37. Roger.
01 36 00	CC	Roger. In 2 minutes, Echo will be almost directly overhead.
01 36 05	P	Roger.
01 36 08	C	Could you give us a cabin steam and suit temperature, please?
01 36 11	P	Roger. Suit steam is 69 [degrees] and cabin is plus 11. That dropped down very suddenly when the excess cabin-water light came on. I think I'm going to—increase . . . I'll try to increase suit-water flow one more time. If that doesn't work I'll drop—down—to closed and start over again.
01 36 46	CC	Aurora Seven, cut back your cabin water.
01 36 49	P	Okay. Cabin water going back. I'll start now at two. This is 20 degrees below launch value.
01 36 58	CC	Roger. I'm going to give you a Z cal.
01 37 00.5	P	Roger.
01 37 07	CC	Okay. I'm going to give you an R cal.
01 37 10	P	Be my guest.
01 37 35	CC	Aurora Seven, Cap Com. Do you read?
01 37 37	P	Roger. Loud and clear.
01 37 38.5	CC	Roger. Everything looks good down here, except for your fuel usage; you better watch that a little bit.
01 37 44	P	Roger.
01 37 50	CC	Aurora Seven, have you deployed the balloon?
01 37 52	P	That is negative. Stand by.
01 38 03	P	Balloon deploy, now. The balloon is out and off. I, I see it way out, but it—I think now it is way out, and drifting steadily away. I don't see the line. I don't see that any attempt was made to inflate the thing. It's just drifting off.
01 38 38	P	I have only the rectangular shape tumbling at this point about 200 yards back, barely visible; and now wait, here is a line. That was the cover, the balloon is out.
01 39 01	CC	Understand. The balloon is out.
01 39 02.5	P	That is Roger.
01 39 09	P	There is very little acceleration here.
01 39 17	CC	Aurora Seven, did the balloon inflate?

01 39 19	P	The balloon is partially inflated. It's not tight. I've lost it at this moment. Wait one, I'll give you a better reading shortly.
01 39 50	P	There is an oscillation beginning.
01 39 54.5	CC	This is an oscillation in the balloon?
01 39 56.5	P	Yes.
01 40 11	P	The line is still not taut. I have some pictures of the line just waving out in back. I would say we have about a one-cycle-per-minute oscillation. It's both in pitch and yaw.
01 40 38.5	CC	How many cycles per minute?
01 40 40	P	One cycle per minute, or maybe 1 cycle in a minute and a half.
01 41 01	P	The moon is just above the horizon at this time.
01 41 17	P	I have a picture of the balloon.
01 41 25	CC	Aurora Seven, Cap Com. Repeat your last message.
01 41 28.5	P	Roger. I've got a washer to put away.
01 41 33	CC	Roger.

BERMUDA (SECOND PASS)

01 41 40.5	F	Aurora Seven, Aurora Seven, this is Bermuda Flight. How do you read? Over.
01 41 45	P	Roger. Bermuda Flight, reading you loud and clear.
01 41 49	F	Switch wobulator switch off.
01 41 51.5	P	Roger. Phase shifter.
01 41 54	F	Mark!
01 41 56	P	Phase shifter is off.
01 42 18	P	Phase shifter is on, now.
01 42 23.5	CC (Cape)	Aurora Seven, Cap Com. What control mode?
01 42 26.5	P	Fly-by-wire.
01 42 28	CC (Cape)	Thank you.
01 43 01	F	Bermuda Flight. How do you read?
01 43 02.5	P	Hello, Bermuda Flight. Reading you loud and clear. How me?
01 43 07	F	Will you run a blood pressure, please? Read you loud and clear.
01 43 10	P	Roger. Blood pressure starting now.
01 43 30	P	I have lost sight of the balloon at this minute.
01 43 34	F	Roger.
01 43 59	P	Also, Bermuda, the balloon not only oscillates in cones in pitch and yaw, it also seems to oscillate in and out toward the capsule; and sometimes the line will be taut, other times it's quite loose.
01 44 20.5	P	It's now about 50 degrees off of the flight path.
01 44 32	P	Pictures of whirls taken, just east of Bermuda, now the balloon line is tight.
01 45 27.5	P	At 01 45 30, I have turned the cabin, or the suit-water valve all the way off and back up to one.
01 47 18	P	I'm taping now the fuel quantity warning lights in preparation for the dark side. I think also excess cabin water I'll tape. It's not a satisfactory lighting arrangement to . . . .

CANARY (SECOND PASS)

01 47 48	P	Hello, Canary Cap Com. Aurora Seven. Loud and clear. How me?
01 48 10.5	CC	Aurora Seven, Aurora Seven, this is Canary Cap Com. How do you read? Over.
01 48 16	P	Hello, Canary Cap Com. Aurora Seven. Loud and clear. How me?
01 48 21	CC	Roger. You're coming into UHF range. Proceed with the short report. Over.
01 48 27	P	Roger, Canary. My status is good; the capsule status is good; my control mode is automatic; gyros normal; maneuver off. Fuel 51–68 [percent], oxygen 85–100 [percent]; my cabin steam vent temperature now is picking up and reading about 19, suit steam vent temperature still reading 70 [degrees]. I have backed it off to zero and reset it at one. Over.
01 49 09	CC	. . . cabin exhaust temperature. Over.
01 49 11.5	P	Cabin exhaust temperature is climbing back up to 19. Over.
01 49 18	CC	Roger. Have you been doing any drifting flight? Over.
01 49 23	P	That is Roger. I did quite a bit of drifting flight on the dark side over Woomera and Canton. Over.
01 49 34	CC	Roger. Did you observe any haze layers? Over.

01 49 40.5	P	Roger, I did observe haze layers but not the ones that were separated from the horizon that we expected, and that John reported. I'll keep a sharp lookout next time and try to see them after sunset. On the light side there is nothing more than the bright, iridescent blue layer, which separates the actual horizon from the deep black of space. Over.
01 50 15.5	CC	Aurora Seven, you are fading rapidly. You are fading. MCC [Mercury Control Center] is worried about your auto fuel and manual fuel consumption. They recommend that you try to conserve your fuel.
01 50 28.5	P	Roger. Tell them I am concerned also. I will try and conserve fuel.
01 50 41.5	CC	Aurora Seven, Aurora Seven, I cannot read you. Do you read Canary Cap Com? Over.
01 50 48.5	P	Roger. Canary, copied your message. Over.
01 50 52	CC	Roger. Understand copied message regarding fuel and consumption.
01 50 56.5	P	That is Roger.
01 51 01.5	CC	Surgeon here has requested a blood-pressure transmission.
01 51 05.5	P	Blood pressure is coming your way now.
01 51 20	CC	We are receiving same at Canaries and it looks good.
01 51 24	P	Roger.
01 51 41.5	CC	Canary Systems indicates all telemetry readings look good.
01 51 46.5	P	Roger. That's good to hear.
01 51 56.5	CC	Aurora Seven, do you have anything to report on your balloon test? Over.
01 52 02.5	P	Roger. The balloon is oscillating through an arc of about 100 degrees. It gets out of view frequently. At this moment, it's nearly vertical. Mark a coastal passage at this time—it seems to—what I'm trying to tell you is that it oscillates 180 degrees, above and below. Over.
01 52 40	P	It also oscillates in and out. Sometimes the line is tight and other times it is not.
01 53 52	P	When I look over to the right side, I have the sensation that—
01 54 05.5	P	Hello.

KANO (SECOND PASS)

01 54 15	CC	This is Kano. How do you read? Over.
01 54 17	P	Hello, Kano. Aurora Seven. Loud and clear. How me?
01 54 32.5	CC	Aurora Seven, Aurora Seven, this is Kano. How do you read? Over.
01 54 37	P	Hello Kano. Loud and clear. How me?
01 54 52	CC	Aurora Seven, Aurora Seven, this is Kano. How do you read? Over.
01 54 59	P	Kano, this is Aurora Seven. Reading you loud and clear. How me?
01 55 04	CC	Aurora Seven, Kano Cap Com. What is your status? Over.
01 55 08.5	P	Roger. My status is good; fuel reads 51 [percent] and—and 69 [percent]; oxygen is 84 [percent] and 100 [percent]; cabin pressure is holding good. All d-c and a-c power is good. The only thing of—to report regarding the flight plan is that fuel levels are lower than expected. My control mode now is ASCS. I expended my extra fuel in trying to orient after the night side. I think this is due to conflicting requirements of the flight plan. I should have taken time to orient and then work with other items. I think that by remaining in automatic, I can keep—stop this excessive fuel consumption. And the balloon is sometimes visible and sometimes not visible. I haven't any idea where it is now, and there doesn't seem to—and it seems to wander with abandon back and forth, and that's all, Kano.
01 56 44	CC	Roger, Aurora Seven. Will you give us a blood-pressure check again—. Over.
01 56 49	P	Roger. Blood pressure is on the air.
01 57 01	CC	Aurora Seven, how are you feeling? Your body temperature is up somewhat. How do you feel? Over.
01 57 07.5	P	Roger. I feel fine. Last time around I—someone told me it was 102 [degrees]. I don't feel, you know, like I'm that hot. Cabin temperature is 101 [degrees]. I'm reading 101 [degrees], and the suit temperature indicates 74 [degrees].
01 57 38.5	CC	Are you perspiring any?
01 57 41.5	P	Slightly, on my forehead.
01 57 50	P	Since turning down the suit water valve, the suit steam vent temperature has climbed slightly—am increasing from one to two at this time. This should bring it down. The cabin steam vent temperature has built back up to 40 [degrees].
01 58 27.5	CC	Roger, Aurora Seven, everything looks okay now. We seem to have lost the body temperature readings from previous stations. We are reading 102 [degrees] right now, but as long as you feel okay right now.
01 58 42	P	Roger, I feel fine.

01 58 46	CC	Can you see anything of the Gulf of Guinea?
01 58 49.5	P	Roger. I just—just passed the coastline, and I am over a solid cloud cover at this time
01 59 05	CC	Roger, Aurora Seven. Would you care to send a greeting to the people of Nigeria?
01 59 09	P	Roger, please send my greetings and best wishes of me and my countrymen to all Africans. Over.
01 59 21	CC	Roger. Thank you very much. I'm sure it will be appreciated. Over.
01 59 24.5	P	Roger.
01 59 54.5	CC	Aurora Seven, Kano. Are we still in contact? Over.
01 59 57.5	P	Say again, Kano.
01 59 59	CC	Roger. Would you repeat in a few words why you thought the fuel usage was great? Over.
02 00 06	P	I expended it on—by manual and fly-by-wire thruster operation on the dark side, and just approaching sunrise. I think that I can cut down the fuel consumption considerably on the second and third orbits. Over.
02 00 32	CC	Roger. Understand. Over.
02 00 43.5	CC	Have you started your night adaptation? Over.
02 00 46	P	Roger.
02 01 08	CC	Aurora Seven, Kano. Just for your own information, the 250 inverter is on 180 degrees right now. Over.
02 01 18	P	Say again, please.
02 01 21	CC	. . . . Over.
02 02 43.5	P	At this time, oh-oh, this doggone food bag is a problem.
02 03 00	P	Actually, the food bag is not a problem, the food inside it is. It's crumbled. I dare not open the bag for fear the crumbs will get all through the capsule.
02 03 43	P	Things are very quiet.

ZANZIBAR (SECOND PASS)

02 04 03.5	P	Roger, Zanzibar. Loud and clear. How do you read Aurora Seven?
02 04 17	CT	Aurora Seven, Aurora Seven, this is Zanzibar Com Tech, transmitting on HF/UHF. Do you copy? Over.
02 04 26	P	Roger. Loud and clear. How me, Zanzibar?
02 04 31	CT	Aurora Seven, Aurora Seven, this is Zanzibar Cap Com. Read you weak, but readable. Do you have a short report for us?
02 04 38.5	P	Roger. My status is good; the capsule status is good; my control mode is automatic; gyros are normal; maneuver is off. Control fuel is 51 [percent] and 69 [percent]; oxygen is 82 [percent] and 100 [percent]. That's about all except I have, so far, been unable to get my suit steam vent temperature down much below 70 [degrees]. Steam vent, or the water control valve, setting at this time is 4 at the prelaunch mark. It may be too high. Turning it off at this time and going to three, which is where the cabin is set. Over.
02 05 40	CC	Aurora Seven, Zanzibar Cap Com. Roger, Roger. Do you have the latest—contingency area times?
02 05 49	P	Roger. I have them.
02 05 51	CC	Very good. Are you going to start your balloon test?
02 05 55	P	The balloon is out. I don't see any reason for not leaving it on through the dark side, and I just saw a particle going by at about 2 or 3 feet per second.
02 06 13	CC	Roger, understand. According to flight plan, you're supposed to go to FBW about now, and he says you're on auto mode and I wondered if you plan to go through with this. Over.
02 06 25.5	P	That is negative. I think that the fact that I'm low on fuel dictates that I stay on auto as long as the fuel consumption on automatic is not excessive. Over.
02 06 39.5	CC	Roger, Aurora Seven. Congratulations on your trip so far and I'm glad everything has gone . . . .
02 06 44.5	P	Thank you very much.
02 06 50.5	P	I now have the wide, blue horizon band. It looks to be, at this time Capsule elapsed 02 0700, to be about the diameter underneath the sun. It seems to be the same thickness underneath the sun as the sun's diameter. North and south it becomes less distinct and lighter. It extends up farther from the horizon.
02 07 29.5	CC	Roger, Aurora Seven. That's a hard one to pronounce, anything that we can do for you . . . .
02 07 38	P	Negative. I think everything is going quite well.
02 07 41.5	CC	Roger, We'll be waiting. Out.
02 07 43.5	P	Roger. See you next time.

02 07 48	CC	Aurora Seven, this is Indian Ocean Ship. Over.
02 07 50.5	P	Roger, Indian Cap Com. Loud and clear. How me?
02 07 54.5	CC	Roger. Loud and clear. We have had transmitter trouble on your previous run. We just got a message from the Cape . . ., to conserve fuel. I monitored part of your transmission to Zanzibar and understand . . . the situation.
02 08 12.5	P	That is Roger.
02 08 14.5	CC	Do you have retrosequence times for 2 Delta, 2 Echo and Golf?
02 08 19	P	That is negative. I have the nominals.
02 08 23.5	CC	Roger. 2 Delta and 2 Echo are still nominal. Area Golf is 03 00 29, 03 00 29.
02 08 35	P	Roger. 03 00 29.
02 08 39	CC	Roger, Aurora Seven, I read you loud and clear. Do you have any comments for the . . . Ocean?
02 08 46.5	P	That is Roger. I believe we may have some automatic mode difficulty. Let me check fly-by-wire a minute.
02 09 07	P	All thrusters are okay.
02 09 11	CC	Roger.
02 09 17.5	P	However, the gyros do not seem to be indicating properly.
02 09 25.5	CC	Roger.
02 09 27	P	And that is not correct either. The gyros are . . . are okay; but on ASCS standby. It may be an orientation problem. I'll orient visually and . . . see if that will help out the ASCS problem.
02 10 11.5	CC	Aurora Seven from Indian Cap Com. Your blood pressure on your . . . fairly high and you are supposed to, if possible, give a blood pressure over Indian Ocean Ship.
02 10 23.5	P	Roger. I've put blood pressure up on the air already. Over.
02 10 29.5	CC	Say again, Aurora.
02 10 31	P	Blood pressure is on the air now.
02 10 35	CC	Roger.
02 10 40	S	Blood pressure is coming through fine.
02 10 42.5	CC	Your blood pressure is coming through fine.
02 10 44.5	P	Roger.
02 10 58	CC	Aurora Seven, this is Indian Cap Com. We have lost telemetry contact. How do you read me? Over.
02 11 04.5	P	Roger. Still reading you okay.
02 11 07.5	CC	. . . report to Cape you have checked fly-by-wire and all thrusters are okay. Is there anything else?
02 11 13	P	That is negative. Except this problem with steam vent temperature. I'm going—I'll open the visor a minute; that'll cool—it seems cooler with the visor open.
02 11 26	CC	Roger. Did you take xylose?
02 11 28.5	P	That is negative. I will do so now.
02 11 35	CC	Roger.
02 11 45	CC	Aurora Seven, confirm you've checked fly-by-wire and all thrusters okay.
02 11 51.5	P	Roger. Fly-by-wire is checked; all thrusters are okay.
02 11 56	CC	Roger.
02 12 28	CC	Aurora Seven, Indian Ocean Cap Com. I do not read your transmission.
02 12 32	P	Roger. Indian Cap Com, Aurora Seven.
02 12 35.5	CC	Out.
02 15 11.5	P	Well, I have—I am in record only, and I am getting warm now.
02 15 34	P	Don't know what to with the cabin.
02 15 45	P	I'll turn it up and see what happens.
02 16 04.5	P	I have gotten badly behind in the flight plan now.
02 17 06	P	Okay, evaluating capsule stability at this time. The capsule is most stable.
02 17 24	P	I seem able to put it at zero rates. All right, I will do that now. At capsule elapsed 02 17 32, I will zero out all rates.
02 17 45	P	That's as close to zero as I can make it. At 02 17 49, my rates are zero and attitudes are zero plus, or at zero, minus 3, minus 48. Let those rest awhile, and I'll see what we can do about suit temperature.
02 18 14	P	Cabin is rising. Suit temperature seems to be rising too. I'm going to let it go out until 02 25 00 to see if this is going to bring it down some.
02 18 49	P	I don't need to exercise. I really don't feel I need the exercise. I would get too warm.
02 19 02	P	We'll be getting to Muchea shortly.
02 19 08.5	P	Have a slight pitch up rate at this time, at 02 19 13. I'll zero that out, now. Fly-by-wire—have a slight yaw left rate—I'll zero out now. Attitudes at this time are minus 30.

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02 19 57.5	P	Both busses are okay. All—let's see—number two battery is down to 22. One, is 24; three, is 24; standby one and two, are 24; isolated, is 27; main, is 23; main IBU, is 27. Two—two is now up. Main battery number two is up.
02 20 34.5	P	I am over the dark side now. The moonrise has not occurred and although I still see the lighted area from the setting sun behind us.
02 22 16.5	P	Now, I do have the haze layer at this time. It seems to be brighter than—it's good to open the cabin, open the visor.
02 23 07	P	The reticle now extincts at about 5.6.

MUCHEA (SECOND PASS)

02 23 21	P	Hello, Muchea Cap Com. Aurora Seven. Loud and clear. How me?
02 23 26	CC	Read you loud and clear also. What's your status?
02 23 28	P	Roger. My status is good; control mode is fly-by-wire; gyros normal; maneuver off. Fuel is 45–6–70 [percent], that's 45–70 [percent], and oxygen is 84–100 [percent]. I have only one minor problem, and that is my inability to get the suit steam vent temperature down, Deke.
02 23 56.5	CC	Roger. What's it running now?
02 23 58.5	P	Well, I'm reading 70 [degrees]. I'm really a little at a loss as to how to get it down, my suit—water valve is set now past the marks. This doesn't seem to being it down, and neither does putting it . . . negative. That's wrong. The cabin was past the marks. The suit temperature is at prelaunch value of about four. I'm going to go to a setting of plus 6 at this time and see if that will bring it down below 70 [degrees]. Over.
02 24 40.5	CC	Okay. Fine. We're indicating 84 [degrees] suit which is a bit high.
02 24 44.5	P	Roger. My gage shows 7, 76 [degrees] on the suit.
02 24 50	CC	Rog.
02 24 52	CC	Okay. Let me give you a couple of retrotimes here. You have a 2 Dog nominal; Gold is 03 . . . 29; Hotel 04 32 26.
02 25 10	P	Roger. Understand 26.
02 25 13.5	CC	We're including your clock is still one second slow.
02 25 18.5	P	Roger.
02 25 20	CC	G.m.t. hack of 15 10 42—mark. [3](02 25 25 c.e.t.)
02 25 26	P	Roger. I'm right on and so is the backup.
02 25 29.5	CC	Roger. Would you send us a blood pressure, please?
02 25 33.5	P	Starting. Roger. Starting now.
02 25 53.5	CC	What mode of communications are you using at this time?
02 25 58.5	P	I am on UHF high, Deke.
02 26 01	CC	Fine. Roger. Would you try using your mike button once instead of your VOX. See how this comes in.
02 26 05.5	P	Roger. Soon as I get through the blood pressure. I can do it now.
02 26 11.5	P	This is using the push to talk. 1, 2, 3, 4, 5, 4, 3, 2, 1. How now?
02 26 18	CC	I see no difference. They're identical.
02 26 20	P	Roger, is the modulation pretty good?
02 26 23	CC	Very good.
02 26 24	P	Roger.
02 26 26	P	Capsule stability, Deke, is very, very, good. I've noticed that I can put in a 1-degree-per-second rate on the needle just by moving heads and arms,—my head and arms. Over.
02 26 42	CC	Very good, excellent. For your information, there will be no flares at Woomera on this pass, since the cloud cover won't allow you to see them anyway.
02 26 50	P	Roger. I was unsuccessful last pass.
02 26 55.5	CC	Okay, I'm going to send you a Z cal at this time.
02 26 59	P	Roger.
02 27 02.5	CC	Mark!
02 27 15.5	CC	Z cal is coming off.
02 27 17.5	P	Roger.
02 27 18.5	CC	On with R cal.
02 27 20	P	Roger.
02 27 33	P	Blood pressure stop.
02 27 34.5	CC	Blood pressure stop. Okay, we're going to oscillate R cal a couple of times here in attempt to reset our temperature problem.

[3] Editor's note

02 27 41.5	P	Roger.
02 27 47	CC	Okay, R cal off. We suggest you go to manual at this point and preserve your auto fuel. Low at this point.
02 27 53.5	P	Roger. Going to manual now.
02 27 57	CC	Roger.
02 28 00.5	P	At this time I'm reading 45–70 [percent] on fuel.
02 28 04.5	CC	Rog. Understand 45–70 [percent].
02 28 07	P	Cabin temperature is 107 [degrees].
02 28 10.5	CC	Cabin 107 [degrees].
02 28 17.5	CC	I don't believe you've ever received any sunrise, sunset times.
02 28 23	P	Roger. Give me the whole lot of them, Deke, or the ones that are coming. Give me rise, set, and rise.
02 28 32	CC	Roger. Will do. Your next sunrise will be 02 50 00.
02 28 40	P	Roger. Copy.
02 28 41.5	CC	Sunset 03 41 20.
02 28 47	P	Roger.
02 28 48.5	CC	Sunrise 04 19 00.
02 28 54.5	P	Roger. Copy.
02 28 59	CC	Well, it sounds like you're doing real well up there, Dad.
02 29 01.5	P	Roger. It's a little warm.
02 29 04	CC	I suspect so.
02 29 09	CC	Been riding your horse the last couple of days.
02 29 12	P	Good.
02 29 23.5	CC	For your information, Cape informs that if we don't stay on manual for quite a spell here we'll probably have to end this orbit.
02 29 31	P	I'll be sure and stay on manual.
02 29 33.5	CC	Roger.
02 29 35.5	CC	You've got a lot of drift left here yet too.
02 29 38.5	P	Say again.
02 29 40	CC	You've got drift capability left yet, too.
02 29 41.5	P	Roger.
02 29 47.5	CC	Did you see any lights over the Australian . . .?
02 29 50.5	P	I did. That is, Roger. I did see some lights. I couldn't identify them, however.
02 29 57.5	CC	Roger. Understand.
02 30 05.5	CC	Would you give us another readout on your suit steam temp? Has this changed any?
02 30 09.5	P	It may have gone down just a tad. It's about zero now; I mean about 70 [degrees] now. It was a little bit higher. The visor is closed and I'm beginning to feel a little cooler.
02 30 24	CC	Very good.
02 30 27	CC	We indicated 2-degree drop at suit inlet, so it sounds like you're making out a bit.
02 30 30	P	Roger. My control mode now, Deke, is manual; gyros free; and the maneuver is off.
02 30 41.5	CC	Roger. I understand. Manual; gyro free; and maneuver off.
02 30 44.5	P	Roger
02 31 23.5	CC	Aurora Seven, this is Muchea Cap Com. Are you reading?
02 31 26	P	Still reading, Muchea.
02 31 28	CC	Very good.
02 31 30	CC	We are just kind of leaving you alone. How is your balloon doing, incidentally?
02 31 33.5	P	I haven't found it since it got dark. It's—it's—it rambles quite a bit, Deke. It's not inflated fully, and it doesn't stretch out on the line tight like I expected. It bounces in and out and oscillates up and down and sideways. Have no good tensiometer readings yet.

WOOMERA (SECOND PASS)

02 32 08	CC	Aurora Seven, Aurora Seven, this is Woomera Cap Com. How do you read? Over.
02 32 12	P	Hello, Woomera. Aurora Seven. Loud and clear. How me?
02 32 17	CC	Roger. You are loud and clear, also.
02 32 20.5	CC	We copied your transmission over Muchea. Understand you still have the balloon on. Is that an affirmative?
02 32 26	P	That is affirmative. I have the balloon on. However, I haven't seen it for some time. It wanders quite a bit and I do not have it in sight at this moment. I believe that—it might be visible against the earth background at this time.
02 32 49	CC	Roger. Do you see the moon at all?

02 32 52	P	I am faced the wrong way and limited in maneuverability I have left because of my fuel state. I can see the terminator between moonlit side, and unmoonlit side. Over.
02 33 08.5	CC	Roger. Understand.
02 33 15	CC	You are manual control. Is that right?
02 33 16.5	P	That is correct. My control mode is manual; gyros free; maneuver off. Over.
02 33 22.5	CC	Roger. Could you give us . . . could you give us cabin temperature?
02 33 31.5	P	Roger. Cabin temperature is 102 [degrees] at this time.
02 33 37	CC	Roger. What is the suit temperature?
02 33 41	P	Okay, stand by.
02 33 49.5	P	Suit temperature is 74 [degrees]; suit steam exhaust is 71 [degrees].
02 33 58.5	CC	Roger. Understand. Are you feeling a little more comfortable at this time?
02 34 02.5	P	I don't know. I'm still warm and still perspiring, but not really uncomfortable. I would like to—I would like to nail this suit temperature problem down. It—for all practical purposes, it's uncontrollable as far as I can see.
02 34 26.5	CC	Roger. Understand. You might have to wait a few more minutes before this takes effect. You are on No. 6. Is that right?
02 34 34	P	That is right. Suit temperature is No. 6.
02 34 39	CC	Roger. Systems reports that your suit temperature has dropped 2 degrees over station, if that's any encouragement to you.
02 34 44.5	P	Roger. Thank you. It is.
02 34 46.5	CC	Roger.
02 34 50	CC	Have you taken any food thus far?
02 34 53	P	Yes, I have. However, the food has crumbled badly; and I hate to open the package any more for fear of getting crumbs all over the capsule. I can verify that eating bite-size food as we packaged for this flight is no problem at all. Even the crumbly foods are eaten with no, with no problem.
02 35 20	CC	Roger. How about water?
02 35 22.5	P	I had taken four swallows at approximately this time last orbit. As soon as I get the suit temperature pegged a little bit, I'll open the visor and have some more water. Over.
02 35 37	CC	Roger. You are still coming in very loud and clear.
02 35 43	P	Roger.
02 35 45	CC	. . . out at this time.
02 37 11	P	For the record now—
02 37 32. 5	P	One of the labels for a fuse switch has slipped out, and sideways, and has tied the adjoining fuse switch together with it. This happened to emergency-main and reserve-deploy fuse switches.
02 38 06.5	P	I caged the gyros. They are too critical. I will try and navigate on the dark side without the gyros.
02 38 30	P	The fuse switch should be glued in better so that turning off one fuse does not turn off the adjoining one.
02 39 35	P	I guess I'd better try to get that xylose pill out. I hate to do this.
02 40 57.5	P	Oh yes. There is the xylose pill. It didn't melt. All the rest of the stuff in here did melt.
02 41 31	P	Okay. Xylose pill being consumed at 02 41 35. The rest of the food is pretty much of a mess. Can't stand this cabin temperature.

CANTON (SECOND PASS)

02 43 39.5	P	Hello, Canton Com Tech. Aurora Seven reads you loud and clear. How me?
02 43 44.5	CC	This is Canton Cap Com. Read you loud and clear. Could you begin your short report, please?
02 43 51	P	Roger, George. My control mode is manual. The gyros are caged, maneuver is off. Fuel is 45 and 64 [percent], a little ahead of schedule. Oxygen reads 82–100 [percent]. Steam vent temperature in the suit is dropping slightly. It's a little below 70 [degrees]. Cabin is 4.6 [psia]. Suit temperature has dropped to about 71 [degrees] now. All the power is good, and here is a blood pressure. Over.
02 44 30	CC	Okay, standing by for blood pressure.
02 44 44	CC	We are receiving the blood-pressure check. Over.
02 44 47	P	Roger.
02 44 50	CC	Do you plan on eating as called for by . . . . Over.

02 44 57	P	I did have the visor open a short time ago for the xylose pill. All of the rest of the food that I have aboard has either crumbled or melted. It's unusable in its present state so I think the xylose pill will constitude my last zero g meal. However, the first one, before the food crumbled, was quite easy. It's no problem to eat this bite-size food—in a weightless state. I also drank some water at that time, which was no problem.
02 45 32.5	CC	Roger. I take it, from what you said then, that you have confirmed that your faceplate is closed for the decision on the third orbit.
02 45 42.5	P	That is correct. My faceplate is closed. Also, what is the trend of my cabin pressure on the ground? Over.
02 45 51	CC	Stand by, please.
02 46 08	CC	We are checking on your request there, Scott. Could you hit that button again? We lost your EKG.
02 46 15	P	Oh, you want blood pressure or EKG?
02 46 17.5	CC	No, we lost the EKG. Possibly you could press on those sensors. Okay, Surgeon informs me that the EKG is now returning. Your other question, cabin pressure is staying at 5.1 [psia] approximately.
02 46 36.5	P	Roger. No change in reading since launch. Is that correct?
02 46 40	CC	Negative on that. It's gone from 5.8 [psia] at launch to approximately 5.1 [psia] in very, very gradual descending trend.
02 46 52	P	Roger. My cabin pressure indicator is reading 4.8 [psia] at this time.
02 47 02	CC	Roger, I have no comment on this, just that the trend appears to be good here on the ground.
02 47 09.5	P	Roger.
02 47 16.5	CC	Do you have any specific comments on your balloon experiments; for example, the best color contrast with the ——.
02 47 36.5	P	Yes, I would say the day-glow orange is the best.
02 47 41	CC	Roger. For your information, the second sunrise should be expected in approximately 3 to 4 minutes.
02 47 47.5	P	Roger, thank you.
02 47 50.5	CC	Everything continues to look very good here on the ground. I've got a reading here on the ground for cabin pressure. This is for your information, is 4.8 [psia]. Now, this does take the trend that has been set up considerably. The suit pressure comes in at 4.9 [psia].
02 48 10	P	Roger.
02 48 14	CC	We find now that the—the O_2 partial pressure is fluctuating slightly, and the—hanging around 4.2 [psia].
02 48 26.5	CC	Did you——?
02 48 29.5	CC	O_2 partial pressure is fluctuating—4.2 [psia]—Over.
02 48 35	P	Roger, copied, George, thank you.
02 48 39	CC	As I said before, everything looks very good here. Surgeon is after me here for you to try another blood pressure. Is this convenient?
02 48 47.5	P	Negative. I won't be able to hold still for it now. I've got the sunrise to worry about.
02 48 52.5	CC	Okay. Roger. We have no further queries. If you have any comments we'll be listening down here.
02 49 00	P	Negative. I have a beautiful sunrise through the window. I'll record it so you can see it.

HAWAII (SECOND PASS)

02 49 07.5	CC	Aurora Seven, Aurora Seven, Hawaii Com Tech. How do you read me? Over.
02 49 12.5	P	Roger, Hawaii, Aurora Seven. Loud and clear. How me?
02 49 17.5	CC	Aurora Seven, this is Cap Com. Can you give me a short report, please.
02 49 22	P	Roger. My control mode is manual; gyros caged; maneuver off. Stand by one. My status is good and the capsule status is good. I want to get some pictures of the sunrise. Over.
02 49 37.5	CC	Roger. Give me the short report first.
02 49 40	P	Roger. Fuel is 45–62 [percent]. Over.
02 49 48	CC	Roger. 45 and 62 [percent].
02 49 50.5	P	Roger.
02 50 31	CC	Aurora Seven. Did you drink over Canton; did you drink any water over Canton?
02 50 36	P	That is negative. I will do, shortly.
02 50 40.5	CC	Roger, Surgeon feels that this is advisable.
02 50 44.5	P	Roger.

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02 50 45.5	CC	Do you have an auto-fuel warning light?
02 50 48	P	That is right. I have reported it, and I believe I reported it a long time ago. It is covered with tape at the moment.
02 50 59	CC	Roger.
02 51 24.5	CC	Aurora Seven, Aurora Seven, Cap Com. Cape Flight advises me that we—that they expected the cabin to do such.
02 51 31.5	P	Roger, thank you.
02 51 43	CC	. . . temperature exhaust . . . steam exhaust?
02 51 39	P	Roger. Suit exhaust is 70 [degrees]. Cabin exhaust is 49 [degrees].
02 51 46	CC	Roger.
02 52 20.5	CC	Aurora Seven. This is Cap Com. Would like for you to return to gyros normal and see what kind of indication we have; whether or not your window view agrees with your gyros.
02 52 34	P	Roger. Wait one.
02 52 47	P	I have some more of the white particles in view below the capsule. They appear to be traveling exactly my speed. There is one drifting off. It's going faster than I am as a matter of fact.
02 53 11.5	CC	Roger. Understand.
02 53 15	P	I haven't seen the great numbers of these particles, but I've seen a few of them. Their motion is random; they look exactly like snowflakes to me.
02 53 29	CC	Roger. Have you tried returning . . . .
02 53 33	P	Negative. Let me get within scanner limits first.
02 53 39	CC	Say again.
02 53 40	P	I must adjust my attitude to within scanner limits first.
02 53 46.5	CC	Roger.
02 54 18.5	P	There were some more of those—little particles. They definitley look like snowflakes this time.
02 54 26	CC	Roger. Understand. Your particles look like definite snowflakes.
02 54 32	P	However—
02 54 33.5	CC	Can we get a blood pressure from you, Scott?
02 54 34.5	P	Roger. Blood pressure—start—now. I have the balloon—now—pretty steadily below me, not oscillating. And go to gyros normal. Gyros normal now.
02 55 07.5	CC	Roger. TM indicates your—zero pitch.
02 55 15	CC	LOS, Scott, we've had LOS. Can you read me? Over.

CALIFORNIA (SECOND PASS)

02 58 16	CT	Aurora Seven, Aurora Seven, this is California Com Tech, California Com Tech. Do you hear me? Over.
02 58 22.5	P	Hello, Cal Com Tech, Aurora Seven. Loud and clear. How me?
02 58 45	CT	Aurora Seven, Aurora Seven, this is California Com Tech, California Com Tech. Do you hear? Over.
02 58 51.5	P	Hello, California Com Tech, Aurora Seven. Loud and clear. How me?
02 58 56	CT	We're reading you loud and clear, also. Stand by for Cap Com.
02 58 59.5	P	Roger.
02 59 06.5	CC	Aurora Seven, California. How do you read?
02 59 09.5	P	Hello, A1, loud and clear. How me?
02 59 12.5	CC	You're loud and clear, Scotty. Short report.
02 59 16.5	P	Roger. Control mode is manual, gyros normal, maneuver off. Fuel is 45–50 [percent]. Balloon is out. Oxygen 81–100 [percent]. And my status is good. The capsule status is good, except I'm unable to get a reasonable suit steam exhaust temperature. Still reading 70 [degrees]. Over.
02 59 42	CC	Roger, seems to me as long as suit inlet is going down that you could continue to increase flow until you feel comfortable.
02 59 52.5	P	Roger.
02 59 55	CC	Understand you're GO for orbit three.
02 59 58	P	I am—Roger. I am GO for orbit three.
03 00 00	CC	Seven, this is California.
03 00 12	P	Go, California.
03 00 15	CC	General Kraft is still somewhat concerned about auto fuel. Use as little auto; use no auto fuel unless you have to prior to retrosequence time. And I think maybe you might increase flow to your inverter heat exchanger to try to bring the temperature down. They are not critical yet, however.

03 00 38	P	Roger, I have gone from 4 to 5 on the inverter at this time. And I think I'll increase just a tad on the suit.
03 00 49.5	CC	Roger. You're sounding good here. Give you a period of quiet while I send Z and R cal.
03 00 55.5	P	Roger.
03 01 06	CC	Seven, this is California sending Z cal on my mark.
03 01 09.5	P	Roger.
03 01 11	CC	One, Mark.
03 01 25	CC	Z cal off.
03 01 26.5	P	Roger.
03 01 29	CC	Stand by for R cal 3, 2, 1.
03 01 35	P	All right now, I'm beginning to get all of those various particles, they—they're way out. I can see some that are a 100 feet out.
03 01 52.5	C	Roger. R cal off.
03 01 55.5	P	They all look like snowflakes to me. No don't—they do not glow of their own accord.
03 02 12	CC	Roger, Seven. Do you—have you . . . perspire or have you stopped perspiring at the moment?
03 02 20	P	No, I'm still perspiring, Al. I think I'll open up the visor and take a drink of water.
03 02 27	CC	Roger. Sounds like a good idea.
03 02 42	CC	Seven, would you give us a blood pressure, please, in between swallows.
03 03 27	P	Okay, there's your blood pressure. I took about 20 swallows of water. Tasted pretty good.
03 03 38	CC	Roger, Seven. We're sure of that, we're getting Alpha times and—Hotel. You have Hotel, I know. How about 3 Alpha?
03 03 48	P	Roger, and Mark now a tensiometer reading. It's as tight as I've seen the string. Mark another tensiometer reading.
03 03 59	CC	Roger. We have those.
03 04 01	P	Now say again your last question?
03 04 06	CC	Do you have 3 Alpha of 03 11 00?
03 04 12	P	03 11 00.
03 04 16	CC	That is correct.
03 04 22	P	Roger. Copied.
03 04 45	CC	Seven, this is California. Do you still read?
03 04 47	P	Roger. Loud and clear.
03 04 50	CC	Roger, we have no further inquiries. See you next time.
03 04 53	P	Roger.

GUAYMAS (SECOND PASS)

03 05 11	CC	Aurora Seven, Guaymas Cap Com.
03 05 13	P	Hello, Guaymas. Go ahead.
03 05 15	CC	Roger, we're reading you loud and clear. We'd like to conduct a wobulator test here. We use White Sands whenever you give us the word.
03 05 23	P	Roger, I have one; it's the yaw gyro on the stop at this time.
03 05 31	CC	Is your wobulator on now?
03 05 33	P	Yes, the wobulator is on.
03 05 35.5	CC	Roger.
03 05 43	CC	What was that on your yaw?
03 05 45.5	P	I have the yaw needle on the 250 stop.
03 05 50.5	CC	Roger.
03 05 52.5	P	I will not cage until after I get rid of the balloon, and then I can start a slow yaw to the left to pick it off the stop.
03 06 04	CC	Roger.
03 06 12	CC	Roger. Can you turn your wobulator on now and leave it on?
03 06 15.5	P	Roger. It has been on, and I haven't touched it.
03 06 19	CC	Roger. Understand.
03 06 20.5	P	Do you want it off?
03 06 24	CC	Roger. On and off in approximately 20-second intervals.
03 06 29	P	Okay, wobulator going off—Now.
03 06 38	CC	Roger. We're relaying this.
03 06 46.5	P	Am I in a position to do a 360 [degree] roll for them at this time?
03 06 51	CC	Your 00 yaw; you do have a yaw input in.
03 06 57	P	Could we do this 360 [degree] roll on this pass at White Sands?
03 07 03	P	Gordo.

03 07 12.5	CC	Aurora Seven, Cape Cap Com.
03 07 15	P	Roger. Cape. Loud and clear and break, break. Guaymas, the wobulator is back on now.
03 07 24.5	P	Roger. Cape. Go ahead.
03 07 26.5	CC	Roger. Aurora Seven, Cape Cap Com back on HF. Give me your report.
03 07 32	P	Roger. Control mode, manual; gyros normal; the maneuver switch is off. Fuel is 45-45 [percent]; oxygen is 70 [percent], or, correction, oxygen is 80 and 100 [percent]. Suit temperature is 68 [degrees], now and coming down pretty well. Suit steam vent temperature is 69 [degrees], and beginning to be a little more comfortable. Over.
03 08 12	CC	Roger, and how do you feel, now?
03 08 15	P	I feel pretty good. Still warm.
03 08 18	CC	Okay, sounds like you'll be all right.
03 08 23	CC	Did you—your normal balloon release time will be 3 plus 34, Scott?
03 08 28.5	P	3 plus 34, Roger.
03 08 31	CC	Roger, can you describe the balloon and its actions a little to us?
03 08 35	P	Yes, it has a random drift. There is no oscillation that I can predict whatsoever. The—the line leading to the balloon sometimes is tight; sometimes is loose—loose enough, so that there are loops in it. Its—its behaviour is strictly random as far as I can tell. The balloon is not inflated well either. It's an oblong shape out there, rather than a round figure; and I believe when the sun is on it, the day-glow orange is the most brilliant, and the silver. That's about all I can tell you, Gus.
03 09 28.5	CC	Roger. Surgeon suggests that you drink as much water as you can. Drink it as often as you can.
03 09 38.5	P	Roger.
03 09 40	CC	Retrosequence times for area 3 B and 3 C are nominal.
03 09 43.5	P	3 B and 3 C nominal. Roger.
03 09 50.5	CC	And we recommend you go to normal on your gyros with the maneuver switch off.
03 09 55	P	Roger. The gyros are normal and the maneuver switch is off.
03 09 59.5	CC	Roger.
03 10 11.5	CC	Would you give us your—your temperature control valve settings, please?
03 10 20	P	Roger, suit is 7.5, cabin is about 10. That's 10 on the cabin and 5 on the inverters. Over.
03 10 35	CC	Roger.
03 10 37.5	CC	Stand by for Z cal.
03 10 39.5	P	Roger, standing by.
03 10 46	CC	R cal.
03 10 53.5	P	Mark a tensiometer reading. It's as tight as I've—as it gets.
03 11 29.5	CC	Aurora Seven, Cap Com.
03 11 32	P	Go ahead, Cap Com.
03 11 33.5	CC	. . . drifting flight yet?
03 11 35	P	Say again.
03 11 36.5	CC	Have you done any drifting flight?
03 11 38.5	P	That is Roger. And if I am to save fuel for retrosequence, I think I better start again. Over.
03 11 49	CC	Roger, I agree with you.
03 11 52	P	My control mode is now manual; gyros are caged, and I will allow the capsule to drift for a little while.
03 12 04	CC	Roger, and John suggests you try to look back, towards the darkness, at sunrise to see those particles.
03 12 14	P	Toward the darkness.
03 12 16	CC	Roger. At sunrise, try to look toward the darkness.
03 12 18.5	P	Okay, I have done that, and—and—tell him no joy.
03 12 24	CC	Roger.
03 12 36.5	CC	Aurora Seven, are you in drifting flight?
03 12 38.5	P	That is Roger.
03 12 40.5	CC	Roger.
03 12 46.5	P	I am looking down almost vertically. It's possible to distinguish, I believe, four separate cloud layers.
03 12 57.5	CC	Understand.
03 13 07	P	Balloon—I'll maneuver enough to get the balloon out in trail so I can photograph its departure.
03 13 35.5	CC	Roger.
03 13 55	P	I, incidently, have those little particles visible in the periscope at this time.

03 14 05	CC	Roger. Understand the periscope.
03 14 22.5	CC	Aurora Seven, Cap Com.
03 14 24	P	Roger. Go ahead.
03 14 26.5	CC	We're still fairly happy with your fuel state now. Don't let—we'd like for you not to let either get down below 40 percent.
03 14 33	P	Roger. I'll try. I have balloon jettison on and off, and I can't get rid of it.
03 14 41	CC	Understand that you can't get rid of the balloon.
03 14 43.5	P	That's right. It will not jettison.
03 14 48.5	CC	Okay.
03 15 19	CC	Aurora seven, Cap Com.
03 15 21.5	P	Go ahead, Cap Com.
03 15 23	CC	Give us your blood pressure and fuel reading.
03 15 26	P	Okay. Fuel is 45–42 [percent]. Blood pressure on the air.
03 15 32	CC	Rog.
03 15 58	P	I have the particles visible still. They're streaming aft, but in an arc of maybe a 120 or 130 degrees.
03 16 16.5	CC	Aurora Seven, Cap Com. Say again.
03 16 19	P	Roger, I have these particles drifting aft again, but they do not parallel the line to the balloon exactly. They drift aft within an arc of maybe 120 to 130 degrees.
03 16 36	CC	Roger.
03 16 41	CC	Aurora Seven, Cap Com. Can you give us a comment on the zero g experiment?
03 16 53.5	P	Roger. At this moment, the fluid is all gathered around the standpipe; the standpipe appears to be full and the fluid outside the standpipe is about halfway up. There is a rather large meniscus. I'd say about 60° meniscus.
03 17 27.5	CC	Aurora Seven, Cap Com. Repeat as much of your last message as you can.
03 17 32	P	Roger. The standpipe is full of the fluid. The fluid is halfway up the outside of the standpipe—a rather large meniscus, on angle of about 60 degrees. Over.

CANARY (THIRD PASS)

03 20 31	CC	Aurora Seven, Aurora Seven, this is Canary Cap Com on HF. Do you read? Over.
03 21 00	P	Hello, hello, Canary Cap Com, Aurora Seven. Reading you loud and clear; HF. Transmitting HF. How do you read? Over.
03 21 32.5	CC	Aurora Seven, this is Canary Cap Com on HF. Do you read? Over.
03 21 40.5	P	Roger, Canary Cap Com. Reading you loud and clear; HF. How me? Over.
03 22 04	P	These pictures of the—small groups of closely knit clouds are south of Canary, third orbit.
03 22 48.5	P	This must be crossing [Intertropical Convergence Zone] (ITCZ). I have never seen weather quite like this.
03 22 34	CC	This is Canary Cap Com on HF. Do you receive? Over.
03 23 36.5	CC	Aurora Seven, this is Canary Cap Com. We had no transmissions from you. This is Canary Islands, signing out.
03 24 33	P	I have the Voasmeter out at this time.
03 24 53	P	Hello.
03 25 01	P	Hello, Canary Cap Com, Aurora Seven. Reading you loud and clear. How me?
03 25 08	CC	Aurora Seven, this is Canary Cap Com. Do you read? Over.
03 25 12.5	P	Go ahead, Canary. Reading you loud and clear.
03 25 18.5	P	I am going—I am in the record only position now. I think the best answer to the autokinesis—is that there is none. I noticed none—and I tend to aline the horizontal with my head—it—a horizontal line under zero g is a line parallel to the line drawn between your eyes. I don't get autokinesis. I don't get—now wait a minute, maybe I'm beginning to.
03 26 40	P	I should remark that at 3 26 33, I have in the sky, at any time, 10 particles. They no doubt appear to glow to me. They appeared to be little pieces of frost. However, some appear to be way, way far away. There are two—that look like they might be a 100 yards away. I haven't operated the thruster not for some time. Here are two in closer. Now a densiometer reading on these that are in close. Extinct at 5.5, the elapsed time is 3 27 39. I am unable to see any stars in the black sky at this time. However, these little snowflakes are clearly visible.
03 28 13	P	The cabin temperature has dropped considerable now, and the setting I have on the suit is 7.
03 28 20.5	P	Am going to increase it just a tad more.
03 28 40	P	My suit valve, water valve temperature now is—about 8.
03 28 53	P	Hello, hello, Kano Cap Com, Aurora Seven. Reading you loud and clear. How me?

03 29 24	P	I've noticed that every time I turn over to the right everything seems vertical, but I am upside down.
03 29 34	P	Now, for the record.
03 29 43.5	P	I still feel that, I could easily feel like I am coming in on my back.
03 30 03	P	I could very easily come in from another planet, and feel that I am on my—on my back, and that earth is up above me, but that's sorta the way you feel when you come out of split S, or out of an Immelmann.

KANO (THIRD PASS)

03 30 48	CC	Kano on HF. If you read me, the surgeon requests that you take a blood-pressure check now, a blood-pressure check for the onboard record. Over.
03 31 00	P	Roger. Reading you, Kano, loud and clear. Blood pressure start at this time.
03 31 10	P	Visor is coming closed now.
03 31 39	CC	Aurora Seven, Aurora Seven, this is Kano Cap Com. If you read me, would you do a blood-pressure check for the onboard records. Over.
03 32 55	P	Okay. I'm taking the—I've taken the big back off; going to record only, at this time. Have taken the big back off of the camera and trying to get some more MIT film at this time. The filter is in. The cassette—is in the camera.
03 33 43	P	The zero g senta sensations are wonderful. This is the first time I've ever worn this suit and had it comfortable.
03 34 07.5	P	I don't know which way I'm pointed, and don't particularly care.[4]
03 34 23	P	Roger. At this time I am hearing Kano calling for a blood-pressure check. I will give it to him now. Let's see, I have fuel 45–43, still would like to get just a little rate—just a little one.
03 34 49	P	Let's see, we wanta go back that way.
03 35 35.5	P	I can't see any relationship between thruster action and the fireflies.
03 35 43	P	Mark MIT pictures to 3 35 36, crank two by—at infinity.
03 36 36	P	Coastal passage over Africa.
03 38 33	P	I'm taking many MIT pictures, at capsule elapsed [time] 03 38 38. It will be the only chance we have. I might as well use up all the film.

INDIAN OCEAN SHIP (THIRD PASS)

03 38 54	P	Hello, Indian Com Tech, Aurora Seven. Loud and clear. How me?
03 39 13.5	CT	Aurora Seven, this is IOS Com Tech, on HF and UHF. How do you read? Over.
03 39 18.5	P	Roger. Loud and clear. How me, Indian Cap Com?
03 39 24	CC	Aurora Seven, this is Indian Cap Com. I did not read all of your transmission, but the part I monitored was loud and clear. Go ahead.
03 39 31.5	P	Roger. My status is good, the capsule status is good. I am in drifting flight on manual control. Gyros are caged. The fuel reads 45–42 [percent], oxygen 79–100 [percent]. Steam vent temperatures both read 65 [degrees] now; suit temperature has gone down nicely. It is now 62 [degrees], and all the power is good. The blood pressure is starting at this time. I've just finished taking some MIT pictures, and that is all I have to report at this time.
03 40 16.5	CC	Roger, Aurora Seven. I copy your control mode manual; gyro caged; fuel 45–42 [percent]; oxygen 79–100 [percent]; and I did not hear the last part of your transmission. How do—
03 40 31.5	P	Roger. My status is good; the suit temperature has reduced considerably; steam vent temperatures now read 69 [degrees] on cabin and suit, suit temperature is 62 [degrees], and cabin temperature is 101 [degrees]. Over.
03 40 12.5	CC	Roger. Suit temperature 62 [degrees], and cabin temperature 101 [degrees]. Your blood pressure is starting—and understand you are on the manual. Understand also you are drifting for awhile.
03 41 10	P	That is Roger. I am.
03 41 12	CC	Confirm.
03 41 13	P	I am on manual control. I am allowing the capsule to drift. Over.
03 41 18	CC	Roger.
03 41 19	P	Also another departure from the plan is the fact that I have been unable to jettison the balloon. The balloon is still attached—should be no problem.

[4] In paper 7, Astronaut Carpenter is quoted as follows: "Times when the gyros were caged and nothing was visible out the window, I had no idea where the earth was in relation to the spacecraft. However, it did not seem important to me. I knew at all times that I had only to wait and the earth would again appear in the window."

03 41 33	CC	Roger. Understand no problem expected, but balloon is still attached. Stand by.
03 42 04	CC	Aurora Seven, this is Indian Cap Com. All our retrosequence times are nominal. Do you want me to call them out to you? Over.
03 42 13	P	Negative. I have them all, thank you.
03 42 19.5	CC	Aurora Seven, your last transcription was unreadable. You are fading badly, although intermittently. I will read retrosequence times in the blind. Area 3 Delta, 04 12 32, 04 12 32; Echo 04 22 27; 3 Echo 04 22 27; and the last . . . we have is 04 32 26 . . . now and your capsule clock is still within 1 second.
03 43 05	P	Roger, Kano. I copied all that.
03 43 08.5	CC	Roger, Aurora. You were loud and clear.
03 43 20	P	The sunsets are most spectacular. The earth is black after the sun has set. The earth is black; the first band close to the earth is red, the next is yellow; the next is blue; the next is green; and the next is sort of a—sort of a purple. It's almost like a very brilliant rainbow. It extends at some—
03 43 54	CC	Indian Cap Com. Check you see about all colors between the horizon and the night sky. You seem to see more layers than Friendship Seven.
03 44 05.5	P	Roger. These layers extend from at least 90 degrees either side of the sun at sunset.
03 44 14.5	CC	Aurora Seven, I did not hear your whole sentence. Will you repeat, please? Over.
03 44 19	P	Roger. This bright horizon band extends at least 90° north and south of the position of the sunset.
03 44 45	CC	Roger. Understand. About the balloon, does Mercury Control Center know you did not—
03 44 52	P	Yes. I tried to release it over their station and was unable to do so. You might remind them that the balloon is still on.
03 45 02	CC	Roger, Aurora Seven. Understand.
03 45 25.5	CC	Aurora Seven, Indian Cap Com. Your inverter temperatures are 183 [degrees] for the 150, and 195 [degrees] for the 250. All your other primaries check out okay on telemetry.
03 45 38	P	Roger. Thank you very much.
03 46 15.5	CC	Aurora Seven, do you read? Over.
03 46 18.5	P	Go ahead, Indian Cap Com.
03 46 21	CC	Our medical monitor says that we are reading your respiration. I believe this is almost the first time it's come across.
03 46 28	P	That's very good. I guarantee I'm breathing.
03 46 35	CC	Roger. Understand.
03 46 48	P	The eye patch is in place, this time.
03 48 16.5	P	Going to record—record only at this time.
03 48 50	P	At 3 hours and 48 minutes and 51 seconds elapsed, I'm taking a good swig of water. It's pretty cool this time. Stretching my legs a tad. It's quite dark. I'm in drifting flight. Oh, boy! It feels good to get that leg stretched out. That one and the right one too.
03 49 40	P	I drank an awful lot of water and I'm still thirsty. As a matter of fact, I think there—there is a leak in the urinal, I'm sure.
03 50 38	P	Okay, line touch.
03 51 13.5	P	Okay. I'm shaking my head violently from all sides, with eyes closed, up and down, pitch, roll, yaw. Nothing in my stomach; nothing anywhere. There is now—I will try to poke zero, time zero button. Well, I missed it. I was a little disoriented [5] as to exactly where things are, not sure exactly what you want to accomplish by this but there is no problem of orienting. Your—your—inner ears and your mental appraisal of horizontal, you just adapt to this environment, like—like you were born in it. It's a great, great freedom.
03 53 25.5	P	Don't let me forget about the shiny finish on the star chart. It makes it very hard to read.
03 53 40.5	P	At 3 53.
03 55 30	P	I'm using the—photometer now—to try and get—a reading. I saw a com—no, it's the balloon that I see, still drifting aimlessly, lighted by moonlight at this time.
03 56 09.5	P	None of the colors are—particularly visible. I think——
03 56 19.5	P	Excess cabin water light is on at this time, 03 56 24. Am going to turn it down just a tad—so it will be just about where the suit is. I would say, let's see, from that, that it jumped down to freezing.

[5] The result of this test is the same under 1g and he describes no difficulty in re-establishing relationships.

03 57 00	P	Hello, Muchea Cap Com, Aurora Seven. Loud and clear. How me?
03 57 06.5	CC	Coming in loud and clear.
03 57 08	P	Roger. Deke, my control mode is manual; gyros are caged; the maneuver switch is off. My fuel reads 45 and 42 [percent]; the oxygen is reading 76 and 100 [percent]; steam vent temperatures are 68 [degrees] on the suit and I just got excess cabin water light; the needle dropped down to 20. Reset cabin water at about 6 and in this capsule it seems optimum settings are right between 6 and 7. Outside of that, all things, all systems are good. And blood pressure is starting now.
03 58 01.5	CC	Roger. Okay, starting blood pressure.
03 58 04.5	P	The visor has been open for some time, I've been taking some readings on stars through the haze layer with the photometer. The visor is coming closed now.
03 58 16.5	CC	Roger. Understand visor coming closed.
03 58 20	CC	I'll give you retro time for end of mission and would like to have you set the clock to this at this time.
03 58 26.5	P	Roger.
03 58 28.5	CC	32 34
03 58 31	P	Understand, 04 32 34.
03 58 35	CC	Good.
03 58 35.5	P	Okay. It's going into the clock now—whoop.
03 58 46.5	CC	We indicate 35.
03 58 49	P	I do, too. I overshot. Stand by.
03 59 00.5	CC	That's probably close enough for government work.
03 59 07.5	P	For you, to the second.
03 59 15.5	CC	Roger. Still you indicate 1 second slow on g.e.t.; we indicate you on, on retrotime.
03 59 20.5	P	Roger. I am reading 04 32 34.
03 59 24.5	CC	Would you please exercise prior to your second blood pressure.
03 59 29	P	Roger. I'll give you the calibrated exercise at this time.
03 59 35.5	CC	Roger.
03 59 38.5	P	Exercise start, now.
04 00 11.5	P	Okay, blood pressure start, now. That was 60 cycles in 30 seconds on the exerciser.
04 00 19.5	CC	60 cycles in 30 seconds.
04 00 25	CC	Did you by any chance try T/M keying over the Cape on your last pass?
04 00 31.5	P	I think I may have to mark time for tensiometer reading on the balloon.
04 00 40.5	CC	Very good.
04 00 43	CC	Understand you still have the balloon with you. It's possible if you go to deploy position and back to release, you can—
04 00 51.5	P	Roger. I've tried that a number of times, Deke. I just can't get rid of it.
04 00 57	CC	Okay. Well, she'll probably come into your face on retrofire; but I'm sure you'll lose it shortly after that.
04 01 02	P	Yeah, I figure. I hope so.
04 01 06	CC	Okay, for your information, cloud—is five-tenths and it's only one-eighth to the north over Port Moresby; so if you see some lights up in that area, we'd like to know about it.
04 01 18	P	Roger, I'll let you know.
04 01 24	CC	Could you give us a c.e.t. hack, please.
04 01 27	P	Roger. C.e.t. on my mark will be 4 hours 1 minute, 35 seconds, stand by. MARK, 4 01 35.
04 01 39	CC	Roger. Still one second off; that's fine.
04 01 45.5	CC	The flight plan calls for you to have a drink of water over here. Do you feel like you need one–
04 01 51	P	Roger. I just, I have had three long drinks of water. The last one was, I think, about 10 minutes ago, Deke.
04 02 00	CC	You're probably loaded for bear, then.
04 02 01.5	P	Roger.
04 02 14	CC	—?
04 02 17	P	Roger. Deke, the haze layer is very bright. I would say 8 to 10 degrees above the real horizon. And I would say that the haze layer is about twice as high above the horizon as the—the bright blue band at sunset is; it's twice as thick. A star, stars are occluded as we pass through this haze layer. I have a good set of stars to watch going through at this time. I'll try and get some photometer readings.
04 03 12.5	CC	Roger. Understand. It's twice as—sunset.
04 03 14.5	P	It is not twice as thick. It's thinner, but it is located at a distance about twice as far away as the top of the—the band at sunset.
04 03 29	CC	Understand.

04 03 33	P	It's very narrow, and as bright as the horizon of the earth itself.
04 03 41	CC	Rog.
04 03 59.5	P	This is a reading on Phecda in—in the Big Dipper prior to entry in the, the, into the haze layer. It occludes—it is extinct at roughly 2.5. The reticle extincts at 5.5. TM mark for the time in the middle of the haze layer. Spica—stand by.

WOOMERA (THIRD PASS)

04 05 02	CC	Aurora Seven, Aurora Seven, this Woomera Cap Com. How do you read? Over.
04 05 05.5	P	Roger. Stand by, Woomera.
04 05 08.5	CC	Roger. Standing by.
04 05 15.5	P	In the middle of the haze layer, Phecda will not—I can't even get a reading on it through the photometer. Phecda is now below the horizon, or below and mark about 5 seconds ago, now it emerged from the brightest part of the haze layer. It is now clearly visible. Woomera, my status is very good, fuel is 45 and 42 [percent]. Standby, I'll give you a full report very shortly.
04 05 55.5	CC	Roger. Standing by.
04 06 01.5	P	Visor coming open.
04 06 03.5	CC	Roger. Visor open.
04 06 27.5	CC	Aurora Seven, this is Woomera. Do you read? Over.
04 06 29.5	P	Roger, Woomera, loud and clear.
04 06 32.5	CC	You say visor is open?
04 06 35.5	P	That's negative. I did not open it. I won't open it until I get through with these readings. Phecda now extincts at 1.7 in the mid, in mid position between the haze layer and the earth. Okay, Woomera, my—my status is very good. The suit temperature is coming down substantially. Steam vent temperature is not down much, but the suit environment temperature is 60 [degrees]. I'm quite comfortable. Cabin temperature is 101 [degrees]; cabin is holding an indicated 4.8; oxygen is 75-100 [percent], all d-c power continues to be good, 20 Amps; both a-c busses are good; fuel reads 46 and 40 [percent]. I am in drifting flight. I have had plenty of water to drink. The visor is coming open now. And blood pressure is coming your way at this time.
04 08 00.5	P	Hello, Woomera, Woomera Cap Com, this is Aurora Seven. Did you copy my last? Over.
04 09 27.5	P	Cabin temperature, cabin water flow is all the way off and reducing back to about 7.5 now, a little bit less. At this time cabin steam vent going to record only.
04 09 52.5	P	Cabin steam vent is 10; suit steam vent is 62. I would like to have a little bit more pad on the temperature, but I can't seem to get it. The suit temperature is 60 [degrees]; the cabin temperature continues at 102 [degrees]. I have 22 minutes and 20 seconds left for retrofire. I think that I will try to get some of this equipment stowed at this time.
04 11 07.5	P	There is the moon.
04 11 31.5	P	Looks no different—here than it does on the ground.
04 11 51	P	Visor is open and the visor is coming closed now at this time.
04 12 28	P	I have put the moon—in the center of the window and it just drifts very, very little.
04 12 49.5	P	There seems to be a stagnant place in the, my helmet. The suit is cool, but along my face it's warm.
04 13 51	P	And there is Scorpio.
04 14 46.5	P	All right, let's see.
04 15 04	P	It's very interesting to remark that my attitude—and the—is roughly pitchup plus 30 [degrees], roll right 130 [degrees], and yaw left 20 [degrees]. The balloon at this time is moving right along with me. It's keeping a constant bearing at all times. There is the horizon band again; this time from the moonlit side. Let me see, with the airglow filter, it's very difficult to do this because of the lights from that time correlation clock. Visor coming open now. It's impossible to get dark-adapted in here, with that light the way it is.
04 17 23.5	P	All right for the record. Interesting, I believe. This haze layer is very bright through the airglow filter. Very bright. The time now is 4 17 44.
04 18 00.5	P	Now, let me see, I'll get an accurate band width.
04 18 21	P	That's very handy, because the band width—there is the sun. . . . The horizon band width is exactly equal to the X. I can't explain it; I'll have to, to—

04 19 22.5	P	Sunrise. Ahhhhh! Beautiful lighted fireflies that time. It was luminous that time. But it's only, okay, they—all right, I have—if anybody reads, I have the fireflies. They are very bright. They are capsule emanating. I can rap the hatch and stir off hundreds of them. Rap the side of the capsule; huge streams come out. They—some appear to glow. Let me yaw around the other way.
04 20 25	P	Some appear to glow but I don't believe they really do; it's just the light of the sun. I'll try to get a picture of it. They're brilliant. I think they would really shine through 9 on the photometer. I'll rap. Let's see.
04 21 39.5	P	Taking some pictures at F 2.8 and bulb. The pictures now, here, one of the balloon. The sun is too bright now. That's where they come from. They are little tiny white pieces of frost. I judge from this that the whole side of the capsule must have frost on it.

HAWAII (THIRD PASS)

04 22 07	CT	Aurora Seven, this is Hawaii Com Tech, how do you read?
04 22 10	P	Hello, Hawaii, loud and clear. How me?
04 22 19	P	Hawaii Com Tech.
04 22 21	CT	Seven, Hawaii Com Tech, I read you momentarily on UHF. How do you read? Over.
04 22 26	P	Roger, reading you loud and clear Hawaii. How me?
04 22 31.5	CC	Aurora Seven, Hawaii Cap Com. How do you read me?
04 22 35	P	Roger, Do you read me or do you not, James?
04 22 39.5	CC	Gee, you are weak; but I read you. You are readable. Are you on UHF-Hi?
04 22 44.5	P	Roger, UHF-Hi.
04 22 47.5	CC	Roger, Orientate the spacecraft and go to the ASCS.
04 22 53.5	P	Roger, Will do.
04 22 59	P	Roger, Copied, Going into orbit attitude at this time.
04 23 13	CC	Aurora Seven, Aurora Seven, do you copy? Over.
04 23 16	P	Roger. Copy. Going into orbit attitude at this time.
04 23 24	CC	Roger.
04 24 11	CC	Aurora Seven, Hawaii Cap Com. Do you read me? Over.
04 24 14	P	Roger. Go ahead, Hawaii.
04 24 15	CC	Is your maneuver switch off?
04 24 18	P	The maneuver switch is off.
04 24 20	CC	Roger. Are you ready to start your pre-retrosequence checklist?
04 24 23.5	P	Roger. One moment.
04 24 36	P	I'm alining my attitudes. Everything is fine. I have part of the stowage checklist taken care of at this time.
04 24 47	CC	Roger.
04 25 11.5	CC	Aurora Seven, do you wish me to read out any of the checklist to you?
04 25 17	P	Roger. Let me get the stowage and then you can help me with the pre-retrograde.
04 25 24	CC	Roger. Standing by.
04 25 55	CC	Aurora Seven, can we get on with the checklist? We have approximately 3 minutes left of contact.
04 26 00	P	Roger. Go ahead with the checklist. I'm coming to retroattitude now and my control mode is automatic and my attitudes-standby. Wait a minute, I have a problem in.
04 26 33.5	P	I have an ASCS problem here. I think ASCS is not operating properly. Let me—. Emergency retrosequence is armed and retro manual is armed. I've got to evaluate this retro—this ASCS problem, Jim, before we go any further.
04 27 04	CC	Roger. Standing by. Make sure your emergency drogue deploy and emergency main fuses are off.
04 27 13.5	P	Roger. They are. Okay, I'm going now to fly-by-wire, to Aux Damp, and now—attitudes do not agree. Five minutes to retrograde; light is on. I have a rate of descent, too, of about 10, 12 feet per second.
04 27 46.5	CC	Say again, say again.
04 27 49	P	I have a rate of descent of about 12 feet per second.
04 27 54	CC	What light was on?
04 27 56.5	P	Yes, I am back on fly-by-wire, trying to orient.
04 28 06	CC	Scott, let's try and get some of this retrosequence list checked off before you get to California.
04 28 12.5	P	Okay. Go through it, Jim.
04 28 26.5	P	Roger. Jim, go through the checklist for me.
04 28 29.5	CC	Roger. Squib switch armed; auto retrojettison switch off; gyros normal; manual handle out; roll, yaw and pitch handles in.

04 28 42.5	P	Roll, yaw, and pitch are in.
04 28 46.5	CC	Retroattitude auto; retract scope auto; maneuver switch off; periscope lever up; UHF-Hi power; transmit on UHF; beacon continuous; VOX power on transmit and record; all batteries checked. Do you copy?
04 29 10	P	Roger. It's complete.
04 29 15.5	CC	Transmitting in the blind. We have LOS. Ground elapsed time is on my mark, 4 hours 29 minutes and 30 seconds. Transmitting in the blind to Aurora Seven. Make sure all your tone switches are on; your warning lights are bright; the retro manual fuse switch is on; the retrojettison fuse switch is off. Check your faceplate and make sure that it is closed.
04 29 59	CC	Aurora Seven. Did you copy?
04 30 00.5	P	Roger. Copied all; I think we're in good shape. I'm not sure just what the status of the ASCS is at this time.

CALIFORNIA (THIRD PASS)

04 31 36	CT	Aurora Seven, Aurora Seven, this is California Com Tech, California Com Tech. Do you hear? Over.
04 31 42	P	Hello, California Com Tech. Loud and clear. How me?
04 31 45.5	CT	I'm reading you loud and clear also. Stand by for Cap Com.
04 31 50	CC	Seven, this is Cap Com. Are you in retroattitude?
04 31 53	P	Yes, I don't have agreement with ASCS in the window, Al. I think I'm going to have to go to fly-by-wire and use the window and the scope. ASCS is bad. I'm on fly-by-wire and manual.
04 32 06	CC	Roger. We concur. About 30 seconds to go.
04 32 21	CC	About 10 seconds on my mark.
04 32 23.5	P	Roger.
04 32 28	CC	6, 5, 4, 3, 2, 1.
04 32 36	P	Retrosequence is green.
04 32 40	CC	Roger. Check ASCS quickly to see if orientation mode will hold.
04 32 47	CC	If your gyros are off, you'll have to use attitude bypass.
04 32 51	P	Gyros are off.
04 32 54.5	CC	But you'll have to use attitude bypass and manual override.
04 32 58.5	P	Roger.
04 33 00	CC	4, 3, 2, 1, 0.
04 33 14.5	P	Okay. Fire 1, fire 2, and fire 3. I had to punch off manually. I have a little bit of smoke in the capsule.
04 33 30	CC	Attitudes hold, Scotty.
04 33 31.5	P	Okay, I think they held well, Al. The—I think they were good. I can't tell you what was wrong about them because the gyros were not quite right. But retrojettison—3 fuse switches are on.
04 33 51.5	CC	Roger. We should have retrojettison in about 10 seconds.
04 33 55	P	Roger.
04 33 56.5	P	That was a nice gentle bump. All three have fired. Retroattitude was red.
04 34 05.5	CC	Roger. Should have retrojettison now.
04 34 10	P	Ah, right then at 34 10, on time.
04 34 15	CC	Roger. How much fuel do you have left both tanks?
04 34 19	P	I have 20 and 5 [percent].
04 34 23.5	CC	Roger. I guess we'd better use—
04 34 26	P	I'll use manual.
04 34 27.5	CC	—on reentry, unless ASCS holds you in reentry attitude.
04 34 31	P	Yes, it can. I'll have to do it with manual.
04 34 39	CC	Roger. Recommend you try Aux Damp first; if it's not working, then go to fly-by-wire.
04 34 45	P	Okay, I'll have to do that.
04 34 53	P	The balloon is gone [out of sight]. I am apparently out of manual fuel. I have to go to fly-by-wire to stop this tumbling.[6]
04 35 13.5	CC	Roger. Using fly-by-wire to stop tumbling.
04 35 24.5	CC	Aurora Seven. Understand RSCS did not work.
04 35 27.5	P	I am out of manual fuel, Al.

[6] Tumbling here refers to low rates of all axes; however, the spacecraft was returned to proper attitude by the pilot before it had made ¼ revolution.

04 35 31	CC	Roger.
04 35 34.5	P	.05 g should be when?
04 35 37.5	CC	Oh, you have plenty of time. It should be 04 44 elapsed time
04 35 45	P	Roger.
04 35 46	CC	You have plenty of time. Take your time on fly-by-wire to get into reentry attitude.
04 35 50.5	P	Roger.
04 36 05	CC	I was just looking over your reentry checklist. Looks like you're in pretty good shape. You'll have to manually retract the scope.
04 36 14.5	P	No. I didn't. The scope did come in, Al.
04 36 18.5	CC	Roger. I didn't get that. Very good.
04 36 29.5	CC	How are you doing on reentry attitude? Over.
04 36 32.5	P	Stowing a few things first. I don't know yet. Take a while.
04 36 46	P	Okay.
04 36 54	P	Going to be tight on fuel.
04 37 02.5	CC	Roger. You have plenty of time; you have about 7 minutes before .05 g so take . . .
04 37 10	P	Roger.
04 37 28	P	Okay. I can make out very, very small—farm land, pasture land below. I see individual fields, rivers, lakes, roads, I think. I'll get back to reentry attitude.
04 37 39.5	CC	Roger. Seven, recommend you get close to reentry attitude, using as little fuel as possible and stand by on fly-by-wire until rates develop. Over.
04 37 50	P	Roger. Will do.
04 38 03	CC	Seven, this is California. We're losing you now. Stand by for Cape.
04 38 08.5	P	Roger.

CAPE CANAVERAL (THIRD PASS)

04 40 50.5	CC	Aurora Seven, Cape Cap Com. Over.
04 40 52.5	P	Hello Cape Cap Com, Aurora Seven. Loud and clear.
04 41 08	CC	Aurora Seven, Cape Cap Com. Over.
04 41 10	P	Hello, Cape Cap Com. Go ahead.
04 41 12.5	CC	Roger. Do you have your face, faceplate closed?
04 41 16	P	Negative. It is now. Thank you.
04 41 18.5	CC	Roger. Give me your fuel, please.
04 41 20	P	Fuel is 15 [percent] auto. I'm indicating 7 [percent] manual, but it is empty and ineffective.
04 41 27	CC	Roger. You have a few minutes to start of blackout.
04 41 33	P	Two minutes, you say?
04 41 49	CC	Aurora Seven, Cap Com.
04 41 50	P	Go ahead, Cap Com.
04 41 52.5	CC	Just wanted to hear from you.
04 41 54	P	Roger. It's going to be real tight on fuel, Gus. I've got the horizon in view now. Trying to keep rates very low. I just lost part of the balloon. The string from the balloon.
04 42 10	CC	. . . checklist.
04 42 12	P	Yes. We're in good shape for stowage.
04 42 18.5	CC	Aurora Seven, have you completed your reentry . . . .
04 42 20.5	P	Roger.
04 42 22	CC	Check.
04 42 28.5	CC	The weather in the recovery area is good. You've got overcast cloud; 3-foot waves; 8 knots of wind; 10 miles visibility; and the cloud bases are at 1,000 feet.
04 42 39	P	Roger.
04 42 45	CC	Will give you some more as soon as we get an IP.
04 42 47	P	Roger.
04 43 05	CC	Aurora Seven, Cap Com. Will you check your glove compartment and make sure it's latched and your . . . .
04 43 10.5	P	Roger, it's tight.
04 43 12.5	CC	Rog.
04 43 16	CC	Starting into blackout anytime now.
04 43 18	P	Roger.
04 43 21.5	CC	Roger. We show you still have some manual fuel left.
04 43 24.5	P	Yes, but I can't get anything out of it.
04 43 28.5	CC	Roger.
04 43 40	CC	Aurora Seven, Cap Com. Do you still read?
04 43 42.5	P	Roger. Loud and clear.

04 43 52	P	I don't have a roll rate in yet. I'll put some in when I begin to get the g buildup.
04 44 07.5	P	I only was reading 0.5 g's on the accelerometer. Okay, here come some rates.
04 44 28.5	P	I've got the orange glow. I assume we're in blackout now. Gus, give me a try. There goes something tearing away.
04 44 52.5	P	Okay. I'm setting in a roll rate at this time.
04 45 06	P	Going to Aux Damp.
04 45 13.5	P	I hope we have enough fuel. I get the orange glow at this time.
04 45 30.5	P	Bright orange glow.
04 45 43.5	P	Picking up just a little acceleration now.
04 46 17.5	P	Not much glow: just a little. Reading 0.5 g. Aux Damp seems to be doing well. My fuel, I hope, holds out. There is 1 g. Getting a few streamers of smoke out behind. There's some green flashes out there.
04 47 02.5	P	Reentry is going pretty well. Aux Damp seems to be keeping oscillations pretty good. We're at 1½ g's now. There was a large flaming piece coming off. Almost looked like it came off the tower.[7]
04 47 36.5	P	Oh, I hope not.
04 47 47	P	Okay. We're reading 3 g's, think we'll have to let the reentry damping check go this time. Reading now 4 g's. The reentry seems to be going okay. The rates there that Aux Damp appears to be handling. I don't think I'm oscillating too much; seem to be rolling right around that glow—the sky behind. Auto fuel still reads 14 (percent) at 6.5 g's. Rates are holding to within 1½ degrees per second indicating about 10 degrees per second roll rate. Still peaked at 6.8 g's. The orange glow has disappeared now. We're off peak g. Still indicating 14 [percent] auto fuel; back to 5 g's.
04 49 18.5	P	And I'm standing by for altimeter off the peg. Cape, do you read yet? Altimeter is off the peg. 100 [1,000] ft., rate of descent is coming down, cabin pressure is—cabin pressure is holding okay. Still losing a few streaming. No, that's shock waves. Smoke pouring out behind. Getting ready for the drogue at 45 [1,000 ft].
04 49 58	P	Oscillations are pretty good. I think ASCS has given up the ghost at this point. Emergency drogue fuse switch is on.
04 50 20.5	?	. . .
04 50 29.5	P	Roger. Aurora Seven, reading okay. Getting some pretty good oscillations now and we're out of fuel. Looks from the sun like it might be about 45 degrees. Oww, it's coming like—it's really going over.
04 50 51	P	Think I'd better take a try on the drogue. Drogue out manually at 25 [1,000 ft.]. It's holding and it was just in time. Main deploy fuse switch is on now, 21 [1,000 ft.] indicated [altitude].
04 51 12.5	P	Snorkle override now. Emergency flow rate on. Emergency main fuse switch at 15 [1,000 ft.], standing by for the main chute at 10 [1,000 ft.].
04 51 33.5	P	Cabin pressure, cabin altimeter agree on altitude. Should be 13,000 [feet] now. Mark 10; I see the main is out, and reefed, and it looks good to me. The main chute is out. Landing bag goes to auto now. The drogue has fallen away. I see a perfect chute, visor open. Cabin temperature is only 110 [degrees] at this point. Helmet hose is off.
04 52 39.5	P	Does anybody read. Does anybody read Aurora Seven? Over.
04 52 54.5	P	Hello, any Mercury recovery force. Does anyone read Aurora Seven? Over.
04 53 04.5	CC	Aurora Seven, Aurora Seven, Cape Cap Com. Over.
04 53 07.5	P	Roger. Say again. You're very weak.
04 53 13	CC	Aurora Seven, Aurora Seven, Cape Cap Com. Over.
04 53 16	P	Roger. I'm reading you. I'm on the main chute at 5,000 [feet]. Status is good. I am not in contact with any recovery forces. Do you have any information on the recovery time? Over.
04 54 14	P	Hello, any Mercury recovery forces. How do you read Aurora Seven? Over.
04 54 27	CC	Aurora Seven, Cape Cap Com. Over.
04 54 29	P	Roger. Loud and clear. Aurora Seven reading the Cape. Loud and clear. How me, Gus?
04 54 41.5	P	Gus, how do you read?
04 54 56.5	CC	Aurora Seven . . . 95. Your landing point is 200 miles long. We will jump the air rescue people to you.
04 55 06	P	Roger. Understand. I'm reading.
04 55 27	CC	Aurora Seven, Aurora Seven, Cape Cap Com. Be advised your landing point is long. We will jump air rescue people to you in about 1 hour.
04 55 36	P	Roger. Understand 1 hour.

[7] Tower here refers to cylindrical section of the spacecraft.

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