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POSTLAUNCH MEMORANDUM REPORT FOR MERCURY-ATLAS NO. 6 (MA-6)

PART I - MISSION ANALYSIS

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

Cape Canaveral, Florida

March 5, 1962

CONFIDENTIAL

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POSTLAUNCH MEMORANDUM REPORT

FOR

MERCURY-ATLAS NO. 6 (MA-6)

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NOTICE

NO. 1: LIFT-OFF TIME (2-INCH MOTION) FOR THE MA-6 FLIGHT WAS 9:47:39.002 EST. RANGE ZERO TIME WAS ESTABLISHED AS 9:47:39 EST. ALL TIMES REFERRED TO IN THIS REPORT ARE IN ELAPSED TIME IN HRS:MIN:SEC FROM RANGE ZERO, UNLESS OTHERWISE NOTED.

NO. 2: THE PRESENT REPORT IS PART I OF THE MA-6 POSTLAUNCH MEMORANDUM REPORT AND CONTAINS OVERALL MISSION ANALYSIS WITH A MINIMUM OF DATA. PART II, UNDER SEPARATE COVER, WILL CONTAIN COMPLETE TIME HISTORIES OF DATA, WITHOUT ANALYSIS.

1.0 INTRODUCTION

The first manned orbital spaceflight of a Mercury spacecraft was successfully made on February 20, 1962, from the Cape Canaveral Missile Test Center. Astronaut John H. Glenn Jr., shown in figures 1.0-1 through 1.0-4, was the pilot on the MA-6 mission. This flight was the third orbital flight of a Mercury spacecraft, and the sixth of the series utilizing Atlas boosters.

The flight was planned for three orbits and was a culmination of the program to develop the Mercury spacecraft and to use it for manned orbital flight. The objectives of the flight were therefore to evaluate the performance of the man-spacecraft system in a three-orbit mission, to evaluate the effects of space flight on the Astronaut, and to obtain the Astronaut's evaluation of the operational suitability of the spacecraft and supporting systems for manned space flight.

In general, the spacecraft, booster, and Network system functioned well during the mission. During the second orbit, loss of thrust of the one-pound yaw thrusters caused repeated loss of ASCS orbit mode, requiring the Astronaut to control the spacecraft for most of the mission. In spite of this and other minor problems, the three-orbit mission was completed successfully and recovery was effected in the planned area by the Destroyer "Noa" within 20 minutes after landing.

The Astronaut's performance during all phases of the mission was highly satisfactory. No deleterious effects of weightlessness were noted, and the Astronaut was found in postflight examination to be in excellent health.

All mission objectives for this flight were accomplished.

[redacted]

Figure 1.0-1.- John Glenn and his backup pilot Scott Carpenter.

[redacted]

Figure 1.0-2.- John Glenn prior to the MA-6 mission.

[redacted]

Figure 1.0-3.- John Glenn in the MA-6 spacecraft prior to hatch closure.

[redacted]

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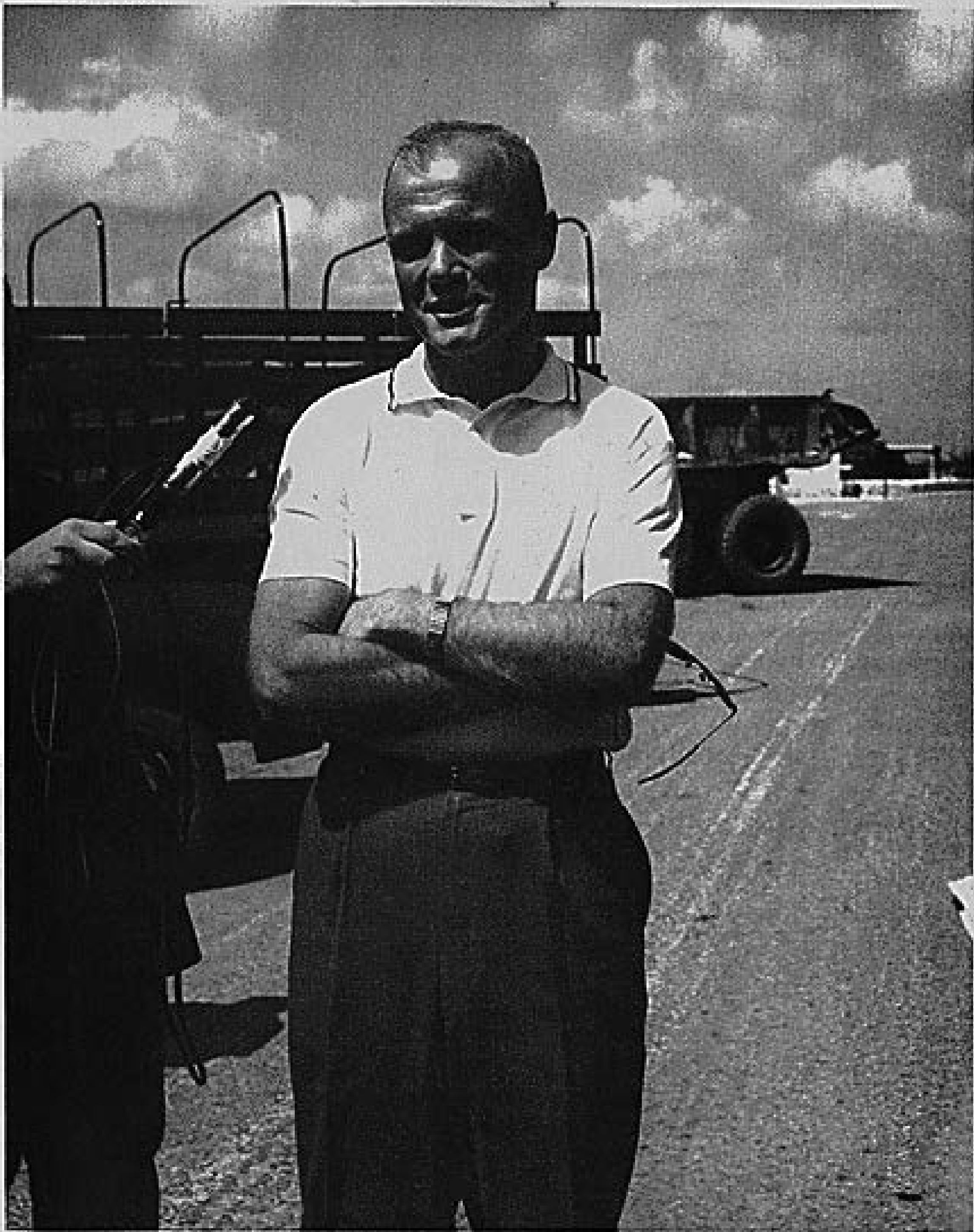

Figure 1.0-4.- Postflight photograph of astronaut John Glenn.

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2.0 MISSION DESCRIPTION

The MA-6 flight was a 3-orbit mission with Astronaut John Glenn as pilot. Unscheduled prelaunch holds totaled 2 hours and 17 minutes as a result of difficulties with the GE guidance rate beacon and a spacecraft-hatch bolt, for topping fuel and loxing the launch vehicle, and to verify the Bermuda computer after a ground power failure. The vehicle lifted off at approximately 0947 e.s.t on February 20, 1962, 3 hours and 42 minutes after the astronaut entered the spacecraft.

All booster functions were normal during launch, and vibration levels and frequencies were acceptable and comparable to those experienced during the MA-5 launch. Spacecraft orbital insertion conditions were very good. Deviations from nominal values of inertial flight-path angle and velocity were -.05 degrees and -7 ft/sec, respectively, with a resultant capability of nearly 100 orbits. GE-Burroughs and AZUSA guidance data both indicated a "GO" condition after sustainer engine cutoff. The perigee and apogee of the orbit differed from the nominal values of 87.0 and 144.4 nautical miles by 0.1 nautical miles and 3.5 nautical miles, respectively.

Spacecraft separation, rate damping, and turnaround were accomplished satisfactorily. With the exception of steadily rising temperatures on both inverters, all spacecraft systems performed satisfactorily during the first orbit.

The pilot observed the launch vehicle tankage in its slightly lower orbit for some time, checked out the spacecraft control systems, performed planned tasks and made scientific observations, and reported small luminous-appearing particles around the spacecraft at sunrise.

At approximately the beginning of the second orbit, the astronaut reported that the spacecraft was not maintaining acceptable attitudes in the orbit mode of control in right yaw, and later in left yaw, evidently because of loss of thrust from the low thrusters. The astronaut elected to control the spacecraft manually to conserve fuel, and flew most of the rest of the mission in manual control modes. Necessary attention to control of the spacecraft prevented accomplishment of some flight-plan items.

However, the astronaut accomplished the major planned tasks, made scientific observations, confirmed that major weather phenomena were visible on the moonlit dark side of the earth, controlled the spacecraft attitudes by visual reference to horizon and stars on the dark side of the earth, and performed spacecraft maneuvers manually, including 180° yaw maneuvers. The spacecraft supported the astronaut adequately, despite the malfunction in the control system.

[redacted]

Also during the second and third orbits, an indication from telemetry that the spacecraft heat shield might be unlocked caused some concern; therefore the empty retropack was retained on the spacecraft during reentry at the end of the third orbit, to hold the heat shield in place in case it was unlatched. The retropack had no detectable effect on the reentry.

The spacecraft attitudes during the retrofire maneuver were controlled by both the automatic control system and the astronaut using manual control. Spacecraft oscillations built up during reentry and were not satisfactorily controlled until the drogue parachute stabilized the spacecraft. The drogue parachute deployed at 28,000 feet rather than the planned 21,000 feet. Landing (04:55:16) occurred approximately 40 nautical miles uprange of the planned landing point. The spacecraft, with the astronaut inside, was recovered approximately 17 minutes after landing by the destroyer Noa. The astronaut was in excellent shape.

Network operations, including telemetry reception, radar tracking, communications, command control and computing were excellent, and permitted effective flight control during the mission.

[redacted]

[redacted]

3.0 LIFT-OFF CONFIGURATION DESCRIPTION

A photograph of the lift-off configuartion consisting of spacecraft and launch vehicle is shown in figure 3.0-1.

3.1 Spacecraft.- Spacecraft No. 13, see figure 3.1-1, was utilized for the MA-6 manned orbital mission. The spacecraft axis system is shown in figure 3.1-2. The primary differences between spacecraft No. 13 (MA-6) and spacecraft No. 9 (MA-5) are listed below:

(a) An astronaut's couch was installed.

(b) A personal-equipment container was installed.

(c) Filters were provided for the astronaut's window.

(d) An indicator was added to the instrument panel to display the temperature of the suit circuit steam vent.

(e) The suit circuit incorporated a constant-bleed orifice (750 cc/min).

(f) The suit shutoff valve spring force was approximately 25 lbs., compared to approximately 40 lbs. for capsule no. 9.

(g) The cabin-fan inlet duct incorporated improved screens.

(h) The latching relay to lock in the no. 2 suit fan was ommitted.

(i) The suit-inlet-snorkel door was located on the conical afterbody.

(j) Cooling plates of the new design were installed under the 150 VA and 250 VA main inverters, and the stainless steel check valves were installed in the coolant line in lieu of aluminum valves.

(k) The manual-proportional control system linkage had shear pins.

(l) Improved heat-conduction paths, and heat sinks, were installed for temperature control of the roll thruster fuel lines near the thrusters.

(m) Indicating lights were added to the instrument panel to show which inverters were operative.

[redacted]

[redacted]

(n) Direct (without fuses) manual switching to inverters was incorporated.

(o) The maximum altitude sensor was provided a separate battery.

(p) One-ohm fuses were installed in all squib circuits.

(q) An integrating accelerometer was installed.

(r) A Super SARAH beacon was incorporated in lieu of an Ultra SARAH.

(s) A reserve chute was installed.

(t) A switch was installed to allow manual control of heat-shield deployment.

(u) The escape tower legs were of heavier construction.

(v) A manually-actuated blood pressure measuring system was incorporated.

The measured parameters for the spacecraft are shown in the following table:

[redacted]

[redacted]

Parameter		Configuration				
		Launch	Orbit	Normal Reentry Configuration	Normal Reentry Configuration Plus Retropack (Rockets Fired)	Flotation
Weight in pounds		4265.26	2986.78	2698.98	2815.95	2421.79
Center of gravity station in inches	Z	167.96	121.18	124.62	123.02	119.74
	X	.31	-.04	-.07	-.06	-.33
	Y	-.08	.07	.01	.01	.16
Moments of inertia, slugs-ft.^{2}	I_z	384.0	281.6	271.0	275.1	258.1
	I_x	7761.1	621.6	544.6	581.8	353.4
	I_y	7767.5	629.3	552.2	589.4	359.5

[redacted]

3.2 **Vehicle.-** The MA-6 booster, No. 109-D, was an Atlas Series-D modified for the mission as on previous Mercury-Atlas flights. A sketch showing the general configuration is shown in figure 3.2-1. The booster differed from the MA-5 Mercury-Atlas booster (93-D) in one major respect.

For the MA-6 booster, the insulation and its retaining bulkhead between the lox and fuel tank dome was removed when it was discovered that fuel had leaked into this insulation prior to launch. The original requirement for this insulation and retainer had been deleted earlier in the operational booster development program as being non-essential, and this insulation is not used in the operational Atlas vehicles. However, this feature was retained in the standard Series D vehicles.

The following minor modifications were incorporated and are planned for future Mercury-Atlas flights:

(a) The gyro canister was modified to include specially selected transistors of the original design type that had good thermal characteristics. This change decreases the possibility of thermal run-away in the gyro torquer and signal amplifier.

(b) The booster lox tank pressure abort parameter was changed from 21.5 ± 1.0 psi to 19.5 ± 1.0 psi to protect against an inadvertent abort due to lox - tank-ullage pressure transients which occur at lift-off.

4.0 EVENTS, TRAJECTORY, AND GUIDANCE

4.1 Sequence of events.- The times at which the major events occurred are given in table 4.1-1.

4.2 Trajectory.- The ground track of the flight is shown in figure 4.2-1, and the altitude-longitude profile is shown in figure 4.2-2.

The launch trajectory data, shown in figure 4.2-3, are based on the real time output of the Range Safety Impact Predictor Computer (which used AZUSA MK II and Cape FPS-16 radars) and the GE-Burroughs guidance computer. The data from these tracking facilities were used during the time periods listed below:

Facility	Time, Min:Sec
Cape Canaveral FPS-16	0 to 00:45
AZUSA MK II	00:45 to 01:08
GE-Burroughs	01:08 to 05:02

The parameters shown for the "planned" launch trajectory were computed using the 1959 ARDC model atmosphere for consistency with other published preflight trajectory documents. The density of the Cape Canaveral atmosphere is approximately 10 percent higher than that of 1959 ARDC atmosphere in the region of maximum dynamic pressure (about 37,000 feet altitude); as a result, the maximum dynamic pressure expected would be about 10 percent higher than that shown as "planned". For this flight, the maximum dynamic pressure experienced was about 12 percent higher than that shown as "planned".

The orbital portion of the trajectory, shown in figure 4.2-4, was obtained by starting with the spacecraft position and velocity vector obtained during the second pass near Woomera (during the second orbit) as determined by the Goddard computer (using radar data from the Mercury tracking network) and integrating backward along the flight to orbital insertion and forward along the flight to the start of retrofire at the end of the third orbit. These integrated values were in excellent agreement with the GE-Burroughs guidance system measured values at orbital insertion and also in good agreement with the position and velocity vectors determined by the Goddard computer for passes near Canary Islands during the first pass (first orbit), Bermuda during the second and third pass (start of second and third orbits) and Muchea during the third pass (third orbit), thus establishing the validity of the integrated orbital portion of the flight trajectory.

[redacted]

The reentry portion of the trajectory, shown in figure 4.2-5, was obtained by starting with the spacecraft position and velocity vector near Corpus Christi, Texas, as determined by the Goddard Computer and integrating backward along the flight to the end of retrofire and forward along the flight to landing assuming that the retro-package had not been jettisoned and that the drogue chute was deployed at the time of 04:49:17 (given by telemetry evend indication) at an altitude of approximately 27,000 feet instead of the planned altitude of 21,000 feet. The spacecraft decelerations from the integrated reentry trajectory agree within reading accuracy with the decelerations measured by the onboard accelerometer; in addition, the times of drogue and main chute deployment from the integrated reentry trajectory and from spacecraft onboard measurements agree within one second. This agreement between the integrated values and independently measured values onboard the spacecraft serves to verify the validity of the integrated reentry portion of the trajectory. The integrated values at the end of retrofire were adjusted by adding the effects of a nominal retro-rocket total impulse of 38,880 lb-sec at nominal spacecraft retro-fire attitudes of -34° pitch with zero roll and zero yaw and the results when compared with the orbital integrated values at the start of retrofire show the velocity to be about 7 feet per second low (or that the actual retrorocket performance gave 7 feet per second more imparted velocity to the spacecraft than expected). The fact that the spacecraft landed approximately 40 nautical miles short of the nominal landing point can probably be attributed to spacecraft pitch attitude during retrofire and retrorocket performance since an error of $\pm$ 1 foot per second in retro-velocity will give an error in landing range of $\pm$5.2 nautical miles from the nominal landing point, and an error of $\pm 1.0^{\circ}$ in pitch attitude during retrofire will give an error in landing range of $\pm$10.0 nautical miles from the nominal landing point. The reentry trajectory and the landing point were only slightly affected by the retro-package being left onboard the spacecraft. The integrated landing point was about 4 nautical miles short of the spacecraft pickup point (see section 9.0).

The aerodynamic parameters for the planned and integrated reentry trajectories were computed using the MSC model atmosphere (NASA Project Mercury Working Paper No. 205), which is based on Discoverer Satellite program data above 50 nautical-mile altitude, the 1959 ARDC model atmosphere between 25 and 50 nautical-mile altitudes, and the Patrick AFB atmosphere below 25 nautical-mile altitude.

In the trajectory figures the above integrated values are labeled "actual".

[redacted]

A comparison of the planned and actual trajectory parameters is given in table 4.2-1. The difference between the planned and actual trajectory parameters are due to the actual cutoff velocity and flight-path angle being slightly lower than the planned conditions.

4.3 Guidance.- The GE-Burroughs Atlas guidance system performed excellently in this flight. The guidance system locked on the vehicle in both track and rate at 00:68, approximately as planned, and lost lock at 05:32 (31 seconds after SECO).

In figures 4.3-1 to 4.3-3 the velocity and flight-path angle are shown in the region of cutoff. GE-Burroughs data are shown in figure 4.3-1 and the AZUSA data used in the Range Safety Impact PredictorCComputer (IP 7090) are shown in figure 4.3-2 to illustrate the noise level during the time of the GO-NO-GO computations. Both the GE-Burroughs and the AZUSA data are considered very good except for the two AZUSA points immediately after engine cutoff. The reason for these two points with such large errors is not known at this time. The points are obviously in error but are included in the figures since these points were generated by the IP 7090 computer and received by the Goddard computers as shown in the figures.

The GE-Burroughs system gave a cutoff which was about 7 ft/sec low in velocity and about 0.05° low in flight-path angle. These values are within the expected accuracy range for the system.

In figure 4.3-3 these data are shown as flight-path angle versus velocity. This is the type of display used by the Flight Dynamics Officer in the Mercury Control Center for the orbital GO-NO-GO decision. Both GE-Burroughs and AZUSA data indicated a GO decision.

TABLE 4.1-1 SEQUENCE OF EVENTS

Event	Planned Time[a] Hr:Min:Sec	Actual Time Hr:Min:Sec	Difference Seconds
Booster-engine cutoff	00:02:11.4	00:02:09.6	-1.8
Tower release	00:02:34.2	00:02:33.3	-0.9
Escape rocket firing	00:02:34.2	00:02:33.4	-0.8
Sustainer-engine cutoff discrete (SECO)		00:05:01.4	
Tail-off complete	00:05:03.8	00:05:02	-1.8
Spacecraft separation	00:05:03.8	00:05:03.6	-0.2
Retrofire initiation	04:32:58	04:33:08	+10.0
Retro (left) no. 1	04:32:58	04:33:08	+10.0
Retro (bottom) no. 2	04:33:03	04:33:13	+10.0
Retro (right) no. 3	04:33:08	04:33:18	+10.0
Retro assembly jettison	04:33:58		
0.05 g relay	04:43:53	04:43:31*	-22.0 (0)[b]*
Drogue chute deploy	04:50:00	04:49:17.2	-42.8
Main chute deploy	04:50:36	04:50:11	-25.0 (-1.0)[b]
Main chute jettison (water impact)	04:55:22	04:55:23	+1.0 (-27.0)[b]

[a]Preflight calculated, based on nominal Atlas performance.

[b]The numbers in parentheses show the difference between the actual event and the postflight-calculated reentry event times based on actual insertion parameters.

* 0.05 g relay was actuated manually by astronaut when he was in a "small g field".

TABLE 4.2-1 COMPARISON OF PLANNED AND ACTUAL TRAJECTORY PARAMETERS

Condition and Quantity	Planned	Actual	Difference
Cutoff conditions (including tail-off):			
Range time, seconds	303.8	302.0	-1.8
min:sec	05:03.8	05:02	
Geodetic latitude, deg north	30.4273	30.4533	0.0260
Longitude, deg west	72.5268	72.5865	0.0597
Altitude, feet	528,428	528,381	-47
nautical miles	87.00	86.96	-0.04
Range, nautical miles	436.4	433.7	-2.7
Space-fixed velocity, feet per second	25715	25708	-7.0
Space-fixed flight-path angle, deg	0	-.0468	-.0468
Space-fixed heading angle, deg east of north	77.4756	77.4826	.0070
Post-posigrade firing conditions:			
Range time, seconds	305.8	306.8	1.0
min:sec	05:05.8	05:06	
Geodetic latitude, deg north	30.4572	30.5128	0.0556
Longitude, deg west	72.3797	72.2923	-0.0874
Altitude, feet	528460	528361	99
nautical miles	87.0	86.96	-0.04
Range, nautical miles	444.2	449.4	5.2
Space-fixed velocity, feet per second	25737	25730	-7.0
Space-fixed flight-path angle, deg	-0.0030	-0.0517	-.0487
Space-fixed heading angle, deg east of north	[redacted] 5541	77.6399	0.0858

[redacted]

TABLE 4.2-1 Concluded

COMPARISON OF PLANNED AND ACTUAL TRAJECTORY PARAMETERS

Condition and Quantity	Planned	Actual	Difference
<u>Orbit parameters:</u>			
Perigee altitude, statute miles	100.1	100.03	-0.07
nautical miles	87.0	86.92	-0.08
Apogee altitude, statue miles	166.2	162.17	-4.03
nautical miles	144.4	140.92	-3.48
Period, min:sec	88:32	88:29	-00:03
Inclination angle, deg	32.52	32.54	0.02
<u>Maximum conditions:</u>			
Altitude, statute miles	166.2	162.17	-4.03
nautical miles	144.4	140.92	-3.48
Space-fixed velocity, feet per second	25737.0	25732.0	-5.0
Earth-fixed velocity, feet per second	24420.0	24415.0	-5.0
Exit acceleration, g's	7.7	7.7	0
Exit dynamic pressure, lbs/ft^2	966* 878**	982	16.0
Entry deceleration, g's	7.6	7.7	0.1
Entry dynamic pressure	447	472	25.0
<u>Landing point:</u>			
Latitude, deg:min	21°07'N	21°26'N[a]	00°19'N
Longitude, deg:min	68°00'W	68°41'W[a]	00°41'W

*Based on Cape Canaveral atmosphere.

**Based on 1959 ARDC model atmosphere.

[a]"Actual" landing coordinates shown above were those resulting from the trajectory integration. The retrieval point 20 minutes after landing was reported as 21°25'N and 68°37'W by the recovery ship (see section 9.0).

[redacted]

[redacted]

5.0 SPACECRAFT MEASUREMENTS

Overall, the spacecraft as an entity performed adequately. Some malfunctions were experienced, and are discussed in the following paragraphs. Also discussed in this section, from an overall mission viewpoint, are the spacecraft systems' general performance. Flight measurements (data) are generally not shown, except to clarify a discussion or present measurements of particular interest.

Complete time histories of spacecraft data, without analysis, are presented in the following report:

Postlaunch Memorandum Report

for

Mercury-Atlas No. 6 (MA-6)

Part II - Data

[redacted]

5.1 **Spacecraft control system.-**

General.- With the single exception of the yaw 1-pound thrusters, the spacecraft control system appears to have functioned normally throughout the entire flight. Discrepancies reported by the pilot between the attitude indicators and the ground reference are discussed below. Thruster malfunctions are discussed in detail in section 5.1.3.

5.1.1 System description.- The spacecraft had the following control systems modes:

(a) Automatic stabilization control system (ASCS), with orbit mode, orientation mode, and auxiliary damping mode.

(b) Fly-by-wire system.

(c) Manual proportional system.

(d) Rate stabilization control system (RSCS).

(a) and (b) used the automatic system thrusters, while (c) and (d) used the manual system thrusters. Combinations of (a) and (c), (b) and (c), or (b) and (d) may be used simultaneously. The amplifier-calibrator incorporated new single-pulse orbit-mode logic, thus eliminating the double orbit pulses that have been experienced in the past with dirty repeater sectors. In addition, the horizon scanner reference levels were set at approximately 25% to lessen cold cloud effects, and scanner slaving was programmed for 8.5 minutes in each 30-minute period.

5.1.2 **Flight description and analysis.-**

Powered flight and turnaround.- Systems operation was normal in this period, although the 5 seconds of separation rate-damping was delayed 2.5 seconds by the sequence circuitry associated with the .20g switch, thus leading to a fairly large initial roll error at the start of turnaround. Turnaround was managed adequately, although the time required (38 seconds) to settle into orbit mode was longer than normal, due to the initial roll error. Spacecraft attitudes and rates near insertion are listed in the following table:

[redacted]

Axis	Attitude:Rate		
	Separation	Separation plus 2.5 sec (start of damping)	Separation plus 7 sec (start of turnaround)
Roll	0°:-1°/sec	-12°:-6°/sec	-22°:
Pitch	-8°:+0.4°/sec	+2°:+5.5°/sec	+4°:
Yaw	180°:-0.3°/sec	170°:-2.5°/sec	160°:

<u>Orbital phase</u>.- Except for the thruster malfunction discussed in section 5.2.3, the control system functioned essentially as designed. Control system exercises and usage modes are discussed in section 7.0. With the initiation of the first yaw maneuver, attitude indicators began to disagree with true spacecraft attitudes. Such disagreements are inherent in the system, and will occur whenever the yaw or roll attitudes deviate from 0° for an extended period of time, as demonstrated mathematically and with operational hardware. Numbers will be different depending upon the presence of either scanner slaving or fixed pitch orbital precession, but the effects will be similar. Each disagreement has been examined and can be explained per system design.

The following hypothetical maneuver is cited to best illustrate this point:

> "Assume that the spacecraft and gyros are properly erected in the normal orbit attitude, and that the spacecraft is then yawed 90° and maintained in this yaw heading for 1/8 orbit (11.25 min or 45° orbital travel), while the astronaut maintains a local vertical using the window reference. During this 1/8 orbit the fixed pitch precession signal (about 4°/min) will drive the vertical gyro spin axis in a direction 90° from the orbital plane and at the end of this period the pitch attitude indicator will disagree with the spacecraft true attitude by 45°. At the same time the astronaut will have rolled the spacecraft 45° to maintain his vertical position with respect to the local horizon. If the spacecraft is then restored to the normal orbit attitude, the gyro spin axis will maintain its position in space, resulting in permanent attitude errors in both axes (unless corrected by slaving)."

[redacted]

The 180° yaw maneuver, initiated at 3:14:00 is cited for reference as the best example of the above (see figure 5.1.2-1). Indicated attitude errors, produced by spacecraft maneuvering, can be avoided by leaving the gyros caged during such maneuvers. New gyro references can best be restored with continuous scanner slaving if the gyros are uncaged at approximately 0° pitch, and then the capsule permitted to remain at orbit attitude (-34°) for approximately five minutes.

Three gyro cagings were executed by the astronaut during this mission phase. In each instance the spacecraft was pitched down to -15°, rather than level. In addition, during the first caging, the capsule roll attitude was at -19°.

Horizon scanner operation was as expected with short roll scanner "ignore" periods occurring just prior to sunset. All "ignores" produced by the pitch scanner can be correlated with maneuvers. Eight scanner slaving cycles occurred, as controlled by the programmer, and promptly removed all maneuver and caging errors.

Retrofire.- Retrofire occurred at 4:33:08 and was completed by 4:33:33. The astronaut provided backup to the ASCS system with manual proportional control, maintaining slightly better attitudes than were experienced on the MA-5 mission. Pitch and roll held within 1° with the yaw deviation not exceeding 2°.

.05g and reentry.- At 4:39:39 reentry pitch-up was initiated by the astronaut with the .05g relay manually actuated at 4:43:31. The .05g roll rate was initiated at 4:44:41, utilizing both manual and fly-by-wire thrusters, and reached -11°/sec within 2 seconds. By 4:46:30, pitch and yaw oscillations, with a period of 1.5 sec were in evidence with rates changing ±2°/sec. The astronaut attempted to provide damping utilizing both manual and fly-by-wire thrusters. By 4:47:17 the pitch rates had increased to greater than ±10°/sec with a period of 1.1 sec while yaw rates were kept within ±6°/sec at the same frequency until 4:47:20 when they also exceeded ±10°/sec. It is estimated that manual fuel depletion occurred at this time. Analysis of stick motions and rates shows that at least 50% of the thrust pulses opposed the direction of motion, 25% were approximately 90° out of phase thus decreasing and then aiding, producing no net effect. The remaining 25% actually assisted in increasing the oscillations. Extrapolation of the rate traces provides a spacecraft swing of ±5° in the center of this time period.

At 4:47:39 the astronaut switched on the auxiliary damping system. Pitch and yaw rates decreased to within ±2°/sec in a four-second period while the roll rate decreased from -20° /sec to nominal -11°/sec.

[redacted]

At 4:48:32 the oscillations again began to build up in pitch and yaw.

By 4:48:40 rates were changing ±10°/sec, with a period of 3.5 seconds per cycle while the roll rate showed an irregular decrease. Automatic system fuel depletion is estimated to have occurred at approximately 4:48:30. At 4:49:17 the drogue chute was deployed, with antenna fairing release and main chute deploy occurring at 4:50:11.

Behavior during the second period of oscillation compares with estimates for reentry without control. Extrapolations provide a spacecraft swing of ±25° pitch and ±40° yaw. Attitudes with respect to the vertical cannot be determined.

[redacted]

5.1.3 Reaction Control System.-

Configuration.- The Reaction Control System (RCS) was of the standard configuration in both the automatic and manual subsystems. Heat sink modifications to reduce the hydrogen peroxide feed-line temperatures to the automatic and manual roll thrust assemblies were incorporated on the launch pad.

Prelaunch Activities.- Prelaunch servicing of the manual and automatic subsystems was normal with all components functioning properly during system servicing operations and thrust chamber static firings. One adnormality was a high decomposition rate from the automatic subsystem during surveillance. The actual surveillance rate evolved was 99% of the system allowable maximum; however, because of the decomposition rate linearity with time, the system was considered flight-worthy.

Flight Performance.- Prior to 01:29:24, both auto and manual subsystems functioned properly and delivered the expected thrust levels in all axes. At 01:29:24 in the first orbit, the ASCS called for 1 lb yaw-left automatic thrust chamber operation from which no rate response was received for 5 orbit-mode pulse signals. Immediately after this malfunction, the astronaut selected the manual proportional control mode and returned the spacecraft to proper yaw attitude. Repeated signals to the thrusters in both ASCS and fly-by-wire control modes substantiated that the 1 lb yaw-left chamber was not functioning properly. This condition persisted until 01:48:22 when, in the fly-by-wire mode, this thruster began to function and deliver the proper rate response. Except for a few isolated pulses of possible low thrust values, the 1 lb yaw-left operated properly for the remainder of the flight.

Within one minute and eighteen seconds of return to proper operation by the 1 lb yaw-left chamber, the 1 lb yaw-right chamber ceased to respond (01:49:40) in both ASCS and fly-by-wire control modes. The 1 lb yaw-right chamber remained inoperative for the duration of the flight except for apparent intermittent operation in the period between 04:30:00 and 04:34:00.

With the exception of the 1 lb yaw thrust chambers, all remaining chambers in both the automatic and manual subsystems functioned properly throughout the flight with no notable exceptions. At one time the astronaut voiced the opinion that a possible pitch-thrust chamber malfunction was evident but this report was not substantiated by the data. The manual-proportional control system exhibited proper operation at all times, when selected, with the possible exception of an instance where it appeared that the control handle may have been left with a slight deflection from neutral after a control maneuver. This condition appeared to have been corrected by the astronaut with no difficulty.

Feed Line Temperatures in Flight.- Feed line temperatures of both automatic 1 lb roll and manual roll thrust chambers were measured during flight. Manual roll feed line temperature increased approximately 30°F from prelaunch ambient conditions due to aerodynamic heating during powered flight. At completion of spacecraft turnaround, manual roll feed lines temperatures were stable at approximately 106°F.

Automatic 1 lb roll feed lines were only slightly affected by the boost phase and indicated a total temperature increase of less than 10°F from prelaunch ambient to completion of spacecraft turnaround. Maximum temperature in orbit of the manual roll feed lines was approximately 106°F. Maximum temperature in orbit of the automatic roll feed line was approximately 120°F. The effect of solar radiation on feed line temperatures was evident from data during second and third orbits. During sunlight periods of flight, slight increasing temperature trends were noted and in periods of darkness temperatures did not show an increasing trend.

Reentry heating effect on all instrumented feed lines was very pronounced with manual roll reaching a maximum of approximately 145°F and automatic roll a maximum of approximately 200°F.

Postflight Inspection.- All thrust chamber assemblies of Spacecraft 13 were disassembled on February 26, 1962, for the purpose of visual examination. Photography of noted observations was accomplished concurrently with disassembly. Loose foreign particles found upstream of the fuel-metering orifices of both 1 lb yaw thrusters were probably the cause of intermittent malfunction of the yaw thrusters. These foreign particles have been visually identified as portions of fuel distribution (Dutch weave) screens located downstream of the fuel metering orifices. The time and method by which these particles went upstream of the fuel orifice is unknown. Examination results are listed in Table 5.1.3-1, and typical photographs are shown in Figures 5.1.3-1 and 5.1.3-2.

Fuel Consumption.- The fuel consumption is shown in Table 5.1.3-2, and the reentry portion is shown in Figure 5.1.3-3.

TABLE 5.1.3-1 RESULTS OF POSTFLIGHT EXAMINATION OF THRUST CHAMBER

Thrust Chamber Assy.	Heat Barrier Screen	Orifice Condition	Dutch Weave Condition	Remarks
1 pound Yaw Right, S/N 101	Clear	5 particles on upstream face	Top screen burned and heavily eroded in center	Particle diameter approx. same as .016 orifice and length somewhat larger than .016
1 pound Yaw Left, S/N 55	Clear	Numerous dust size particles on upstream face	Top screen burned and moderately eroded	Particle size of the order 100-200 microns
1 pound Pitch Down, S/N 114	Clear	1 particle on upstream face	Small hole in top screen. Slightly burned	Particle size of the order 100-200 microns
1 pound Pitch Up, S/N 108	Clear	9 particles on upstream face	Top screen burned and practically eroded in center	Particle size same as 1 lb Yaw right, above
1 pound Roll CCW, S/N 12	Clear	Clean	Normal - only slightly discolored	
1 pound Roll CW, S/N 211	Clear	Clean	Normal - only slightly discolored	
Auto - 6 lb Roll CW, S/N 211	Clear	Clean	Normal	
Auto - 6 lb Roll CCW, S/N 12	Clear	Clean	Slight erosion	
Auto - 24 lb Pitch Up S/N 241	Clear	Clean	NA	

TABLE 5.1.3-1 (Continued)

Thrust Chamber Assy.	Heat Barrier Screen	Orifice Condition	Dutch Weave Condition	Remarks
Man. - 24 lb Pitch Up, S/N 215	Clear	Clean	NA	
Auto - 24 lb Pitch Down, S/N 12	Clear	Clean	NA	
Man. - 24 lb Pitch Down, S/N 205	Clear	Clean & wet	NA	
Auto - 24 lb Yaw left S/N 107	Clear - appears as only 1 screen	Clean	NA	
Man. - 24 lb Yaw Left, S/N 85	Clear	Clean	NA	
Auto - 24 lb Yaw Right, S/N 54	Clear	Clean	NA	
Man. - 24 lb Yaw Right, S/N 213	Clear & wet	Clean & wet	NA	
Man. - 6 lb Roll CCW, S/N 2	Clear & wet	Clean	Normal	
Man. - 6 lb Roll CW, S/N 7	Clear & wet	Clean	Normal	

TABLE 5.1.3-2

FUEL CONSUMPTION

		Auto System		Manual System	
Time	Maneuver or Mode	Fuel Used lbs	Fuel Remain lbs	Fuel Used lbs	Fuel Remain lbs
00:00:00	Launch	0	36.0	0	24.4
00:06:00	Turnaround and damping	5.8	30.2	0	24.4
01:37:00	Orbit 1	4.2	26.0	0.6	23.8
03:10:00	Orbit 2	6.0	20.0	11.8	12.0
04:33:00	Orbit 3 (to retro)	8.6	11.4	5.2	6.8
04:43:27	Retro to .05g	4.0	7.4	5.6	1.2
04:49:20	.05 to drogue	7.4*	0	1.2*	0
04:50:11	Drogue to main	0	0	0	0

NOTE: Data accuracy to ±0.5 lb fuel.

Postlfight examination of onboard data revealed the automatic fuel depleted near 04:48:30 and manual at approximately 04:47:20 The manual fuel quantity indicator averaged an indiactor error of approximately 8% more fuel than actual for fuel indication below 70%. The auto fuel quantity indicator averaged an indicator error of approximately 3% more fuel than actual for fuel indications throughout the scale range. Neither of the above error percentages reflects possible visual reading error of the FQI gauges.

*Fuel depletion occurred during this period.

5.2 **Environmental Control System (ECS).-**

5.2.2 General.- The ECS provided adequate environmental conditions for the astronaut throughout the flight. The uncomfortably warm conditions reported by the astronaut after landing are discussed in Section 7.0.

5.2.3 System Description.- The primary change in the ECS from the spacecraft no. 9 (MA-5) configuration was the addition of a constant-bleed orifice to the suit circuit. This orifice provided a continuous oxygen flow greater than the astronaut's anticipated metabolic requirement. The excess gas was exhausted into the cabin.

5.2.4 Countdown.- The temperature of the main inverters increased to higher than expected levels during the countdown. This indicated that the freon flow to the inverter cold plates, though adequate during precount checks, was inadequate during the final count. Temperatures of the 150-VA and 250-VA inverters at liftoff were 162°F and 120°F, respectively.

5.2.5 Launch.- The launch phase was normal. The cabin and suit pressures maintained a 5.5 psi differential above ambient during ascent and held at 5.7 and 5.8 psia, respectively.

5.2.6 Orbit.- Cabin and suit pressures maintained 5.7 and 5.8 psia, respectively, throughout the orbital flight. The decay in these pressures that had been observed in previous flights was absent for at least three possible reasons:

(a) Low cabin leakage (less than 500 cc/min.).

(b) Possible excess oxygen, supplied by the suit-circuit constant-bleed orifice, exhausted into the cabin from the suit circuit.

(c) Possible leakage from secondary oxygen supply.

The oxygen partial pressure agreed with suit pressure to within 0.5 psia and was consistently lower. Part of this difference is contributed by water vapor in the suit circuit that contributed a partial pressure of approximately 0.3 psi which, of course, is not included in the oxygen partial pressure measurement. A more careful calibration than those made for previous flights has resulted in a more satisfactory performance of this instrument.

The cabin air temperature, after the initial heating period, fluctuated about as expected as the spacecraft passed through the alternate periods of darkness and sunlight. The astronaut reported that at least five attempts to reduce cabin air temperature, by increasing water flow to the cabin heat exchanger, resulted in illumination of the excess water light. This indicated that the cabin heat exchanger was operating near its maximum capacity for the existing conditions. Even so, the mean cabin air temperature was steadily reduced during the mission after the first hour in orbit.

The suit inlet temperature (figure 5.2.6-1) varied between 65° and 75°F during the orbit phase. The astronaut reported a coolant flow of 1.7 lbs./hr. to the suit heat exchanger, and a stream exhaust temperature of 65°F. Thes values are both higher than anticipated and contradict each other since freezing of the exchanger would be expected at this flow rate. No explanation of this anomaly can be offered at this time.

The 150- and 250-VA inverter temperatures (figure 5.2.6-1) increased steadily from launch values of 162° and 120°F, to 204°and 197°F, respectively, at landing. Postflight testing revealed that the check valve between the coolant supply and the cold plates was stuck in the closed position and would not permit coolant to flow to the cold plates in orbit. The coolant tank was charged with 25 pounds of water before the flight. The coolant quantity indicating system showed a usage of 7.2 pounds. Postflight weighing indicated a usage of 11.8 pounds. The difference in calibration and final system temperatures can account for about 3.8 pounds of the 4.6 pounds discrepancy; the remaining 0.8 pounds is considered to be instrument error.

5.2.7 Reentry and Postlanding.- The maximum cabin temperature during this period was 103°F, which is satisfactory. The suit inlet temperature increased to 86°F during the postlanding phase. This value is reasonable since the air temperature in the landing area was 76° and the suit compressor raises the temperature in the suit circuit by approximately 10°F.

5.2.8 Anomalies.- Examination of the flight data and postflight checks of the environmental control system have revealed several anomalies. As shown in fig. 5.2.8-1, the secondary oxygen supply exhibited an unexpected decay in pressure, first noted after approximately 01:50:00; however, it is not known when this decay began since the secondary oxygen bottle was serviced to about 8000 psig before flight and the pressure transducer had a maximum indicating value of only 7500 psig. Postflight tests indicated that the secondary system was free of leaks. Also, the postflight checks indicated a usage rate of only 0.13 pounds per hour through the suit circuit compared with about 0.18 pounds per hour obtained during prelaunch tests. Finally, the pressure decay rate of the primary supply decreased to much lower than expected values during the last of the mission, and during the last three quarters of an hour in orbit the decay rate of the secondary supply was essentially zero. No explanation for these anomalies can be offered at this time.

[redacted]

5.4 Spacecraft Mechanical, Rocket, and Pyrotechnic Systems.- All systems apparently functioned normally, with the exception of early drogue chute deployment and indication of heat shield deployment during orbital flight. These anomalies, along with general systems performance, are discussed in the following paragraphs.

Parachutes.- The performances of the drogue and main parachutes upon deployment were satisfactory. Since neither parachute was recovered, a detailed post-launch visual inspection could not be made. However, observation by the astronaut verified that both parachutes were deployed cleanly and were undamaged during descent. The main chute deployed at a pressure altitude of 10,000 feet, as determined from pressures measured onboard. This is within the specification limits of 10,600 ± 750 feet.

The drogue parachute deployed at a higher-than-normal altitude, probably above 27,000 feet pressure altitude. Onboard pressure measurements (commutated) indicate a pressure altitude of approximately 29,000 feet at the time of drogue chute deployment, and the integrated trajectory is consistent with a drogue deployment at about 27,000 feet. The astronaut reported an altitude of 30,000-35,000 feet indicated at the time of drogue deployment. The astronaut stated that he had raised his arm to manually initiate drogue deployment when deployment occurred automatically. The drogue chute barostats actuated properly within specification pressure altitudes of 21,000 ± 1500 feet in postflight tests. The reason for the higher-than-normal altitude at drogue deployment is not known at this time; the investigation is continuing.

Rockets and Pyrotechnics.- A post-flight examination of the spacecraft and analysis of data indicates that all rockets and pyrotechnics functioned as intended. It cannot be determined whether certain pyrotechnics actually fired (such as redundant clamp-ring bolts and tower jettison rocket ignition) since the available evidence shows only that the resulting function was satisfactory.

Explosive-Actuated Hatch.- After the spacecraft was secured onboard the recovery ship, the astronaut initiated the hatch explosive-mechanism thru the use of the interior actuator push-button on the hatch. From visual inspection the hatch appeared to fire satisfactorily.

Landing Bag.- The landing-attenuation system apparently performed normally, as evidenced by the astronaut's statements and from postflight examinations. The landing bag was found to be torn in several places, from unknown causes, but no restraining cables or straps were broken. The usual minor damage to ablation shield retaining studs and to the bulkhead-protective shield was experienced. The main pressure bulkhead was undamaged except for a small dent near the ce[redacted]

[redacted]

Heat Shield-Deploy Mechanism.- Post-launch tests of the heat shield-deploy limit switches revealed a switch which would allow a "deployed" signal without a rotational (unlocking) movement of the heat shield unlatching mechanism. In addition, the pilot reported noises and other indications of heat shield deployment when he manually initiated the heat shield deployment at 2½ minutes after main chute deployment, thus leading to the conclusion that the shield mechanism was not unlatched in orbit.

[redacted]

5.5 **Electrical and Sequential.-**

5.5.1 **Electrical System.-** The spacecraft electrical system was a specification spacecraft configuration.

One-ohm fuse resistors were installed in all squib firing circuits. Inverter monitor lights were installed to tell the Astronaut when the 150 VA and 250 VA inverters were operating.

Main bus voltage and D.C. current were as expected throughout the mission. Fans and ASCS A.C. bus voltages were also normal.

The inverter temperatures were about 162°F on the 150 VA inverter and 120°F on the 250 VA inverter at lift-off and increased gradually throughout the mission to 212° and 203°, respectively. This indicated that the inverters received little or no inflight cooling. Inverter cooling is discussed in section 5.3.

5.5.2 **Sequential System.-** The sequential system performed as was expected during the flight with the following exceptions:

(a) Spacecraft separation T/M segment 47, cap sep telelight, periscope extend, and damping command to the ASCS were received three seconds after spacecraft separation indication from booster telemetry. The time discrepancy is attributed to MA-6 not having electrically latched capsule adapter bolt fire relays to keep the capsule separation circuitry armed during posigrade firing. Ealier capsules had this latching feature as will subsequent capsules.

(b) Heat-shield-deployed indication (segment 51) on telemetry came on prematurely and cycled ON-OFF several times during flight. This was caused by a defective limit switch (left-hand switch). Further investigations are planned to determine exact defect of the switch. The landing bag was deployed manually by the Astronaut at about 2½ minutes after main chute deploy and functioned properly.

(c) Re-entry was performed with the retropack attached. This prevented the .05g event from occurring automatically, and was initiated manually by the Astronaut. Retro-package separation indications did not occur since the electrical signal to fire the retropack separation bolt was never given. This caused the cameras to remain on high speed from retro attitude command until power was removed after impact.

(d) The drogue chute was deployed prematurely at about 28,000 feet. The reason for this is unknown at the present time. The 21,000 foot barostats were removed after flight and subjected to a pre-installation acceptance test and functioned properly. Further tests of the static sy[redacted]rmed and are discussed in the Mechanical Systems secti[redacted] report.

[redacted]

5.6 **Vibration.**- Vibrations measured during the powered phase of the MA-6 mission were almost identical with those measured during the MA-5 mission. These vibrations can be seen as oscillations on the spacecraft pitch rate gyro output, as shown in figure 5.6-1. The information available indicates that the pilot's performance was not impaired by these vibrations.

[redacted]

[redacted]

6.0 LAUNCH VEHICLE (BOOSTER) PERFORMANCE

General.- All booster systems performed satisfactorily. The following items are noted for information.

6.1 Abort Sensing and Implementation System (ASIS).- The ASIS performed satisfactorily. None of the abort parameters was near its abort threshold. As expected in normal sequence, an ASIS abort signal was generated following SECO (sustainer engine cutoff).

6.2 Cutoff.- SECO and ASCO (auxilliary sustainer cutoff) were transmitted and at least one was received and properly acted upon by the booster. Instrumentation does not permit determination of whether or not both signals were acted upon by the booster.

6.3 Booster lifetime in orbit.- Computed data based upon probable thrust having been imparted to the booster tankage by the spacecraft posigrade rockets (-4 feet per second) indicates at least 10 orbits to be expected from the booster. Tracking during the third orbit indicated a perigee of 95.75 nautical miles and an apogee of 131.0 nautical miles, and a period of 87.38 minutes. No useful tracking data were obtained after the fourth orbit.

6.4 Aerodynamic loads.- The angle of attack times dynamic pressure (αq) for the flight is shown in figure 6.3-1.

[redacted]

7.0 PILOT ACTIVITIES, AND MEDICAL REPORT

This section reports in three parts the reactions of the pilot during this first orbital flight. Leading off is a slightly edited narrative account of the mission by the pilot obtained within two hours after landing. The pilot discusses with clarity and good understanding the major events of the flight and expresses his satisfaction with his ability to control the spacecraft. This section is followed by a medical report covering the detailed pre- and postflight medical examinations and the evaluation of inflight physiological data. These medical findings indicate that the pilot's reactions both during and after the flight were normal. This section is concluded with a report on the many, diverse activities of the pilot during the flight in controlling the vehicle and making scientific observations.

7.1 Brief Summary of MA-6 Orbital Flight* by Astronaut Glenn.- There are many things that are so impressive, it's almost impossible to try and describe the sensations that I had during the flight. I think the thing that stands out more particularly than anything else right at the moment is the reentry during the fireball. I left the shutters open specifically so I could watch it. It got a brilliant orange color; it was never too blinding. The retropack was still aboard and shortly after reentry began, it started to break up in big chunks. One of the straps came off and came around across the window. There were large flaming pieces of the retropack - I assume that's what they were - that broke off and came tumbling around the sides of the capsule. I could see them going on back behind me then and making little smoke trails. I could also see a long trail of what probably was ablation material ending in a small bright spot similar to that in the pictures out of the window taken during the MA-5 flight. I saw the same spot back there and I could see it move back and forth as the capsule oscillated slightly. Yes, I think the reentry was probably the most impressive part of the flight.

Starting back with highlights of the flight: Insertion was normal this morning except for the delays that were occasioned by hatch-bolt trouble and by the microphone fitting breaking off in my helmet. The weather cleared up nicely and after only moderate delays, we got off.

Lift-off was just about as I had expected. There was some vibration. Coming up off the pad, the roll programing was very noticeable as the spacecraft swung around to the proper azimuth. There also was no doubt about when the pitch programing started. There was some vibration at lift-off from the pad. It smoothed out just moderately; never did get to very smooth flight until we were through the high q area. At this time - I would guess a minute and fifteen to twenty seconds - it was very noticeable. After this, it really smoothed out and by a minute and a half, or about the time cabin pressure sealed off, it was smooth as could be.

The staging was normal, though I had expected a more sharp cutoff. It felt as though the g ramped down for maybe half a second. For some reason, it was not as abrupt as I had anticipated it might be. The accelerometers read one and a quarter g's when I received a confirmation on staging from the Capsule Communicator. I had been waiting for this message at that point because I was set to go to tower jettison as we had planned, in case the booster had not staged. At this time, I also saw a wisp of smoke and I thought perhaps the tower had jettisoned early.

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* Astronaut's spontaneous report recorded onboard the Destroyer Noa shortly after the MA-6 mission on February 20, 1962. Superficial editing only.

The tower really had not jettisoned at that time and did jettison on schedule at 2+34. As the booster and capsule pitched over and the tower jettisoned, I had a first glimpse of the horizon; it was a beautiful sight, looking eastward across the Atlantic.

Toward the last part of the insertion, the vibration began building up again. This I hadn't quite expected; it wasn't too rough but it was noticeable. Cutoff was very good; the capsule acted just as it was supposed to. The ASCS damped and turned the spacecraft around. As we were completing the turnaround, I glanced out of the window and the booster was right there in front of me. It looked as though it wasn't more than a hundred yards away. The small end of the booster was pointing toward the northeast and I saw it a number of times from then on for about the next seven or eight minutes as it slowly went below my altitude and moved farther away. That was very impressive.

I think I was really surprised at the ease with which the controls check went. It was almost just like making the controls check on the Procedures Trainer that we've done so many times. The control check went off like clockwork; there was no problem at all. Everything damped when it should damp and control was easy. Zero-g was noticeable at SECO. I had a very slight sensation of tumbling forward head-over-heels. It was very slight; not as pronounced an effect as we experience on the centrifuge. During turnaround, I had no sensation of angular acceleration. I acclimated to weightlessness in just a matter of seconds; it was very surprising. I was reaching for switches and doing things and having no problem. I didn't at any time notice and tendency to overshoot a switch. It seemed it's just natural to acclimate to this new condition. It was very comfortable. Under the weightless condition, the head seemed to be a little farther out of the couch which made it a little easier to see the window, though I could not get up quite as near to the window as I thought I might.

The rest of the first orbit went pretty much as planned, with reports to the stations coming up on schedule. I was a little behind at a couple of points but most of the things were going right according to schedule, including remaining on the automatic control system for optimum radar and communications tracking. Sunset from this altitude is tremendous. I had never seen anything like this and it was a truly beautiful, beautiful sight. The speed at which the sun goes down is very remarkable, of course. The brilliant orange and blue layers spread out probably 45° to 60° each side of the sun tapering very slowly toward the horizon. I could not pick up any appreciable Zodiacal light. I looked for it closely; I think perhaps I was not enough night adapted to see it. Sunrise, I picked up in the periscope. At every sunrise, I saw little specks, brilliant specks, floating around outside the capsule. I have no idea what they were. On

[redacted]

the third orbit, I turned around at sunrise so that I could face into the sun and see if they were still heading in the same direction and they were. But I noticed them every sunrise and tried to get pictures of them.

Just as I came over Mexico at the end of the first orbit, I had my first indication of the ASCS problem that was to stick with me for the rest of the flight. It started out with the yaw rate going off at about one and one-half degrees per second to the right. The capsule would not stay in orbit mode, but would go out of limits. When it reached about 20° instead of the 30° I expected, it would kick back into orientation mode and swing back with the rate going over into the left yaw to correct back to its normal orbit attitude. Sometimes, it would cross-couple into pitch and roll and we'd go through a general disruption or orbit mode until it settled down into orbit attitude. The yaw would again start a slow drift to the right and the ASCS would kick out again into orientation mode. I took overmanually at that point and from then on, through the rest of the flight, this was my main concern. I tried to pick up the flight plan again at a few points and I accomplished a few more things on it, but I'm afraid most of the flight time beyond that point was taken up with checking the various modes of the ASCS. I did have full control in fly-by-wire and later on during the flight, the yaw problem switched from left to right. It acted exactly the same, except it would drift off to the left instead of the right. It appeared also that any time I was on manual control and would be drifting away from regular orbit attitude for any appreciable period of time that the attitude indications would then be off when I came back to orbit attitude. I called out some of these and I remember that at one time, roll was off 30°, yaw was off 35°, and pitch was off 76°. These were considerable errors and I have no explanation for them at this time.* I could control on fly-by-wire and manual very adequately. It was not difficult at all. Fly-by-wire was by far the most accurate means of control, even though I didn't have accurate control in yaw at all times.

Retrorockets were fired right on schedule just off California and it was surprising coming out of the zero-g field that the retrorockets firing felt as though I were accelerating in the other direction back toward Hawaii. However, after retrofire was completed when I could glance out of the window again, it was easy to tell, of course, which way I was going, even though my sensations during retrofire had been that I was going in the other direction. I made retrofire on automatic control. Apparently, the solid-on period for slaving just prior to retrofire brought the gyros back up to orbit attitude, because they corrected very nicely during that period. The spacecraft was just about in orbit attitude as I could see it from the window and through the periscope just prior to retrofire. So, I feel that we were right

* For explanation of these differences, see Section 5.1.

[redacted]

in attitude. I left it on ASCS and backed up manually and worked right along with the ASCS during retrofire. I think the retroattitude held almost exactly on and I would guess that we were never more than 3° off in any axis at any time during retrofire.

Following retrofire, a decision was made to have me reenter with the retropackage still on because of the uncertainty as to whether the landing bag had been extended. I don't know all the reasons yet for that particular decision, but I assume that it had been pretty well thought out and it obviously was.* I punched up .05g manually at a little after the time it was given to me. I was actually in a small g-field at the time I pushed up .05g and it went green and I began to get noise, or what sounded like small things brushing against the capsule. I began to get this very shortly after .05g and this noise kept increasing. Well before we got into the real heavy fireball area, one strap swung around and hung down over the window. There was some smoke. I don't know whether the bolt fired at the center of the pack or what happened. The capsule kept on its course. I didn't get too far off of reentry attitude. I went to manual control for reentry after the retros fired and had no trouble controlling reentry attitude through the high-g area. Communications blackout started a little bit before the fireball. The fireball was very intense. I left the shutters open the whole time and observed it and it got to be a very,very bright orange color. There were large flaming pieces of what I assume was the retropackage breaking off and going back behind the capsule. This was of some concern, because I wasn't sure of what it was. I had visions of them possibly being chunks of heat shield breaking off, but it turned out it was not that.

The oscillations that built up after peak-g were more than I could control with the manual system. I was damping okay and it just plain overpowered me and I could not do anymore about it. I switched to Aux. Damp as soon as I could raise my arm up after the g-pulse to help damp and this did help some. However, even on Aux. Damp, the capsule was swinging back and forth very rapidly and the oscillations were divergent as we descended to about 35,000 feet.** At this point, I elected to try to put the drogue out manually, even though it was high, because I was afraid we were going to get over to such an attitude that the capsule might actually be going small end down during part of the flight if the oscillations kept going the way they were. And just as I was reaching up to pull out the drogue on manual, it came out by itself. The drogue did straighten the capsule out in good shape. I believe the altitude was somewhere between 30,000 and 35,000 at that point.

I came on down; the snorkels, I believe, came out at about 16,000 or 17,000. The periscope came out. There was so much smoke and dirt on

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* For further discussion[redacted] see Section 8.2

** Reentry oscillations [redacted] in Sections 5.1 and 7.3.

[redacted]

the windshield that it was somewhat difficult to see. Every time I came around to the sun - for I had established my roll rate on manual - it was virtually impossible to see anything out through the window.

The capsule was very stable when the antenna section jettisoned. I could see the whole recovery system just lined up in one big line as it came out. It unreeled and blossomed normally; all the panels and visors looked good. I was going through my landing checkoff list when the Capsule Communicator called to remind me to deploy the landing bag. I flipped the switch to auto immediately and the green light came on and I felt the bag release. I was able to watch the water coming towards me in the periscope. I was able to estimate very closely when I would hit the water. The impact bag was a heavier shock than I had expected, but it did not bother me.

Communications with the recovery ship Noa were very good. The Noa had me in sight before impact and estimated 20 minutes to recovery which turned out to be about right. When the destroyer came alongside, they hooked on with the shepherd's hook and cut the HF antenna. During capsule pickup, I received one good solid bump on the side of the ship as it rolled. Once on deck I took the left hand panel loose and started to disconnect the suit hose in order to hook up the hose extension prior to egressing through the upper hatch. By this time I was really hot - pouring sweat. The capsule was very hot after reentry and I really noticed the increase in humidity after the snorkels opened. I decided that the best thing at that point was to come out the side rather than through the top. I am sure I could have come out the top if I had had to, but I did not see any reason to keep working to come out the top. So I called the ship and asked them to clear the area outside the hatch. When I received word that the area was clear, I removed the capsule pin and hit the plunger with the back of my hand. It sprung back and cut my knuckles slightly through the glove. The noise of the hatch report was good and loud but not uncomfortable.

In summary, my condition is excellent. I am in good shape; no problems at all. The ASCS problems were the biggest I encountered on the flight. Weightlessness was no problem. I think the fact that I could take over and show that a pilot can control the capsule manually, using the different control modes, satisfied me most. The greatest dissatisfaction I think I feel was the fact that I did not get to accomplish all the other things that I wanted to do. The ASCS problem overrode everything else.

[redacted]

7.2 Aeromedical investigations.-

7.2.1 Introduction.- The aeromedical investigations conducted with the MA-6 mission can be logically grouped into two distinct areas: (1) the preflight and postflight clinical examinations (static examinations) and (2) the preflight and inflight physiological studies (dynamic studies). These investigations are designed to ascertain the state of the astronaut's health and to provide information reflecting human responses to space flight. The MA-6 mission provided a period of weightlessness of sufficient duration so that the pilot's physiological responses attained a relatively steady state. In the much shorter Mercury-Redstone Flights, little time was available in weightlessness for the astronaut's physiological adjustment mechanisms to stabilize.

The astronaut's activities during the time immediately prior to his countdown and flight have some indeterminate but probably significant effect on his countdown and flight responses. For this reason his activities for the approximate 9 hour period prior to his arrival at the spacecraft are listed in table 7.2.1-1.

7.2.2 Clinical studies.- Detailed medical examinations were performed prior to space flight and as soon after flight as recovery practices permitted. Initial examinations were accomplished to determine the astronaut's state of health and his medical fitness for flight. In addition, such clinical evaluations serve as baseline medical data which may be correlated with inflight physiological information.

7.2.2.1 Data sources.-

(a) Yearly physical examinations beginning with astronaut selection in 1959.

(b) Detailed preflight clinical examinations conducted on January 22, 1962, and February 12, 1962.

(c) Preflight examination conducted on launch morning.

(d) Postflight medical evaluations on the recovery ships and at Grand Turk Island Medical Facility.

The numerous preflight examinations on Astronaut Glenn disclosed no significant medical abonormalities; his physical and mental health remained excellent throughout.

7.2.2.2 Postflight.- Emergence from the spacecraft onboard the Destroyer Noa occurred 39 minutes after landing. The pilot was described as appearing hot, sweating profusely and fatigued. He was lucid, although not talkative.

[redacted]

After removal of his pressure suit, and a shower, he became more communicative and described a mild sensation of "stomach uneasiness" or "stomach awareness" which occurred while the spacecraft was on the water 17 minutes awaiting recovery. This sensation did not commence until after spacecraft landing, and cleared spontaneously within 1½ hours. No nausea or vomiting was experienced.

This stomach uneasiness could be attributed to several factors. One factor could be the combination of temperature and humidity after landing. At landing, the ambient air temperature was 75°F with 60-65 percent relative humidity and the water temperature was 81°F. The suit inlet temperature was 83°F and the cabin air temperature was 101°F. A second factor could be the moderate dehydration of the astronaut as evidenced by weight loss (5-5/16 pounds vs. a 2-1/2 pound loss during a three orbit centrifuge simulation), diminished urine output with increased specific gravity for the 24 hours post-recovery, increased blood concentration, and the recovery physician's clinical impression.

The astronaut had a minimal fluid intake, having ingested the equivalent of 94 cc of water (as applesauce puree) during the 13 hours from breakfast at 0250 to shipboard at 1545 e.s.t. His urine output during this period was 800 cc. He reported voiding this specimen just prior to reentry. The fluid intake and output is shown in the following table:

FLUID INTAKE AND OUTPUT (all times e.s.t.)

Urine output*:	countdown		0 cc
	inflight		800 cc, Sp. Gr. 1.016
	postflight, shipboard		0 cc
	Total		800 cc
Fluid intake:	countdown		0 cc
	inflight**		94 cc
	postflight, shipboard	1545 hours	265 cc iced tea
		1830 hours	240 cc water
		1850 hours	125 cc coffee
		Total	724 cc

* See also Table 7.2.2.2-1

** 119.5 grams of applesauce puree (78% water).

The only other intake during the flight was one 5.0 gram sugar tablet (xylose) for a test of intestinal absorption.

[redacted]

[redacted]

The postflight positive physical findings and vital signs are compared with preflight values in the following table:

Variables	Preflight	Postflight
General status	Eager for flight	Alert, but not talkative; sweating profusely; appeared fatigued; not hungry.
Weight:	171 7/16 pounds at 0315 hours	166 2/16 pounds at 1850 hours
Temperature:	98.2°F (oral)	99.2°F (rectal at 1600 hours) 98°F (oral at 2400 hours)
Respiration:	14	14
Pulse:	68	72
Blood pressure:	118/80 (left arm, sitting)	120/60 (left arm, supine) at 1545 hours 128/68 (left arm, sitting) at 2130 hours
Heart and lungs:	Normal	Normal - no change
Skin:	No erythema or abrasions	Erythema of biosensor sites. Superficial abrasions second and third fingers of right hand.
Extremities:		

Measurements

	Preflight left	Preflight right	Postflight left	Postflight right
Wrist	6 7/8"	7"	6 3/4"	7"
Calf (max)	16 7/8"	16 1/2"	16 5/8"	16 1/8"
Ankle (min)	9 3/8"	9 1/8"	9"	9 1/4"

All times e.s.t.

[redacted]

The postflight physical examination onboard the destroyer recorded the vital signs noted above. There were two small, superficial skin abrasions of the knuckles of the second and third fingers of the right hand but without deformation or fracture. These were received when the explosive hatch actuator recoiled against the pilot's gloved hand. The skin also revealed an area of moderate erythema (reddening) and a skin depression under the left arm blood pressure microphone; furthermore, there was a mild reaction to the moleskin adhesive plaster which attached the four ECG electrodes. Results of the eye, ear, nose and throat examinations were normal. The heart rhythm, size and sounds were normal and the lungs were clear, without physical evidence of atelectasis (lung collapse). Results of the examination of the abdomen were normal, and the lower extremities showed no evidence of edema (swelling) nor thrombosis (clotting). The results of the general neurologic examination were also normal.

Blood and urine samples were obtained and processed for later analysis. Results available to date are listed in table 7.2.2.2-1.

Approximately three hours after landing, the astronaut was transferred to the Aircraft Carrier U.S.S. Randolph where a posterior-anterior and lateral chest X-ray, standard 12-lead electrocardiogram, and body weight were obtained.

Later the astronaut flew to Grand Turk Island where a general physical examination was begun at 2130 hours e.s.t., approximately 6-3/4 hours after spacecraft landing. The vital signs at that time are included with the postflight values above. Except for the previously described superficial skin abrasions, the results of the entire examination were normal. During the subsequent 48 hours, comprehensive examinations by medical specialists were conducted. Special tests were performed in an effort to delineate any effect of space flight upon the astronaut's balance (inner ear); no effect was detected. Both the general and the specialists' examinations revealed no significant changes. The medical studies were completed at 1400 e.s.t., February 22, 1962.

In summary, the preflight and postflight clinical studies revealed no significant differences and, except for the immediate postflight moderate dehydration, were completely within normal limits.

7.2.3 Physiological studies.-

7.2.3.1 Data sources.- Data reflecting physiological responses to flight were obtained by evaluating the biosensor real time recordings from range stations and from the continuous onboard recording. In addition, various inflight tests and the pilot-observer-camera film were utilized for further objective analysis. Subjective evaluation included pilot reports from onboard voice and the total postflight debriefing. The countdown

[redacted]

period provided baseline preflight information. Useful comparative measurements were available from the Mercury-Atlas Centrifuge Three Orbital Simulation; and from the pad simulated launch, simulated flights, and the January 27 launch attempt. Environmental control system data were correlated with the physiological responses where appropriate.

7.2.3.2 Bioinstrumentation.- In addition to that used in the manned Mercury-Redstone flights (two ECG leads, respiratory rate sensor, and body temperature sensor), a blood pressure device was utilized in flight. The blood pressure apparatus consisted of a pneumatic nylon cuff, placed on the left upper arm, and a microphone located under the cuff over the brachial artery. To obtain the blood pressure the cuff was inflated manually. The record consisted of the sound pulses superimposed on a cuff pressure decay curve. This record was displayed on the second ECG channel.

The total biosensor monitoring time, from astronaut insertion until just prior to landing, was eight hours and fifteen minutes. The biosensor readout quality was excellent throughout the countdown and flight with the exception of the respiratory trace. As in prior flights, variation with head position and air density combined to reduce the quality of the respiration trace. There were brief periods of noise on the ECG channels during countdown and flight usually occurring during vigorous pilot activity.

7.2.3.3 Preflight.- Figure 7.2.3.3-1 depicts the pulse rate, respiration rate, body temperature, and blood pressure values recorded during the MA-6 countdown. Values for the same physiological functions obtained from the simulated launch of January 19, 1962, and the launch attempt of January 27, 1962, are also shown. These are plotted coincident with significant events. Pulse and respiration rates were determined by counting the rates for 30 seconds every 3 minutes until ten minutes prior to lift-off, and thereafter, 30 second duration counts were made each minute.

The pulse rates during the scrubbed flight countdown of January 27 varied from 60-80 beats/minute with a maximum of 88 beats/minute. These were essentially the same as those observed during the MA-6 countdown, as shown in figure 7.2.3.3-1. Respiration rates were similar, varying from 12-20 breaths/minute. Blood pressure values from the simulated launch also approximated those observed during the MA-6 countdown.

The increase in pulse rate to 110 beats/minute and blood pressure to 135/90 observed prior to lift-off can be attributed to anticipation.

The low suit inlet temperature maintained during countdown resulted in the pilot feeling cold and was accompanied by a fall in body temperature from 98.5° to 97.6°F.

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An examination of the electrocardiographic wave form obtained during the MA-6 countdown revealed a number of variations in the pacemaker activity (point where the stimulus of the heart beat originates). These included sinus pauses, sinus bradycardia, premature atrial and nodal beats, premature ventricular beats, and a brief (16 beats) run of nodal rhythm. On several instances some of these reported findings occurred with deep respiration. Similar findings were recorded from the simulated launch of January 19 and from the scrubbed flight of January 27. These are considered normal physiological variations.

Samples of MA-6 records from the time of insertion, and at T-50 seconds, are shown in figures 7.2.3.3-2 and 7.2.3.3-3.

7.2.3.4 <u>Flight</u>.- Figure 7.2.3.4-1 depicts the inflight physiological data and includes values from the Mercury-Atlas Three Orbit Centrifuge Simulation for comparison. Pulse rates were counted every 30 seconds during MA-6 launch and reentry and for 30 seconds at three minute intervals throughout the remainder of the flight. Due to irregularity in the respiratory recording, rates were counted for 30 seconds whenever quality permitted and varied from 8-19 breaths/minute throughout flight.

The pulse rate from lift-off to spacecraft separation (powered flight phase) reached a maximum of 110 beats/minute. The pulse rate varied from 88-114 beats/minute in the first 10 minutes of weightlessness. It then remained relatively stable with a mean rate of 86 beats/minute during the next 3 hours and 45 minutes of flight. At the time of retrorocket firing the rate was 96 beats/minute and during reentry deceleration and the return to gravity the highest rate was 134 beats/minute just prior to drogue deploy at a time of maximum spacecraft instability. This rate was the highest noted during the mission except for that during exercise as discussed below. These rates are within accepted ranges and suggest that acceleration, weightlessness, deceleration and return to gravity were within tolerable limits.

The ECG variations noted during the preflight observation period were not observed in flight, and analysis revealed only normal sinus rhythm with short periods of sinus bradycardia (slowing) and sinus arrhythmia (variation). There were rare periods where trace quality deteriorated so that only pulse rate determinations were possible. ECG variations noted during the Mercury-Atlas Three Orbit Centrifuge Simulation included: sinus arrhythmia, sinus bradycardia, atrial and nodal premature beats, and rare premature ventricular contractions. These are considered normal physiological variations.

Blood pressure determinations were made ten times in flight; the first at 00:18:30 and the last at 03:14:00. The values are shown in figure 7.2.3.4-1 and range from 123-143 mm Hg systolic to 58-82 mm Hg diastolic. The mean blood pressure values for the periods of Mercury-Atlas Three Orbit

[redacted]

Centrifuge Simulation, countdown, and flight are presented in the following table:

	Mean Value	Systolic Range	Diastolic Range
3-Orbit Atlas Centrifuge	114/80 mm Hg	92 - 136 mm Hg	68 - 92 mm Hg
Countdown	125/89 mm Hg	105 - 145 mm Hg	82 - 92 mm Hg
Inflight	131/69 mm Hg	118 - 144 mm Hg	51 - 87 mm Hg

The inflight mean value shows widening of the pulse pressure (difference between systolic and diastolic levels) when compared to the centrifuge and countdown levels. The mean blood pressure value from static Procedures Trainer simulations was 120/73. The widened pulse pressure is of uncertain physiological significance and more information is needed before conclusions can be reached.

Samples from the inflight record are shown in figures 7.2.3.4-2 through 7.2.3.4-4.

The inflight exercise device is illustrated in figure 7.2.3.4-5. Exercise was accomplished by a series of pulls on the elastic bungee cords. An exercise period over Zanzibar on the first orbit raised the pilot's pulse rate from 88 beats/minute to 134 beats/minute after 30 seconds. The pulse rate returned to 84 beats/minute within two minutes. The blood pressure was 129/70 mm Hg both before and after exercise.

The Environmental Control System effectively supported the pilot throughout the mission. It should be noted, however, that body temperature gradually rose from a lift-off value of 97.6°F to 99.2°F at bioplug disconnect. The suit inlet temperature increased slowly during most of the flight with a more rapid rise after reentry and during parachute descent. During descent the suit inlet temperature increased 1°F/minute for a 15 minute period and probably contributed to the pilot's overheated status observed at egress. No abnormally high body temperature was observed.

7.2.3.5 Pilot inflight observations.- The astronaut's voice reports were consistently accurate, confident, and coherent through all phases of the flight. His voice quality conveyed a sense of continued well being. His mental state appeared entirely appropriate for the situation. Furthermore, the pilot's mood and level of performance was effectively conveyed by his voice reports. His prompt responses to ground transmissions and to sounds from the spacecraft suggest no decrement in hearing ability. Visual acuity was maintained and his report of visual perceptions, especially with regard to colors, was accurate and was confirmed by the inflight photographs.

The pilot's voice report contained a large number of observations of physiological significance. During his postflight debriefing these reports were amplified. Those considered of the most significance are discussed below.

No disturbances in spatial orientation were reported, nor were any symptoms suggestive of vestibular (inner ear) disturbances described during the flight. Voluntary rapid head turning movements produced no unpleasant sensations.

A brief sensation of tumbling forward occurred just after SECO (similar to that described by the astronauts in the MR-3 and MR-4 missions). This sensation ended promptly and was not associated with nausea. Coincident with retrorocket firing, a feeling of movement opposite from flight direction ("back to Hawaii") was noted. This could be expected with the sudden change in spacecraft velocity.

Food chewing and swallowing was accomplished without difficulty. No water as such was ingested during flight.

The pilot urinated without difficulty shortly before reentry. He described "normal" sensations of bladder fullness with the associated urge to urinate.

The pilot noted no difference in the sensations associated with reentry accelerations from those experienced during launch.

The astronaut described weightlessness as a "pleasant" sensation. Control manipulation was not a problem, and there was no observable performance decrement. The restraint harness-couch combination was reported to be comfortable.

In summary, the MA-6 mission provided a period of extended weightlessness during which the Astronaut's physiological responses apparently stabilized. The values attained were within ranges compatible with normal function. No subjective abnormalities were reported by the pilot.

7.2.4 <u>Conclusions</u>.-

(a) The physiological responses observed during the MA-6 mission are all consistent with intact, normal function.

(b) The preflight and postflight medical evaluations revealed no significant differences and were completely within normal limits with the exception of moderate dehydration.

(c) The MA-6 mission provided an exposure to weightlessness of sufficient duration to permit physiological responses to reach a relatively steady state.

(d) No symptoms reflecting disturbed vestibular (inner ear) function were reported. This lack of findings occurred even though specific attempts were made to stimulate the vestibular organ in flight.

(e) Four hours and thirty-eight minutes of weightlessness were tolerated without observable performance decrement.

(f) The pilot's subjective evaluation of his body processes and sensations during the flight all conveyed normal function.

(g) Acceleration - weightlessness transition periods did not produce any recognized physiological deterioration. Specifically, re-entry acceleration after 4 hours and 38 minutes of weightlessness did not produce any unexpected symptoms, and physiological data remained within anticipated limits.

(h) The Environmental Control System effectively supported the pilot throughout the mission.

(i) The astronaut's apparent fatigue noted in the immediate post-flight evaluation can be attributed to a number of factors. The most logical explanation is dehydration following overheating plus the cumulative effects of the various stresses experienced in the pre and inflight periods.

(j) His mild gastrointestinal discomfort ("stomach uneasiness") which occurred after landing may likewise be attributed to the increased environmental temperature and moderate dehydration of the astronaut. The motion of the spacecraft on the sea may be a contributory factor. This sensation cleared after a brief period of rest and rehydration.

TABLE 7.2.1-1.- SIGNIFICANT EVENTS PRIOR TO LAUNCH
(all times e.s.t.)

DATE	TIME	EVENT
February 19, 1962	2130	Retired
February 20, 1962	0220	Awakened and showered
	0250	Breakfast
	0305	Physical examination
	0428	Suiting started
	0505	Entered transfer van
	0520	Arrived at Pad 14 and remained in transfer van
	0558	Ascended gantry
	0606	Insertion
	0625	Countdown resumed
	0947	Launch

Astronaut Glenn began his 72-hour, prelaunch low residue diet on February 16, 1962. On the night prior to flight, the pilot obtained 4 hours and 50 minutes of dozing, light sleep. No medication was administered.

[redacted]

8.0 FLIGHT CONTROL AND NETWORK PERFORMANCE

8.1 Network description.- The Mercury Network consists of the Mercury Control Center (MCC) at Cape Canaveral (CNV), stations at Atlantic Missile Range (AMR), Bermuda (BDA), and at fourteen other locations along the orbital ground track, plus communications and computing centers at the Goddard Space Flight Center. The Network affords the capability of data acquisition for real-time monitoring and mission control, and for postflight analysis.

This section of the report describes the flight monitoring and control, and presents information on the performance of the communications, telemetry, tracking, computing, and command systems.

8.2 Flight control summary.- This summary presents the results of the flight as determined in real time. It is recognized that the results may be different from those obtained from an analysis of the data and presented in other sections of this report.

The launch and insertion into orbit very closely approximated nominal conditions. The pilot's performance throughout the flight was excellent, and he was able to deal with the unusual situations which arose. Several problems developed in the spacecraft automatic control system. The ASCS system was unable to maintain the spacecraft within the preset attitude limits about the yaw axis after approximately one orbit because of lack of thrust from the 1-pound yaw thrusters. This same malfunction was reflected in the system's operation when the astronaut elected to control with the fly-by-wire mode; however, he was able to maintain satisfactory attitude control about the yaw axis by using the larger thrusters. The horizon scanner and gyro reference system appeared to be in error mainly in the roll axis while the spacecraft was on the dark side of the earth. The manual-proportional control system worked well throughout the flight. The cooling system for both main inverters appeared to be inoperative throughout the entire flight and the inverter temperatures reached values as high as 210 to 220°F; however, no inverter malfunctions occurred.

On the first pass over Canaveral, segment 51 of the commutator showed a signal indication which, if correct, indicated that the spacecraft heat shield had been deployed. A great deal of analysis and discussion followed and a decision was first made that the signal, although a correct telemetry output, was the result of a faulty switch and that the normal sequence of events should be followed. Further discussion, however, indicated that

[redacted]

the safest approach would be to allow the retropackage to remain on. The retropackage straps would then hold the heat shield in place until sufficient dynamic force was exerted on the shield to maintain its position throughout reentry heating. The opinion was that the heat effects of the retropackage on the capsule heat shield and afterbody would not be damaging. Therefore, the pilot was directed during the retrofire maneuver over CAL to keep the retrojettison switch in the disarm position. The successful reentry proved this to be a sound decision. The remainder of the flight was nominal and no other major system malfunctions occurred. It must be strongly emphasized that although the malfunctions which did occur were minor with a pilot in the spacecraft to make decisions and take corrective action, these malfunctions would have made an unmanned flight extremely difficult to handle and may possibly have resulted in the inability to reenter the spacecraft and obtain successful recovery.

8.3 Network performance summary.- Generally, the Network performance was excellent. All systems were fully operational at lift-off and the few minor malfunctions did not affect the flight monitoring and control of the mission. Acquisition of data from tracking, telemetry, and air/ground voice systems was satisfactory in both quantity and quality for real-time monitoring and for postflight analysis. The relaying of air/ground voice back to the Mercury Control Center from all sites which have point-to-point voice capability contributed, substantially in enabling MCC to maintain close real-time monitoring of the mission.

8.3.1 Trajectory.- The following paragraphs discuss details of tracking, data transmission, computing, and trajectory displays.

Tracking.- The radar tracking on this flight was satisfactory and was superior to that of MA-4 or MA-5. All sites provided data for all passes whenever the spacecraft was above their horizon. The quantity and quality of data were more than adequate. Minor problems existed in S-band phasing and handover, but this caused negligible loss of data; the communications used for this were satisfactory.

Interference, source unknown, caused some concern on C-band at Canaveral and Bermuda, but did not cause any extensive loss of data. It is apparent that the extensive maintenance, training, and work on tracking procedures throughout the Network has paid dividends. Satisfactory C-band tracking was accomplished during most of the "blackout" period. Two Cape radars had satisfactory S-band tracking for the first two minutes of blackout and were then turned off, having reached the end of their range interval. Radar-tracking coverage is shown in figure 8.3.1-1. Details of the acquisition-aid performance are not currently available. However, acquisition was in all cases satisfactory.

Data transmission.- The transmission of both high speed and low speed data was satisfactory throughout the mission.

Computing and trajectory displays.- At lift-off, the selected source for display at the MCC was the output of the IP 7090. Cape FPS-16 tracking was utilized until approximately 00:00:50 when the IP 7090 switched to AZUSA. AZUSA was displayed for approximately the next 20 seconds, at which time GE-Burroughs via Goddard was selected and was displayed throughout the powered flight. The GE radar acquired both rate and track at 00:01:08 and never lost lock throughout the powered flight. The quality of the GE data was excellent up to SECO and during the GO-NO-GO computation.

The programed phase of the flight showed a minor deviation of +0.75° in flight-path angle, and +1.0 n.m. in altitude, at BECO. After staging, steering corrected this deviation in both altitude and flight-path angle. A maximum deviation of +2.8 n.m. in crossrange, and a residual of +50 fps in yaw velocity existed at cutoff. The yaw velocity looked very good up to approximately 35 seconds before cutoff, then appeared to lack response to steering with the final results as stated above. There appears to be conflicting evidence on this particular point since the calculated impact point at the Canary Islands (CYI) was right on the expected ground track, which is difficult to resolve with a residual velocity of 50 fps in yaw. This matter will be further investigated. The cutoff conditions displayed in MCC are listed in table 8.3.1-1.

Low-speed tracking data from the remote sites were excellent, such that the orbit was well defined by the end of the first orbit. Subsequent tracking in the second and third orbits showed negligible changes in the orbit parameters. The number of radar observations received from each site is shown in table 8.3.1-2.

The "A" computer was lost during the second orbit between Hawaii (HAW) and California (CAL). A restart was made in less than 5 minutes using the HAW vector, thus the computer was ready to accept the White Sands (WHS) data. A "B" computer malfunction caused the Texas (TEX) and Eglin (EGL) data on Orbit 2 and EGL data on reentry to be ignored.

During the reentry, tracking data appeared to pinpoint the landing location with a high degree of confidence, and the final values from the Goddard computers indicated only 2 n.m. difference between the landing location as obtained from CAL data and from the Cape FPS-16 data (see table 8.3.1-3). However, the landing point as reported by the recovery ship, and as computed by the Cape IP 7090 computer using Cape and San Salvador FPS-16 data, does not agree with the Goddard computations. The discrepancies between the Cape and Goddard computations have not been resolved at this writing, but are being investigated.

The low-frequency cyclic noise pattern was apparent in both GE-Burroughs and AZUSA data but slightly lower in amplitude than in MA-5 and much lower than MA-4. At insertion GE gave an inertial velocity of 25,727.6 feet/second and an inertial flight-path angle of -0.0674 degrees, while AZUSA figures were 25,733.3 and -0.0907, respectively.

The performance of the computing system and the tracking facilities was excellent throughout the mission.

[redacted]

8.3.2 Telemetry.- The data provided by the telemetry system was generally adequate and of good quality. Coverage was satisfactory, with data acquisition throughout each pass at every site when above the radio horizon. Coverage is shown graphically in figure 8.3.2-1 (a, b, and c) and in tabular form with decommutator figures, range and elevation in table 8.3.2-1. Signal strengths were satisfactory, ranging up to 400 microvolts. Several sites reported low signal levels, as compared with previous missions.

Ionization "blackout" of telemetry began at approximately 04:42:52, as seen at Canaveral, and ended at approximately 04:47:14, as seen at Grand Turk. Thus the period lasted 4 minutes and 22 seconds. Data flow charts were drawn up based on the telemetry summary messages from the sites. The majority of the data points fall within ± 3% of a faired curve. A few exceptions were evident, however, in that figures from several sites were consistently off the faired curves of fuel quantity by as much as 10%. See figure 8.3.2-2.

[redacted]

[redacted]

8.3.3 Air/ground voice.- The performance of the primary air/ground voice system (UHF system) was good throughout the mission. Signal strengths were adequate to provide very good signal-to-noise ratios essentially at all times the spacecraft was above the local visual horizon at the network sites. In most instances, the RF refraction increased the coverage over visual line-of-sight by one to two minutes. UHF in-range times averaged almost seven minutes during a pass.

The HF voice system provided some additional coverage, though (as expected) not as satisfactory as UHF. HF was of particular value on the first and third orbits where Canary, California, Guaymas, Zanzibar, Indian Ocean Ship, Muchea, and Canton were able to converse with the astronaut beyond the capability of the UHF system.

It is interesting to note that in some instances where the HF was being used as the spacecraft approached the station, the quality of communications improved considerably as the elevation angle became positive, particularly as the switch was made to UHF.

Figure 8.3.3-1 shows approximate coverage, compared with times above the visual horizon. Through the air/ground voice system, MCC was able to follow the recovery procedure, monitoring all conversations until after the spacecraft was aboard the recovery ship.

[redacted]

8.3.4 Command System.- The command system for MA-6 operated in a generally satisfactory manner during the mission. Some airborne-system anomalies are discussed below. A preliminary evaluation of the data shows that the 600-watt stations appeared to have coverage beginning at a slant range of 400-450 N.M., and that the 10 KW stations appeared to have coverage beginning at a slant range of 650-700 N.M. A summary of the command handover exercises is shown in Table 8.3.4-1, and a summary of the command transmissions is shown in Table 8.3.4-2.

Ground System.- There were several problems involving the command equipment and the coder relay panels during the month prior to launch; however, no delays in the launch countdown resulted.

A total of eleven (11) functions were successfully transmitted from the sites: Auxiliary Sustainer Cutoff (ASCO) was transmitted from San Salvador, three sets of R and Z calibrations were transmitted from Muchea, and two sets of R and Z calibrations were transmitted from Cape Canaveral.

Command coverage from all sites was satisfactory with the exception of Muchea on the third pass. A combination of slant ranges in excess of 450 nautical miles, airborne antenna patterns, and only 600 watts of RF power resulted in only one minute and 30 seconds of coverage above receiver threshold.

Airborne System.- Command Receiver "A", operating from the 18-volt isolated bus, appeared to be much more sensitive to signal strengths above 30 microvolts than Receiver "B", which operates from the 18-volt standby bus. Below 30 microvolts, both receivers' operation coincided. Generally, the onboard recorded signal strengths were about 6 db lower than on the MA-4 and MA-5 missions. The reason for the difference in recorded signal strengths is not known at this time. The airborne antenna pattern problem, which was experienced on MA-4 and MA-5, was again evident from the MA-6 onboard records. Spacecraft attitude changes are definitely reflected on the signal strength records.

Ionization blackout occurred on the Command frequency between 04:43:03:5 GET and 04:47:12 GET.

The following anomalies were experienced, and are being investigated:

(a) Triggering of the "All Function Events Channel" occurred five times during ionization blackout. The tone channels triggered are unknown, but are coincident with burst of signal into the receivers. It is known that the tones keyed were not clock changes, R and Z calibrations, [redacted] The characteristics of the inputs to the command receive[redacted] the oscillograph record reproductions of figures 8.3.4-1 through 8.3.4-3.

[redacted]

(b) What is assumed to be random noise with a signal strength from one to 4 microvolts was recorded between 01:14:00 GET to 01:15:07 GET. Command carrier was not present during this period.

[redacted]

8.3.5 Ground communications.- All the ground communications networks provided good support for the mission. Except for a few short prelaunch outages, all the voice, teletype, and datalines were available at all times, and the quality of transmission was satisfactory.

Single-sideband voice communication with the two ships was very satisfactory, as provided by AMR. Part of the link from the Indian Ocean Ship had to be relayed through ascension.

[redacted]

TABLE 8.3.1-1.- ORBITAL INSERTION CONDITIONS DISPLAYED AT MCC

Quantity	Actual	Nominal
Velocity ratio with posigrades (Av. of GO-NO-GO)	1.0002	1.00058
Inertial flight-path angle (Av. of GO-NO-GO)	$-.0674^{\circ}$	$-.0013^{\circ}$
Insertion altitude (Av. of GO-NO-GO)	86.4 n.m.	86.98 n.m.
Inclination angle	32.54°	32.5°
Orbit capability	7*	
Insertion velocity with posigrades	25,728 fps	25,736 fps
Apogee altitude	141 n.m.	144 n.m.

*Maximum number computed; actual orbit capability was approximately 100 orbits.

[redacted]

[redacted]

TABLE 8.3.1-2.- SUMMARY OF LOW-SPEED TRACKING DATA

	1st Pass					2nd Pass					3rd Pass				
	Total Poss. Valid Obs.	Total Obs.	Valid	Non-Valid	DC*	Total Poss. Valid Obs.	Total Obs.	Valid	Non-Valid	DC*	Total Poss. Valid Obs.	Total Obs.	Valid	Non-Valid	DC*
BDA-16	71	56	53	3	43	66	56	47	9	42	65	60	58	2	49
BDA-V	71	61	53	8		DATA NOT AVAILABLE					DATA NOT AVAILABLE				
CYI-V	68	72	63	9	50	54	54	46	9	34	OUT OF RANGE				
MUC-V	82	93	76	17	50	80	61	60	1	50	70	69	65	4	50
WOM-16	40	85	40	45	40	33	65	29	36	29	OUT OF RANGE				
HA[redacted]16	OUT OF RANGE					15	15	15	0	15	40	38	38	0	38
HA[redacted]V	OUT OF RANGE					56	34	30	4		64	23	14	9	
CA[redacted]16	OUT OF RANGE					38	29	28	1	28	42	20	17	3	17
CA[redacted]V	OUT OF RANGE					DATA NOT AVAILABLE					DATA NOT AVAILABLE				
GY[redacted]V	65	64	51	13	44	PASSIVE					PASSIVE				
WH[redacted]16	34	56	28	28	28	41	63	31	32	31	41	61	34	27	34
T[redacted]V	64	71	46	25	0	60	64	60	4	47	53	60	54	6	41
EGL-16	40	39	38	1	38	40	42	41	1	38	40	23	22	1	18
EGL-V	DATA NOT AVAILABLE					DATA NOT AVAILABLE					DATA NOT AVAILABLE				
CNV-16		71	43	28	35		58	54	4	44		33	27	6	22

* Differential Correction

NOTE: Verlort not used in DC after correction on FPS-16

V - Verlort (S-band)

16 - FPS-16 (C-band)

[redacted]

TABLE 8.3.1-3.- SUMMARY OF LANDING-POINT PREDICTIONS

BASED ON RADAR TRACKING

CONDITION*	LATITUDE	LONGITUDE
1. Retrofire time confirmed by CAL	21°08'N	68°01'W
2. DC on CAL tracking	21°32'N	68°55'W
3. DC on WHS tracking	21°29'N	68°48'W
4. DC on TEX tracking	21°29'N	68°48'W
5. DC on EGL tracking	21°31'N	68°53'W
6. DC on CNV tracking	21°31'N	68°53'W
Cape IP 7090 impact data:		
1. Based on Cape FPS-16 tracking	21°21'N	68°31'W
2. Based on San Sal FPS-16 tracking	21°24'N	68°35'W
Value reported by recovery	21°25'N	68°37'W

*DC - Differential correction

[redacted]

TABLE 8.3.2-1.- TELEMETRY RECEPTION SUMMARY

ORBIT I

Station	TM Acq.	TM LOS	Decommutator Lock On	Decommutator LOS	Slant Range N.M. Acq.	Slant Range N.M. LOS	Elevation degrees Acq.	Elevation degrees LOS
CNV	00:00:00	00:06:20	00:00:00	00:07:30*	--	750	--	0
BDA	00:03:02	00:10:26	00:03:40	00:10:26	750	868	0	-1.2
ATS	NOT IN RANGE							
CYI	00:14:15	00:21:23	00:14:41	00:21:20	800	850	0	0
KNO	00:21:13	00:28:21	00:21:50	00:28:21	850	900	-.3	-.5
ZZB	00:29:51	00:37:51	00:30:01	00:38:01	920	990	-.2	-.6
IOS	00:40:02	00:48:31	00:43:12	00:46:56	1000	1040	-.6	-1
MUC	00:49:21	00:57:55	00:49:32	00:51:21	1020	990	-.4	-.8
WOM	00:54:00	01:02:41	00:54:16	01:02:37	810	1060	+3	-1.5
CTN	01:09:19	01:17:42	01:09:36	01:17:40	900	1150	+.3	+.4
HAW	NOT IN RANGE							
CAL	01:26:41	01:31:23	01:27:18	01:31:23	840	920	-.7	-2.1
GYM	01:26:47	01:33:25	01:27:01	01:33:15	730	950	+.9	-2.5
TEX	01:29:24	01:36:18	01:29:32	01:36:14	830	820	-.7	+.6
EGL	01:32:00	01:37:05	01:32:11	01:37:00	800	880	-1	-1.5

*Includes data from downrange via submarine cable.

[redacted]

[redacted]

TABLE 8.3.2-1.- TELEMETRY RECEPTION SUMMARY (Continued)

ORBIT II

Station	TM Acq.	TM LOS	Decommutator Lock On	Decommutator LOS	Slant Range N.M. Acq.	Slant Range N.M. LOS	Elevation degrees Acq.	Elevation degrees LOS
CNV	01:33:20	01:40:03	01:33:27	01:41:00*	840	850	0	0
BDA	01:36:38	01:43:53	01:36:49	01:43:53	860	890	-1.2	-1.4
ATS	01:51:54	01:58:31	01:53:04	01:58:21	880	830	-.2	+1
CYI	01:47:55	01:53:58	01:48:11	01:53:53	850	910	-.2	-.2
KNO	01:54:47	02:01:21	01:55:07	02:01:21	890	940	-.6	-.6
ZZB	02:04:05	02:10:51	02:04:13	02:10:51	920	1040	.23	-1.1
IOS	02:12:17	02:22:09	02:13:27	02:21:54	1100	1050	-1.9	-.9
MUC	02:22:51	02:31:23	02:23:06	02:31:22	1008	960	-.3	0
WOM	02:27:36	02:35:45	02:27:45	02:35:39	950	1020	+.5	-1.5
CTN	02:42:51	02:49:45	02:42:59	02:49:38	870	907	-1.5	-1.3
HAW	02:49:01	02:55:19	02:49:29	02:55:08	940	830	-1.3	-.8
CAL	02:58:11	03:04:48	02:58:35	03:04:48	880	730	-1.5	+.7
GYM	02:59:59	03:06:44	03:00:13	03:06:34	610	880	+3	-1.5
TEX	03:03:14	03:09:39	03:03:16	03:09:31	810	810	-.8	-.4
EGL	03:05:35	03:12:07	03:05:46	03:12:00	670	1000	+2	-3

*Includes data from downrange via submarine cable.

[redacted]

[redacted]

TABLE 8.3.2-1.- TELEMETRY RECEPTION SUMMARY (Concluded)

ORBIT III

Station	TM Acq.	TM LOS	Decommutator Lock On	Decommutator LOS	Slant Range N.M. Acq.	Slant Range N.M. LOS	Elevation degrees Acq.	Elevation degrees LOS
CNV	03:06:51	03:13:46	03:06:53	03:15:42*	780	920	0	0
BDA	03:09:56	03:17:03	03:10:06	03:17:03	870	900	-1.2	-1.2
ATS	03:24:44	03:32:25	03:25:06	03:31:22	900	920	-.5	+.5
CYI	NOT IN RANGE							
KNO	NOT IN RANGE							
ZZB	NOT IN RANGE							
IOS	03:46:55	03:56:49	03:48:10	03:56:30	1050	1100	-1	-1.4
MUC	03:56:31	04:04:12	03:56:49	04:04:08	1020	940	-.7	-.16
WOM	04:03:16	04:06:19	04:03:31	04:06:01	870	1000	+1	-1.4
CTN	N/A							
HAW	04:21:49	04:28:49	04:22:02	04:28:39	920	770	-2	+.1
CAL	04:31:17	04:37:57	04:31:27	04:37:56	900	540	-2	+3.6
GYM	04:33:44	04:39:49	04:34:04	04:39:39	770	740	-5	-1.1
TEX	04:36:53	04:42:32	04:36:58	04:42:34	930	603	-3	-5
EGL	04:39:00	04:42:52	04:39:21	04:42:48	800	500	-1	+1.4
CNV	04:40:52	04:42:55	04:40:56	04:42:53	590	150	+1	+17
CNV	--	--	04:47:22**	04:50:10**	--	--	--	--

*Includes data from downrange via submarine cable.
**Data from downrange via submarine cable

[redacted]

[redacted]

TABLE 8.3.4-1.- COMMAND HANDOVER SUMMARY

Station	Command Handover Plan		Actual Handover		Maximum Signal Recorded in Microvolts
	ON	OFF	ON	OFF	
Canaveral (H)		00:06:00		00:06:01	65
Bermuda (H)	00:05:58	00:12:00	00:05:58	00:12:00	50
Muchea (L)	00:45:00	00:59:00	00:45:00	00:59:00	21
Guaymas (L)	01:20:00	01:33:00	01:20:00	01:33:00	28
Canaveral (H)	01:33:00	01:38:00	01:33:03	01:38:01	65
Bermuda (H)	01:37:58	01:45:00	01:37:58	01:45:00	65
Muchea (L)	02:15:00	02:32:00	02:15:00	02:32:00	40
Hawaii (H)	02:45:00	02:56:00	02:45:00	02:56:00	40
California (H)	02:56:00	03:04:00	02:56:00	03:04:00	50
Guaymas (L)	03:04:00	03:06:00	03:04:00	03:06:00	20
Canaveral (H)	03:06:00	03:12:00	03:06:04	03:12:03	55
Bermuda (H)	03:12:00	03:18:00	03:12:00	03:18:00	50
Muchea (L)	03:54:00	04:05:00	03:54:00	04:05:00	12
Hawaii (H)	04:15:00	04:30:00	04:15:00	04:30:00	50
California (H)	04:30:00	04:38:00	04:30:00	04:30:00	50
Guaymas (L)	04:38:00	04:40:00	04:38:00	04:40:00	13
Canaveral (H)	04:40:00	04:45:45	04:40:07	04:45:53	50
San Salvador (H)	04:45:45	04:50:50	04:45:52	04:50:57	45

(H) 10 KW RF Power
(L) 600 Watts RF Power

[redacted]

[redacted]

TABLE 8.3.4-2.- COMMAND FUNCTION SUMMARY

Station	*Function	Time/Duration of Function	Successfully Received	Airborne-Receiver Signal Strength in Microvolts
San Salvador	ASCO	00:05:01.7/4 Sec	Yes	20
Muchea	Z Cal	00:51:47.5/21 Sec	Yes	16
Muchea	R Cal	00:52:14/32 Sec	Yes	17
Canaveral	Z Cal	01:36:12/10 Sec	Yes	62
Canaveral	R Cal	01:36:24/14 Sec	Yes	64
Muchea	Z Cal	02:27:21/15 Sec	Yes	36
Muchea	R Cal	02:27:55/36 Sec	Yes	35
Canaveral	Z Cal	03:09:58/9 Sec	Yes	55
Canaveral	R Cal	03:10:09/11 Sec	Yes	53
Muchea	Z Cal	04:00:08/17 Sec	Yes	7
Muchea	R Cal	04:00:32.5/23 Sec	Yes	9

*ASCO - Auxiliary Sustainer Cutoff

R Cal - Instrumentation Full-scale Calibration

Z Cal - Instrumentation Zero Calibration

[redacted]

[redacted]

9.0 RECOVERY

9.1 **Recovery plans.**- Figure 9.1-1 shows the Atlantic recovery areas where ships and aircraft were positioned at the time of launch. Areas 1 through 6 were available in the event that it became necessary to abort the mission during powered flight. Recovery forces were distributed so as to provide for recovery within a maximum of 3 hours after landing in areas 1 and 4, and a maximum of 6 hours in areas 2, 3, 5, and 6. Areas 7, 8, and 9 were available for landing at the end of orbits 1, 2, and 3, respectively, and recovery forces were distributed to provide for recovery within a maximum of 3 hours. A total of 24 ships and 15 aircraft were on station in these Atlantic recovery areas at launch time. In addition, helicopters, amphibious surface vehicles and small boats were positioned for recovery support near the launch pad.

Figure 9.1-2 shows the contingency recovery aircraft that were on alert at various staging bases in the event that a landing occurred any place along the 3-orbit ground track. These aircraft were equipped to locate the spacecraft and to provide emergency on-scene assistance if required.

9.2 **Recovery operations.**- All recovery forces were on station at planned launch time. Weather conditions were favorable for location and retrieval in all Atlantic recovery areas and were good in contingency areas. Recovery communications were good throughout the entire operation and the recovery forces were informed of mission status during the launch, orbital, and reentry phases.

During the third orbit, recovery units in area 9 were alerted to expect a landing in their area and at 04:42:00 (13 minutes prior to landing) were informed that the landing was calculated to occur at 21°29' north latitude and 68°48' west longitude. This information was transmitted to the recovery forces as CALREP 1 (calculated landing position report), see figure 9.2-1. Continued radar tracking made little change in this prediction and at 04:46:00 (9 minutes prior to landing) the recovery forces were directed to orient their search about this position. This information was transmitted as DATUMREP 1, indicating that this was the best landing position information available at that time. In the meantime, lookouts on the destroyer NOA stationed in the DD16 position heard a noise like an explosion, and approximately 20 seconds later, the main parachute and spacecraft were sighted at an estimated slant range of 5 miles and elevation angle of 35°. The noise was described as similar to the "sonic-boom" noise made by aircraft traveling at supersonic speeds.

[redacted]

The NOA established communications with the astronaut and at 05:07:00 (12 minutes after landing) was alongside the spacecraft. The astronaut remained in the spacecraft during retrieval. Photographs of the spacecraft prior to and during retrieval are shown in figures 9.2-2 and 9.2-3. A "shepherd's crook" was used to attach a lifting line to the spacecraft which was hoisted clear of the water at 05:12:00 and secured on the recovery ship at 05:15:00 (20 minutes after landing).

The astronaut first decided to egress from the spacecraft through the top, and began the standard procedure of removing the right-hand instrument panel. However, considering the time and effort normally associated with this egress route and the fact that he was uncomfortable, he elected to egress by the quicker route through the side hatch. He actuated the side hatch explosive mechanism from inside the spacecraft, and was clear of the spacecraft at 05:34:00 (39 minutes after landing).

The following retrieval information was reported by the recovery ship:

Position of pickup - 12°25.6' North; 68°36.5' West
Winds - 18 knots from 119° true
Waves - 2 feet
Water temperature - 81°F
Air temperature - 75°F

9.3 Recovery aids.- All spacecraft recovery aids apparently functioned normally.

Search aircraft reported contact with both SARAH recovery beacons and with the UHF transceiver. These aircraft were proceding towards the calculated landing position at this time and were well within the available range of these systems.

The dye marker and flashing light were reported to be functioning normally.

The SOFAR bomb signal was received and a fix was available at the recovery center about one hour after landing. This fix was approximately 4 miles from the spacecraft retrieval position as shown in figure 9.2-1.

The SEASAVE beacon fixes as reported by the Navy and FCC HF/DF networks are shown in figure 9.2-1. The first fix was available at the recovery center at 05:20:00. A later fix was available at 05:27:00. Both fixes were about 25 nautical miles from the retrieval point.

10.0 APPENDIX

10.1 Spacecraft postflight inspection.-

General condition.- The general condition of the spacecraft interior and exterior was excellent. (See figure 10.1-1). The exterior of the spacecraft showed the usual slight discoloration due to aerodynamic heating. Also, there were deposits of 2024 aluminum alloy, which had evidently been deposited in a molten state, adhering to the surface of several widely separated shingles. It is likely that the aluminum retropack cover is the source of these deposits.

A brownish deposit was found on a portion of the spacecraft window exterior surface. The nature of this deposit has not been determined. As on previous flights, the window was found to be fogged with water condensate between the two outer panes.

Structure.- The spacecraft did not experience any structural damage which would have compromised the safety of the mission.

Ablation shield.- The external surface of the shield (see figure 10.1-2) was charred in the normal pattern. The center plug of the shield had separated and extended outward approximately 0.5 inch, as in most of the previous missions. A pie-shaped segment of the shield is of a darker background color than the adjacent area. The same area contains several radial marks approximately 4 inches in length. It is likely that a large piece of the retropack slipped off in this direction. There are two small deposits, metal-like but of undetermined composition, on the shield.

Heat-shield deployment instrumentation.- The heat-shield deploy switch between stringers 2 and 3 had a very loose rotary stem. The switch would make and break electrical contact when the rotary stem was moved up and down along its longitudinal axis. This malfunction could account for the impact-bag-deployed signal that was received during the flight.

Landing bag.- The landing bag had several tears, and it was impossible to determine whether these occurred during impact or in postflight handling. No landing bag straps or cables were broken, but some straps were kinked. There was minor damage to the heat shield retaining studs and the bulkhead protective shield, probably from impact as in previous flights. However, no damage occurred to the spacecraft equipment in this area.

The large pressure bulkhead had a dent from an undetermined cause near the center approximately 1.5 inches long. The center area is not covered by the bulkhead [redacted]

[redacted]

10.2 **Launch Operations**.- The spacecraft launch operations were planned about a 610-minute split count with a 17½ hour built-in hold at T-390 minutes for spacecraft peroxide and pyrotechnic servicing. To provide additional assurance that the projected launch time of 0730 A.M. e.s.t., February 20, 1962, could be met, a 90-minute hold was scheduled at T-120 minutes.

The second half of the split count was picked up at 1130 P.M. e.s.t. on February 19, 1962. Launch was at 0947 A.M. e.s.t. on February 20, 1962, after two hours and 17 minutes of unplanned holds. The following is a sequence of important events, including holds, which occurred in the countdown:

T-390 min.	Count was picked up.
T-120 min.	Built-in 90-minute hold. Due to a sudden drop in the booster rate-beacon Automatic Gain Control the first backup beacon was substituted for the original during this 90-minute scheduled hold period. The hold was extended an additional 45 minutes to complete installation and re-validate the beacon.
	An additional 10-minute hold was required by the spacecraft to replace a broken microphone bracket in the Astronaut's helmet.
T-120 min.	Picked up count.
T-117 min.	Completed second G.E. guidance loop test.
T-87 min.	Started hatch installation.
T-60 min.	A 40-minute hold was required to replace a broken bolt on the spacecraft hatch. A third G.E. guidance loop test was performed during this hold.
T-45 min.	A 15-minute hold was required to add approximately 10 gallons of fuel to the booster.
T-22 min.	A 25-minute hold resulted from a malfunction of the main LOX fill pump outlet valve. The final 20% of LOX tanking was accomplished by using a smaller pump via a 6-inch line, resulting in a slower operation.
T-6:30 min.	A 2-minute hold was required by the Mercury Flight Director to investigate an outage in the source power to the Bermuda computer.

[redacted]

[redacted]

10.3 Weather conditions.- The weather conditions in the launch area at lift-off were as follows:

Cloud cover	0.2 Alto cumulus
Visibility	10 miles
Surface winds	North at 18 knots (gusts to 25 knots)

A plot of the launch area wind direction and speed in shown in figure 10.3-1 for altitutdes up to 60,000 feet.

Landing area weather conditions were as follows:

Cloud cover	0.2
Visibility	10 miles
Surface winds	ESE at 14 knots
Waves	2 feet

[redacted]

[redacted]

[redacted]

10.4 Spacecraft History.-

Spacecraft No. 13 was delivered to Hangar "S", Cape Canaveral, Florida on August 27, 1961. Upon arrival, spacecraft entered a short work period during which the individual systems checks were completed satisfactorily prior to preparing the spacecraft for the altitude chamber runs. The following is a general resume of major changes accomplished at the launch site prior to launch:

(a) Reaction-Control System.-

(1) Roll thrust chamber heat sinks were added.

(2) Sham-ban flare seals were removed from the automatic system inlet and outlet connections of the thrust-chamber solenoid valves to reduce the possibility of leakage in the area of the thruster. Subsequently, all sham-ban seals that were accessible were replaced with voi-shan seals.

(3) Nine solenoid valves were replaced during the sham-ban seal removal because of the possibility of Kel-F existing on the solenoid outlets.

(4) The clockwise automatic roll-thruster assembly was replaced.

(b) Communications.- No outstanding problems were experienced with the communication equipment after the spacecraft arrived at Hangar "S". Readouts from the range on the C band radar beacon showed jitter and varying signal strength. These problems disappeared, as expected, when the service tower was removed.

(c) Electrical.-

(1) Flight batteries were activated on November 8, 1961. These batteries were replaced on February 10, 1962 when one battery cell lost voltage and another had a short to case.

(2) Both mercury cell auxiliary battery units were replaced by new units on January 13, 1962.

(3) Inverter switching circuitry was modified to provide a non-fused circuit to the standby inverter in the manual mode.

(4) The original 150 VA inverter malfunctioned during a hangar test and was replaced.

(5) The [redacted] switch was replaced.

[redacted]

(6) The removable half of all fuse block holders was reinforced.

(7) The removable telelight panel was removed, reworked, and reinstalled.

(8) The retrorocket relay panel was replaced.

(9) Due to an internal malfunction, the thrust cut-off sensor was replaced.

(10) During a hangar check, the maximum altitude sensor timed out early. This unit was replaced.

(11) The satellite clock was replaced on two separate occasions due to malfunctions.

(12) Indicator lights showing which inverter was operative were added to the instrument panel.

(d) Environmental Control System.-

(1) An advanced design type of cold plates were installed under the 150 and 250 VA main inverters.

(2) Screens with .06" diameter holes were installed in the cabin fan inlet ducts.

(3) The aluminum check valves in the freon-water inverter cooling system were replaced with stainless steel valves.

(4) The high pressure O_2 reducer was replaced, due to a leak prior to the altitude chamber runs.

(5) The primary O_2 system shutoff valve stem was removed, reworked and reinstalled due to leaking O-rings.

(6) A manual blood pressure system was installed.

(7) During the first run of SEDR 77-13, the No. 1 suit fan was below specification performance. This fan was replaced.

(8) An indicator was installed on the instrument panel to give a readout of suit circuit steam vent exhaust temperature.

(9) The CO_2 absorber was replaced after the spacecraft was moved to the launching complex.

(10) The suit circuit demand regulator was replaced.

(e) Automatic Stabilization and Control System.-

(1) During dynamic testing of the ASCS, the yaw repeater of the amplifier-calibrator would not come off its stop. The amplifier-calibrator was replaced with a new unit which included a new logic board for fuel conservation.

(2) Fuses were added in the power leads leading to the rate gyros.

(3) Eight-watt heater blankets were added to the scanners.

(f) Instrumentation.-

(1) Instrument panel and pilot observer cameras were removed, checked and reinstalled.

(2) The "E" package location near the pilot's right foot caused some discomfort and was objectionable because it presented a problem in removing the egress hatch. The package was relocated in the area of the right-hand bay.

(3) Instrumentation was added to monitor the hydrogen peroxide line temperatures on the "B" nuts of the No. 1 auto-roll thrusters and the manual-roll thrusters.

(4) The instrument panel camera was replaced due to a malfunction, after the spacecraft was moved to the launching complex.

(g) Miscellaneous.-

(1) The main and reserve flight parachutes were replaced with chutes of a more recent packing date.

(2) A personal-equipment container was fabricated and installed.

(3) Removable filters were provided for the pilot observations window.

(4) Astronaut couch was installed.

Spacecraft No. 13 was transported to Complex 14 on January 3, 1962 and was mated with the Atlas booster. All normal systems tests were successfully completed. However, due to various holds, four extra simulated flight tests and one additional launch simulation test were performed. The capsule was successfully launched on February 20, 1962.

[redacted]

10.6 Telemetry, instrumentation, and onboard film.- The instrumentation system flown in MA-6 was essentially the same as in MA-5. Small changes between the two spacecrafts were required to accommodate those parameters associated with a manned mission. Other changes are as follows:

(a) Heat shield temperature in MA-6 was measured by means of a chromel-alumel thermocouple.

(b) MA-6 used only two cameras, pilot-observer and instrument-observer, deleting the earth-sky and periscope cameras.

(c) A different type of color film was used in the pilot-observer camera.

(d) In MA-6, the mixed sequence of events were superimposed on the vernier clock signal.

A complete list of the instrumented parameters is included in Table 10.6-1.

10.6.1 Flight performance and results.-

Telemetry.- Both telemetry transmitters exhibited a center-frequency shift and signal strength rise when the escape tower was jettisoned. This effect, resulting from a change in antenna VSWR was anticipated and will be taken into account when setting the center frequencies for the transmitters on future spacecrafts. The change in VSWR is generally insignificant enough that the transmitters can be adjusted so that the center frequencies will be within specification for both tower-on and tower-off conditions. The signal strengths and deviation from center frequency as read by AMR when the spacecraft passed over the Cape are shown in Table 10.6.1-1

Data quality.- The quality of the data reduced from the on-board tape was very good. Scatter and noise caused by tape speed variations was insignificant and easily compensable on the continuous channels. The only problem area occurred during the time of exit maximum dynamic pressure when vibrational affects on the recorder caused almost complete loss of data; however, the real-time data during the same period covers the lapse.

A comparison of the hand controller (stick position) data as instrumented on continuous and commutated channels shows the definite advantage of instrumenting this parameter by means of a continuous channel. About 50 per cent of the stick position data are lost on the commutated channel and the commutated data which are present are difficult to interpret.

[redacted]

Photographic- The instrument-observer camera malfunctioned prior to the start of the flight, during the 60-second test at T-55 minutes in the count. The film slipped out of the film gate with the camera continuing to run, giving an indication it was operating properly.

The results obtained from the pilot-observer camera were generally good. The use of the Ecktachrone ER color film is an improvement over that which has been used in previous capsules.

On-board timing.- The vernier-clock channel malfunctioned throughtout the entire flight. Each time the pilot-observer camera operated a spurious pulse was produced in the vernier clock signal; at times, when the camera operated at high speed, the signal was rendered almost useless. The satellite clock is presently being redesigned to include a 1-PPS output which can be used to directly modulate the voltage-controlled oscillator. The new design will utilize, as a trigger, the same 28v dc signal which steps the clock digital counters. This will be a great improvement in signal-to-noise ratio and should elminate the problem.

From the instrumentation standpoint, the most serious problem resulting from the MA-6 mission was in the respiration rate and depth channel. The principle of operation of the circuit is a thermistor sensor which is heated by a dc voltage; when the subject breathes on the sensor, it cools and changes resistance, producing a voltage change on the output of a direct-coupled transistor amplifier. The basic problem is that the thermistor temperature is subject to changes in ambient temperature and flow. Because of changes in temperature and flow, the base line of the respiratory signal varied from a value of 10 per cent set during the suiting procedure up to a maximum of 85 per cent at lift-off. After lift-off, the base line fell steadily until it reached a low of 10 per cent at 02:08:00; then it began to rise again and had attained a 40 per cent level at loss of signal. The sensitivity of the signal degraded in direct proportion to the base line shift since the sensitivity decreases as the base line increases. The sensitivity problem is further complicated by the fact that the position of the sensor is not fixed to the position of the pilot's head. In the MA-6 mission, much of the data were lost because the pilot was not breathing directly on the sensor. Both the subcarrier oscillators encoding the respiration data performed per specification and did not contribute to the above effects.

[redacted]

10.6-1.- COMMUTATOR POINT ASSIGNMENT FOR MA-6

COMM. HF	COMM. LF	PARAMETER	RANGE
1	1	3-volt reference	3 v
2	2	Zero ground reference	0.v
3	3	AC amplifer power supply monitor	7 v ac
4	4	Body temperature	95° - 107° F
5	5	Command receiver, all channels signal	On-Off
6	6	Oxygen partial pressure	0 - 800 mm Hg
7		"A" command receiver signal strength	0 - 80 μ volts
	7	"B" command receiver signal strength	0 - 80 μ volts
8	8	Suit pressure	0 - 15 psia
9	9	Oxygen supply pressure primary	0 - 7500 psig
10	10	Cabin air temperature	40° - 200° F
11	11	Suit inlet air temperature	40° - 100° F
12	12	Oxygen supply pressure secondary	0 - 7500 psig
13	13	Y-axis accelerometer (13, 43 and 73)	± 0.5g, ± 4g
14	14	X-axis accelerometer (14, 44 and 74)	± 0.5g, ± 4g
15	15	Z-axis accelerometer (15, 45 and 75)	± 30g
16	16	Pitch attitude ASCS calibrator	-140° to + 180° F
17	17	Roll attitude ASCS calibrator	-130° to + 200° F
18	18	Yaw attitude ASCS calibrator	-70° to + 250° F
19		Roll CW manual - fuel line temperature	0 - 250° F
	19	Roll CCW manual - fuel line temperature	0 - 250° F
20		Lo roll CCW auto - fuel line temperature	0 - 250° F
	20	Lo roll CW auto - fuel line temperature	0 - 250° F
21	21	250 va inverter temperature	40° - 300° F
22	22	Static pressure	0 - 15 psia
23	23	Stick position roll	± 13°
24	24	Stick position pitch	± 13°
25	25	Stick position yaw	± 13°
26	26	Elapsed time (10 seconds)	
27		"A" command receiver signal strength	0 - 80 μ volts
	27	"B" command receiver signal strength	0 - 80 μ volts
28	28	Elapsed time (1 minute)	
29	29	Elapsed time (10 minutes)	
30	30	Elapsed time (1 hour)	
31	31	Elapsed time (10 hours)	
32	32	150 va inverter temperature	40° - 300° F
33	33	Time of retrograde (10 seconds)	
34	34	Time of retrograde (1 minute)	
35	35	Time of retrograde (10 minutes)	
36	36	Time of retrograde (1 hour)	
37	37	Time of retrograde (10 hours)	

[redacted]

[redacted]

10.6-1.- COMMUTATOR POINT ASSIGNMENT FOR MA-6 (continued)

COMM. HF	COMM. LF	PARAMETER	RANGE
38	38	Horizon scanner pitch ignore	On-Off
39	39	Reaction control supply pressure (auto)	600 - 2200 psig
40	40	Reaction control supply pressure (manual)	600 - 2200 psig
41	41	AC voltage monitor (fans bus)	95 - 120v ac
42	42	DC current monitor	0 - 50 amps
43	43	Y-axis accelerometer	
44	44	X-axis accelerometer	
45	45	Z-axis accelerometer	
46	46	Tower release	On-Off
47	47	Capsule separation	On-Off
48	48	Retro attitude command	On-Off
49		"A" command receiver signal strength	
	49	"B" Command receiver signal strength	
50	50	Retrofire timing signal	On-Off
51	51	Impact bag deploy	On-Off
52	52	Integrating accelerometer signal	0 - 600 ft/sec
53	53	Retro assembly jettison	On-Off
54	54	Drogue chute deploy	On-Off
55	55	Antenna fairing release	On-Off
56	56	Main chute deploy	On-Off
57	57	Main Chute Jettison	On-Off
58	58	Reserve chute deploy	On-Off
59	59	Pilot abort	On-Off
60	60	Mayday	On-Off
61	61	Tower escape rockets	On-Off
62	62	Standby inverter "On"	On-Off
63	63	ASCS slaving signal	On-Off
64	64	Calibrate Z/Cal, R/Cal(also 25%,50%,75% Ref.)	On-Off
65	65	High pressure reaction jet solenoids (+ pitch)	On-Off
66	66	High pressure reaction jet solenoids (- pitch)	On-Off
67		18-volt ISOL voltage	16 - 22v dc
	67	18-volt standby voltage	16 - 22v dc
68	68	Oxygen emergency rate mode	On-Off
69	69	High pressure reaction jet solenoids (+ roll)	On-Off
70	70	High pressure reaction jet solenoids (- roll)	On-Off

[redacted]

[redacted]

10.6.1.- COMMUTATOR POINT ASSIGNMENT FOR MA-6 (continued)

COMM. HF	COMM. LF	PARAMETER	RANGE
71		"A" command receiver signal strength	
	71	"B" command receiver signal strength	
72	72	Periscope retract signal	On-Off
73	73	Y-axis accelerometer	
74	74	Y-axis accelerometer	
75	75	Z-axis accelerometer	
76	76	Heat shield temperature (thermocouple)	0° - 2500° F
77	77	ASCS bus voltage	95 - 125v ac
78	78	High pressure reaction jet solenoids (- yaw)	On-Off
79	79	High pressure reaction jet solenoids (+ yaw)	On-Off
80	80	Retrorocket temperature	0° - 150° F
81		HF telemetry transmitter temperature	40° - 300° F
	81	LF telemetry transmitter temperature	40° - 300° F
82	82	Cabin pressure	0 - 15 psia
83	83	DC voltage monitor	18 - 28v dc
84	84	Coolant pressure	230 - 485 psig
85	85	Horizon scanner roll ignore	On-Off
86	86	Horizon scanner output monitor roll	± 35°
87	87	*.05g relay actuation	On-Off
88	88	Horizon scanner output monitor pitch	± 35°
89	89	Synchronize pulse	
90	90	Synchronize pulse	

[redacted]

10.6-1.- COMMUTATOR POINT ASSIGNMENT FOR MA-6 (continued)

HIGH FREQ. SYSTEM	CONTINUOUS CHANNELS	RANGE
0.40	Roll rate and low roll thruster (mixed)	± 10°/sec.
0.56	Vernier clock and sequence of events (mixed)	1-PPS
0.73	DC volts	18 - 28v dc
1.3	R.R. and D	
1.7	EKG (left side, right side)	
2.3	EKG and blood pressure (upper chest, lower chest)	
3.0	Reference	
3.9	Stick position, roll	± 13°
10.5	High frequency commutator (PAM)	

LOW FREQ. SYSTEM	CONTINUOUS CHANNELS	RANGE
0.40	Pitch rate and low pitch thrusters (mixed)	± 10°/sec.
0.56	Yaw rate and low rate thrusters (mixed)	± 10°/sec.
0.73	D.C. Current	0 - 50 amp
1.3	R.R. and D	
1.7	EKG (left side, right side)	
2.3	EKG and blood pressure (upper chest, lower chest)	
3.9	Stick position pitch	± 13°
5.4	Stick position yaw	± 13°
10.5	Low frequency commutator (PAM)	

ON-BOARD TAPE RECORDER TRACK ASSIGNMENTS

TRACK	INFORMATION
1	Open
2	High frequency telemetry multiplex
3	Voice
4	PDM high frequency
5	PDM low frequency
6	Low frequency telemetry multiplex
7	Open

10.6.1-1 TELEMETRY SIGNAL STRENGTH AND DEVIATION FROM CENTER FREQUENCY AS RECORDER BY AMR

	S/S in DBM		Deviation from* Center Freq.,KC	
	Low	High	Low	High
Lift-off	-30	-30	+13.9	-45.2
Tower release	-52	-52	- 1.0	-29.0
Orbit 1	-35	-52	- 5.0	-21.5
Orbit 2	-30	-45	- 3.0	-20.9
Orbit 3	-60.5	-55.5	0.	-18.0

*Specification deviation: ±26 KC (High Link)
±22 KC (Low Link)

[redacted]

10.7 AMR optical coverage.- AMR optical coverage including quantity of instrumentation committed and data obtained during launch phase is in table 10.7-1. AMR optical tracking from lift-off or first acquisition to limits of visibility is shown in figure 10.7-1.

Metric film.- Metric films were reduced and results were tabulated by AMR, but these data were not required for evaluation by MSC since the powered flight phase was normal.

Engineering sequential film.- Engineering sequential coverage at AMR Station 1 during launch phase was satisfactory. Thirteen films were reviewed, including 16mm and 35mm films from three fixed cameras and ten tracking cameras. The quality of fixed camera coverage was excellent and indicated normal umbilical ejection, periscope retraction, booster ignition, and lift-off. The quality of tracking camera coverage was good with the exception of some poor quality coverage of the early portion of powered flight due to ground haze conditions at lift-off. All tracking cameras indicated normal booster staging and tower separation.

Documentary film.- Documentary coverage used for engineering evaluation of the mission was satisfactory and film quality was average. Seven motion picture films and numerous still photographs were available for review. Two motion picture films presented a portion of the prelaunch activities, including astronaut preparation at Hangar S, insertion of the astronaut into the spacecraft, closing of the hatch and securing for launch, and portions of the operational activity at the Mercury Control Center during the mission. Coverage and quality of these two films were good. Four motion picture films presented portions of the recovery operation including aerial and shipboard coverage of spacecraft retrieval from the water, removal of the hatch, astronaut egress, transfer from the recovery ship, and the physical examination aboard the carrier. One film included views of the astronaut at Grand Turk Island and the spacecraft being loaded aboard the aircraft for transport to the Cape. Still picture coverage included views similar to those documented by motion picture with the exception of hatch removal prior to astronaut egress onboard the recovery ship. Numerous engineering still photographs were available showing close-up views of the spacecraft after recovery and during postflight inspection at Hangar S.

[redacted]

[redacted]

TABLE 10.7-1.- AMR OPTICAL COVERAGE OF LAUNCH AND REENTRY PHASE

Film Type	Station	No. of Items Committed	No. of Items Obtained	Lost Items	Reason for Loss
Metric	1	15	15	0	N/A
Engineering Sequential	1	47	46	*1	No reentry data
Engineering Sequential	3	1	0	*1	No reentry data
Engineering Sequential	5	1	0	*1	No reentry data
Documentary	1	88	88	0	N/A

*Planned for reentry coverage.

[redacted]

10.8 **Flight safety reviews.**- Two series of meetings were held by the MA-6 Flight Safety Review Board because of the launch postponements.

First series of reviews.- The following meetings were conducted in anticipation of launch on January 24 and January 27, 1962. The launch was rescheduled from January 24 to January 27 when an oxygen leak in the spacecraft Environmental Control System (ECS) was discovered on January 20. The countdown on January 27 was conducted until 20 minutes before launch at which time the weather caused postponement of the launch attempt.

The first spacecraft review meeting was held at 1:00 p.m. on January 18, 1962. The spacecraft history at AMR and the present status of all the spacecraft systems were reviewed and the spacecraft approved as ready for flight. A second review meeting, scheduled after the oxygen leak had been repaired, was held at 11:15 a.m. on January 24, 1962. During this meeting the status of the spacecraft systems was discussed and all systems, including the ECS, were again approved as ready for flight.

The first Booster Review meeting was held at 4:00 p.m. on January 19, 1962. All booster and supporting systems were approved as ready for flight.

The Mission Review meeting was held at 1:00 p.m. on January 25, 1962, and all elements for the flight were found to be in readiness.

When the Flight Safety Board convened at 9:30 a.m. on January 26, 1962, it was reported that the booster was not in a flight status due to broken wires and damaged pins in separation plug no. 2012. This plug carries booster engine autopilot commands, rough combustion cutoff circuitry, and engine indications and is separated at booster separation (staging). The plug was repaired and when the Flight Safety Board met again at 1:00 p.m. on January 26, the booster was ready to be committed to flight.

Weather caused the January 27, 1962, launch attempt to be postponed.

Second series of reviews.- On January 30, 1962, fuel was discovered in the insulation between the structural bulkhead and the insulation bulkhead separating the booster fuel and oxidizer tanks. Fuel had leaked into this area through a flange bolt. The decision was made to remove the insulation and insulation bulkhead, and this work period caused the launch to be rescheduled for February 13, 1962. Weather forced 3 more postponements to February 14, 15, and 20.

No separate spacecraft or [redacted]view meetings were held during this period.

[redacted]

[redacted]

The second Mission Review meeting was held at 3:00 p.m. on February 12, 1962. Satisfactory removal of the booster insulation had been made and all systems were found ready for flight.

Booster status meetings were held on February 13 and 19, and the Flight Safety Board recommended that the mission proceed, as everything was in readiness.

[redacted]

[redacted]

10.9 Test objectives.-

(a) Evaluate the performance of a man-spacecraft system in a three-orbit mission.

(b) Evaluate the effects of space flight on the astronaut.

(c) Obtain the astronaut's opinions on the operational suitability of the spacecraft and supporting systems for manned space flight.

Systems priorities.-

	Priority
(a) Communications system	
(1) Command receiver no. 1	Primary
(2) Command receiver no. 2	Primary
(3) Low frequency telemetry (225.7 mc)	Primary
(4) High frequency telemetry (259.7 mc)	Primary
(5) UHF and HF voice	Primary
(6) C-band beacon	Primary
(7) S-band beacon	Primary
(8) SARAH beacon	Primary
(9) SUPERSARAH beacon	Primary
(10) SEASAVE beacon	Primary
(b) Automatic Stabilization and Control System	Primary
(c) Rate Stabilization Control System	Primary
(d) Reaction Control System	Primary

[redacted]

[redacted]

(e)	Environmental Control System	Primary
(f)	Electrical Power System	Primary
(g)	Explosive devices	Primary
(h)	Cabin equipment	
	(1) Navigation instruments	Primary
	(2) ECS indicators	Primary
	(3) Electrical system indicators	Primary
	(4) Sequential and warning lights	Primary
	(5) ASCS indicators	Primary
	(6) Satellite clock	Primary
(i)	Rocket system	Primary
(j)	Landing and recovery system	Primary
(k)	Instrumentation system	Primary

[redacted]

[redacted]

10.10 Acknowledgement.- The Flight Evaluation Team for the MA-6 flight, and from whose analysis this report is based, was composed as follows:

3.0 LIFT-OFF CONFIGURATION DESCRIPTION

A. J. Saecker
B. P. Brown
H. Herring

4.0 EVENTS TRAJECTORY AND GUIDANCE

J. Mayer
C. R. Hicks
C. C. Allen
S. Hunt
M. S. Burton

5.1 SPACECRAFT CONTROL SYSTEM

G. T. Sasseen
P. F. Horsman
V. M. Mitchell
W. Karakulko
M. Jones

5.2 ENVIRONMENTAL CONTROL SYSTEM

F. Samonski
D. Huges
J. McMann

5.3 COMMUNICATIONS

G. W. Simpson
W. Stelges

5.4 MECHANICAL, ROCKETS, AND PYROTECHNICS

S. T. Beddingfield
J. Janckaitis, Jr.

5.5 ELECTRICAL AND SEQUENTIAL

T. N. Williams
M. Guidry

5.6 VIBRATIONS [redacted]

M. Hilsman

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6.0 LAUNCH VEHICLE BOOSTER PERFORMANCE

B. P. Brown
H. Herring

7.0 PILOT ACTIVITIES AND MEDICAL REPORT

R. Hackworth
Dr. C. P. Laughlin
Dr. E. P. McCutcheon
Dr. H. A. Minners
Dr. D. P. Morris
R. M. Rapp
P. W. Backer
W. Cameron
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J. H. Glenn
H. I. Johnson
J. B. Jones
J. A. O'Keefe
H. A. Kuenel
J. Van Bockel
R. G. Zedeker

8.0 FLIGHT CONTROL AND NETWORK PERFORMANCE

C. C. Kraft
H. C. Kyle
T. Roberts
J. D. Hodge
V. Dauphin

9.0 RECOVERY

R. F. Thompson
J. Stonesifer

10.1 SPACECRAFT POSTFLIGHT INSPECTION

A. J. Saecker
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H. K. Logan
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[redacted]

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10.2 LAUNCH OPERATIONS

B. P. Brown
H. Herring

10.3 WEATHER CONDITIONS

R. V. Capo

10.4 SPACECRAFT HISTORY

A. J. Saecker

10.5 COMMUNICATIONS DETAILS

W. Stelges
G. W. Simpson

10.6 TELEMETRY AND INSTRUMENTATION ONBOARD FILM

M. A. Wedding

10.7 AMR OPTICAL COVERAGE

G. W. Knight
F. B. Blanton

10.8 FLIGHT SAFETY REVIEWS

N. B. Vaughn

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11.0 MISSION CRITIQUE

11.1 Introduction.- The areas of major importance in the MA-6 mission are discussed briefly in this section. Problems and associated actions, recommendations, and conclusions are listed. Appropriate sections of the report are referenced for detailed discussion.

11.2 Problems and items of interest.-

11.2.1 Spacecraft.-

(a) RCS - The hydrogen peroxide distribution (dutch weave) screens downstream of the metering orifices on the 1-pound and 6-pounds thrusters were found to be deteriorated excessively after the flight. Fragments from these screens are suspected of having caused the 1-pound yaw thrusters to malfunction on this mission. Action: NASA and contractor teams are vigorously pursuing a program to provide a suitable replacement before the next mission. (Section 5.1)

(b) ASCS - Differences in spacecraft attitude as observed by astronaut and readout on instruments have all been investigated and found to have been caused by the normal action of the automatic gyro precession and/or gyro slaving while the capsule was maneuvered manually by the astronaut. Action: Studies are underway to provide astronaut control (on-off) of these automatic functions on subsequent spacecraft. (Section 5.1)

(c) ASCS - Differences between desired spacecraft attitudes and achieved attitudes after gyro caging and uncaging while on ASCS as reported by the astronaut have been investigated and found to have resulted from the spacecraft attitude that existed at the time of uncaging. Action: Astronaut training will be modified to include proper training sessions to avoid this trouble. (Section 5.1)

(d) Control System - During reentry the spacecraft experienced unsatisfactory oscillatory motions. Employment of the auxilliary damping mode apparently gave only temporary relief. However, analysis of the data indicates that manual control was not always applied to damp the motion. Also, the data show that the auxilliary damping mode was effective until the fuel was probably depleted. Action: Study the need for a change in flight plan and in the ground rules to insure that sufficient control fuel will be available during entry so that the auxilliary damping mode or RSCS mode can be used to control the oscillations. (Section 5.1)

(e) Instrumentation - The heat-shield-deployed signal during orbit apparently was caused by a defective switch. Action: The switches are to be inspected more closely, rigged farther from the deploy position, and wired in series with the T/M transducer and telelight on subsequent capsule. (Section 10.6)

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(f) ECS - An unexpected decay of the secondary oxygen supply pressure and an expected decrease in main oxygen supply use rate during orbital flight and a change in the "constant bleed" orifice capacity between pre-flight and post-flight checks are unexplained at this time. Action: Post-flight checks of the spacecraft ECS will continue. (Section 5.2)

(g) ECS - Post-flight tests disclosed that stainless steel check valves in the cold-plate water circuit and in the Freon suit-circuit were deficient. Action: Contractor told to remedy this recurring problem. (Section 5.2)

(h) Command system - The command signals were received onboard the spacecraft at about 6 db less than the signals recorded during the MA-4 and MA-5 missions. Action: An investigation is underway to determine the cause of the decrease in signal strength. (Section 8.3.4)

(i) Command system - The all-function-events-channel was triggered five times during the time the spacecraft was passing through the reentry blackout; however, no events were initiated onboard the spacecraft. Action: An investigation is underway to determine the cause and possible significance of these apparent spurious tones. (Section 8.3.4)

(j) Instrumentation - The instrument-panel camera failed before lift-off. Action: Contractor told to take corrective action. (Section 10.6)

(k) Instrumentation - Procedures are now to pressurize spacecraft oxygen bottles to approximately 8000 psig to insure full supply of oxygen for the mission. Presently used pressure transducers can measure only to 7500 psig. Action: Higher-range transducers have been requested for subsequent spacecraft. (Section 10.6)

(l) Structure - Close examination of the spacecraft heat shield and shingles has not disclosed any significant effects from reentering without jettisoning the retrorocket package. Action: None required

(m) Sequential system - The short but unexpected delay, at spacecraft-booster separation, of initiation of rate damping, periscope extension, and cap-sep telelight illumination resulted from proper operation of the sequence system. However, the change that was made to the system to accomplish this was incorporated in spacecraft 13 without full understanding of all parties concerned. Action: The sequence system will be changed to the earlier, satisfactory, configuration for subsequent capsules and

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the contractor will review changes incorporated in other spacecraft for similar undesirable side-effects. (Section 5.1)

(n) Sequential system - The drogue parachute was deployed at an altitude considerably in excess of the planned altitude, probably greater than 27,000 feet compared with a nominal 21,000 feet. Action: Continue post-flight tests on spacecraft electrical and pressure sensing systems. (Section 5.4)

11.2.1 Range - In spite of good radar data during reentry, most of the impact-point predictions missed the actual landing point by large margins. Action: The reason for failure to predict the landing point with accustomed accuracy is being investigated. (Section 8.3.1)

11.3 Conclusions.-

(a) All primary objectives of the MA-6 mission were accomplished.

(b) No deleterious effects of spaceflight on the astronaut's performance or physical condition were evident during or after the mission.

(c) Acceptable launch vehicle performance and spacecraft orbital insertion were achieved.

(d) The spacecraft and its systems are capable of accomplishing the Mercury mission although problem areas still exist.

(e) Astronaut training was generally satisfactory.

(f) Recovery procedures utilized for this mission were satisfactory.

(g) Network performance and support was excellent.

(h) Flight control operational procedures were satisfactory and the value of flight control simulations was demonstrated.

11.4 Recommendations.-

(a) Retrofire and reentry should be performed using the automatic system to conserve fuel.

(b) Air-to-ground communication procedures should be reviewed in an effort to provide better utilization of the astronaut's time in flight.

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(c) Provide the astronaut with a private onboard recording channel, that is not broadcast, to allow voice recording of unusual phenomena or other observations not suitable for unrestricted public dissemination.

(d) Initiate further development or replacement of the respiration sensor.

(e) Continue to monitor the astronaut's ECG, blood pressure, respiration rate, and body temperature in future missions.

(f) Provide for appropriate fluid intake by the astronaut during countdown and flight.

(g) Urge the astronaut to keep the bioplug connected until after landing and, if feasible, until instrumentation is cut off.

(h) Provide for additional training in the use of the pilot's personal equipment in the spacecraft.

(i) Provide reentry dynamic simulation on the Cape Procedures Trainer.

(j) Include automatic pitch-program precession on the Attitude Control System Demonstrator.

(k) Improve the simulation of external reference systems, particularly in yaw.

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