078-11

Post Launch
Mission Operation Report
No. M-932-68-08

MEMORANDUM

10 February 1969

To: A/Acting Administrator

From: MA/Apollo Program Director

Subject: *Apollo 8 Mission (AS-503) Post Launch Report #1

The Apollo 8 mission was successfully launched from the Kennedy Space Center on Saturday, 21 December 1968 and completed as planned with recovery of the spacecraft and crew in the Pacific recovery area on Friday, 27 December 1968. Initial evaluation of the flight based upon quick-look data and crew debriefing indicates that all mission objectives were attained. Further detailed analysis of all data is continuing and appropriate refined results of the mission will be reported in Manned Space Flight Center technical reports.

Based on mission performance as described in this report, I am recommending that the Apollo 8 mission be adjudged as having achieved agency preset primary objectives and considered a success.

Sam C. Phillips
Lt. General, USAF
Apollo Program Director

APPROVAL:

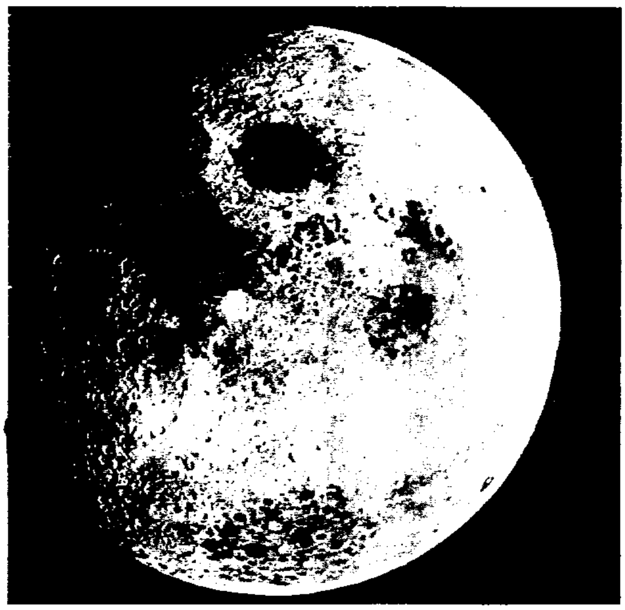
George E. Mueller
Associate Administrator for
Manned Space Flight

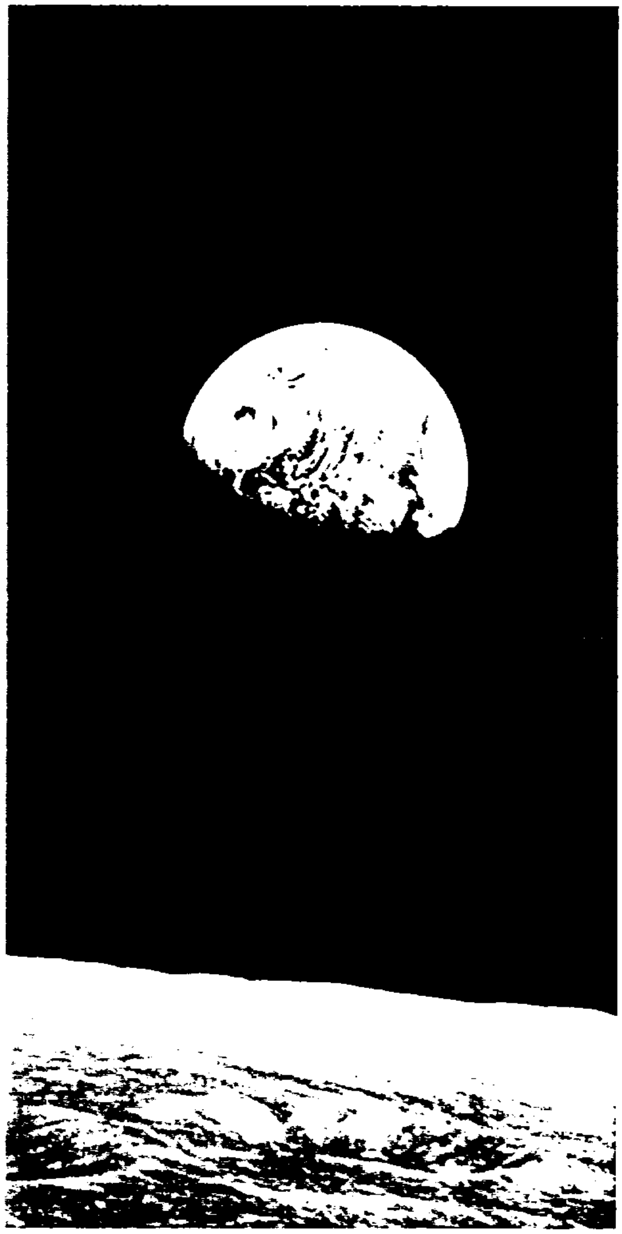
INDEXING DATA

DATE	OPR		T	PGM	SIGNATOR	LOC	
2-10-69	HQS.	M-932-68-08	R	APO	Phillips	078-11	*

Report No. M-932-68-08

POST LAUNCH
MISSION OPERATION REPORT





APOLLO 8 MISSION

OFFICE OF MANNED SPACE FLIGHT
Prepared by: Apollo Program Office-MAO

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NASA MISSION OBJECTIVES

FOR APOLLO 8

PRIMARY OBJECTIVES

- Demonstrate crew/space vehicle/mission support facilities performance during a manned Saturn V mission with CSM
- Demonstrate performance of nominal and selected backup Lunar Orbit Rendezvous (LOR) mission activities, including:
  - Translunar injection
  - CSM navigation, communications, and midcourse corrections
  - CSM consumables assessment and passive thermal control

Sam C. Phillips
Lt. General, USAF
Apollo Program Director

Date: 12 Dec 1968

George E. Mueller
Associate Administrator for
Manned Space Flight

Date: 13 Dec 1968

RESULTS OF APOLLO 8 MISSION

Based upon review of the assessed performance of Apollo 8, launched 21 December 1968 and completed 27 December 1968, this mission is adjudged a success in accordance with the pre-set objectives stated above.

Sam C. Phillips
Lt. General, USAF
Apollo Program Director

Date: 10 FEB 1969

George E. Mueller
Associate Administrator for
Manned Space Flight

Date: 10 Feb. 1969

GENERAL

The Apollo 8 (AS-503) mission was launched from the Kennedy Space Center on Saturday, 21 December 1968, at 7:51 a.m. EST. Initial data review indicates that all mission objectives were successfully accomplished, as well as four detailed test objectives that were not originally planned. Only minor anomalies and discrepancies occurred and these will be discussed in succeeding sections.

COUNTDOWN

The terminal countdown for Apollo 8 began at 21:51 EST on 20 December. Built-in holds of 6 hours at T-9 hours and 1 hour at T-3 hours 30 minutes were initiated as planned and no additional holds were required. Launch occurred on time at the opening of the launch window at 07:51 EST, 21 December.

MISSION SUMMARY

The Apollo 8 space vehicle was launched from Launch Complex 39, Pad A, at the Kennedy Space Center at 07:51 EST on 21 December 1968, after a satisfactory countdown. Following a nominal boost phase, the spacecraft and S-IVB combination was inserted into a parking orbit of 98.0 by 103.3 nautical miles (NM). After a post-insertion checkout of spacecraft systems, the Translunar Injection (TLI) maneuver was initiated at 02:50:37 Ground Elapsed Time (GET) by reigniting the S-IVB engine and burning for 5 minutes 9 seconds.

The spacecraft separated from the S-IVB at 03:20:59 GET, and performed separation maneuvers using the Service Module Reaction Control System (SM RCS). The first midcourse correction of 24.8 feet per second (fps) was conducted at 11:00:00 GET. The translunar coast phase was devoted to navigation sightings, two television transmissions, and various systems checks. A second midcourse correction of 1.4 fps was conducted at 60:59:56 GET.

The 246.9-second duration Service Propulsion System (SPS) lunar orbit insertion maneuver was performed at 69:08:20 GET, and the initial lunar orbit was 168.5 by 59.9 NM. An SPS maneuver to circularize the orbit was conducted at 73:35:07 GET and resulted in a lunar orbit of 59.7 by 60.7 NM. A total of 10 revolutions was completed during the 20 hours 11 minutes spent in lunar orbit.

The lunar orbit coast phase between maneuvers involved numerous landing-site/landmark sightings, lunar photography, two television transmissions, and preparation for Transearth Injection (TEI). The TEI maneuver, 203.7 seconds in duration, was conducted at 89:19:17 GET, using the SPS.

During both translunar and transearth coast phases, passive thermal control roll maneuvers of about one revolution per hour were effected, when possible, to maintain system temperatures within nominal limits. The transearth coast period involved a number of star/horizon navigation sightings, using both the earth and moon horizons, and two additional television transmissions. The only transearth midcourse correction was a 4.8 fps maneuver made at 103:59:54 GET.

Command Module/Service Module separation was at 146:28:48 GET, and the spacecraft reached the entry interface (400,000 feet) at 146:46:13 GET. Entry conditions were a velocity of 36,221 fps (36,219 fps planned) and a flight path angle of -6.5 degrees. Following normal deployment of all parachutes, the spacecraft landed in the Pacific Ocean at 08°07.5'N latitude and 165°01.2'W longitude, less than one nautical mile from the predicted splashdown point. The total flight duration was 147 hours 00 minutes 42 seconds, and the spacecraft and crew were recovered by the USS YORKTOWN after landing.

Almost without exception, spacecraft systems operated as intended. All temperatures varied within acceptable limits and essentially exhibited predicted behavior. Consumables usage was always maintained at a safe level. Communications quality was exceptionally good, and live television was transmitted on six occasions. The crew satisfactorily performed all flight plan functions and achieved all photographic objectives.

Summaries of mission events, orbits, and maneuvers are presented in Tables I, II, and III.

TABLE I

SUMMARY OF MISSION EVENTS

EVENT	TIME, HR:MIN:SEC GET PLANNED	TIME, HR:MIN:SEC GET ACTUAL
Launch Phase		
Range Zero (12:51:00 GMT)	00:00:00	00:00:00
Lift-off	00:00:01	00:00:01
Max Q (Maximum Dynamic Pressure)	00:01:16	00:01:19
S-IC center engine cutoff	00:02:06	00:02:06
S-IC outboard engine cutoff	00:02:31	00:02:34

S-IC/S-II separation	00:02:32	00:02:34
S-II engine ignition	00:02:33	00:02:35
Interstage jettison (2nd plane separation)	00:03:02	00:03:04
Launch escape tower jettison	00:03:08	00:03:09
S-II engine cutoff	00:08:41	00:08:44
S-II/S-IVB separation	00:08:42	00:08:45
S-IVB engine ignition	00:08:42	00:08:45
S-IVB engine cutoff	00:11:24	00:11:25
Insertion into earth parking orbit	00:11:34	00:11:35
<u>Orbital Phase</u>		
Translunar injection ignition	02:50:37	02:50:37
Translunar injection cutoff	02:55:53	02:55:56
S-IVB/Command Module separation	03:20:52	03:20:59
Separation maneuver 1	03:40:00	03:40:01
Separation maneuver 2	Not planned	04:45:01
Start S-IVB propellant dump	05:07:53	05:07:56
End S-IVB propellant dump	05:12:53	05:12:56
Midcourse correction 1 ignition	11:00:00	11:00:00
Midcourse correction 1 cutoff	11:00:02	11:00:02
Midcourse correction 2 ignition	61:08:51	60:59:56
Midcourse correction 2 cutoff	61:09:03	61:00:08
Lunar orbit insertion 1 ignition	69:08:51	69:08:20
Lunar orbit insertion 1 cutoff	69:11:36	69:12:27
Lunar orbit insertion 2 ignition	73:32:17	73:35:07
Lunar orbit insertion 2 cutoff	73:32:27	73:35:16

Transearth injection ignition	89:16:10	89:19:17
Transearth injection cutoff	89:19:28	89:22:40
Midcourse correction 3 ignition	104:16:10	103:59:54
Midcourse correction 3 cutoff	104:16:24	104:00:08
CM/SM separation	146:31:13	146:28:48
Entry interface (400,000 ft)	146:46:13	146:46:13
Begin blackout	146:46:38	146:46:37
End blackout	146:51:44	146:51:42
Drogue parachute deployment	146:54:26	146:54:48
Main parachute deployment	146:55:19	146:55:39
Landing	146:59:49	147:00:42

TABLE II

ORBIT SUMMARY

PARAMETER	EARTH ORBIT INSERTION		LUNAR ORBIT INSERTION 1		LUNAR ORBIT INSERTION 2	
	Planned	Actual	Planned	Actual	Planned	Actual
Apoapsis (NM)	103.3	103.3	170	168.5	60	60.7
Periapsis (NM)	99.4	98.0	60	59.9	60	59.7
Period (Min)	88.19	88.19	128.7	128.7	119.0	119.0
Inclination (Deg)	32.5	32.5	12.29	12.29	12.29	12.29

TABLE III

MANEUVER SUMMARY

MANEUVER	SYSTEM	TIME HR:MIN:SEC		DURATION SEC		VELOCITY CHANGE FPS	
		Planned[a]	Actual	Planned[a]	Actual	Planned[a]	Actual
Translunar Injection	S-IVB	02:50:37	02:50:37	316	318	35,548[b]	35,532[b]
Separation 1	RCS	03:40:00	03:40:01	(c)	(c)	1.5	1.1
Separation 2	RCS	Not Planned	04:45:01	(c)	(c)	9.0	7.7
Midcourse Correction 1	SPS/ RCS	11:00:00	11:00:00	2.4	2.4	24	24.8
Midcourse Correction 2	RCS	61:08:51	60:59:56	12.0	11.8	2.0	1.4
Lunar Orbit Insertion 1	SPS	69:08:51	69:08:20	240	246.9	2,992	2,997
Lunar Orbit Insertion 2	SPS	73:32:17	73:35:07	9.5	9.6	138.5	134.8
Transearth Injection	SPS	89:16:10	89:19:17	198	203.7	3,531	3,519
Midcourse Correction 3	RCS	104:16:10	103:59:54	14	13.7	5.0	4.8

Notes:

(a) Planned values are those planned pre-launch except for midcourse correction durations and velocity changes. These "planned" values represent real-time updates.
(b) These values are velocity at TLI cutoff.
(c) Burn times for the RCS maneuvers shown are not known at this time.

LAUNCH VEHICLE

Early engineering evaluation of the SA-503 Saturn V Launch Vehicle indicates that all test and mission objectives were satisfactorily met. All systems and subsystems appear to have performed near nominal. Further evaluation is being carried out to determine detail performance.

Performance of the S-IC POGO suppression system was nominal and indications are that no POGO existed.

The S-IC outboard engines were cut off 2.4 seconds later than predicted by a fuel level cutoff signal, apparently due to higher than predicted fuel density.

Overall propulsion system performance was near nominal, but near the end of S-II stage burn, oscillations of approximately 18 hertz became evident in engine number 5 parameters, beginning at approximately 451 seconds elapsed time. The oscillations became more pronounced at 480 seconds when a small drop in engine number 5 performance occurred, and they damped out shortly before engine cutoff. There also appears to have been some low amplitude, 18-hertz oscillations in the outboard engine pressures. Accelerometers showed 9- to 11-hertz structural oscillations of small amplitudes in both the longitudinal and lateral directions near the same time period.

Two S-II stage temperature bridge power supplies operated intermittently for about 30 seconds near "Max Q," and another similar S-II power supply operated intermittently from 443 to 470 seconds GET.

The modified augmented spark igniter (ASI) lines on both the S-II and S-IVB engines functioned properly and S-IVB restart was demonstrated satisfactorily. The O_2H_2 burner operated satisfactorily to repressurize the S-IVB fuel tank.

A free return translunar injection was obtained after S-IVB second burn cutoff. After spacecraft separation, the propellant vent, dump, and Auxiliary Propulsion System (APS) ullage burn successfully placed the S-IVB/IU/LTA-B in the slingshot trajectory to achieve solar orbit.

SPACECRAFT

STRUCTURAL AND MECHANICAL SYSTEMS

All structural and mechanical systems performed satisfactorily, with the exception of spacecraft window fogging. The hatch (center, or #3) window was completely fogged over by about 6 hours. The two side windows (1 and 5) were similarly affected, but to a lesser degree. The rendezvous windows (2 and 4) remained clear throughout the flight. This fogging was consistent with what was expected as a result of the Apollo 7 analysis of window fogging, which was caused by a deposit of silicon oil on the inner surface of the outer heat-shield pane. The fogging results from the outgassing of the RTV compound which seals insulation around the window area. A curing process has been used on the compound in windows 1, 3, and 5 of Apollo 9 and subsequent spacecraft.

THERMAL CONTROL

Temperature measurements indicate that both passive and active thermal control elements performed satisfactorily. Passive thermal control during the translunar and transearth coast periods stabilized spacecraft propellant temperatures within the expected nominal range. Tank temperatures were maintained within limits by varying spacecraft orientation. All temperatures were within predicted limits during lunar orbit operations.

FUEL CELLS AND BATTERIES

Fuel cell performance was excellent and no anomalies were observed throughout the mission. All parameters were in good agreement with pre-flight predictions.

The entry and post-landing batteries and pyrotechnic batteries performed all required functions satisfactorily throughout the mission. The entry batteries could be charged to full capacity as required.

CRYOGENICS

The cryogenic storage system performed satisfactorily throughout the mission, and usage was slightly less than predicted. All heaters were operated automatically and all fans were cycled manually to preclude the ac bus voltage problem caused by the arcing motor switch noted on Apollo 7. Quantity balancing between the respective cryogenic tanks was satisfactory.

COMMUNICATIONS

The overall performance of the spacecraft-to-network communication system was nominal. The received downlink carrier power, telemetry, and voice performance corresponded to pre-flight prediction.

Communications system management, including antenna switching, during the mission was very good. Communications during passive thermal control were maintained by sequentially switching between the four omni (omnidirectional) antennas, switching between diametrically-opposite omnis, or switching between the high-gain antenna and one or more omni antennas. All four omni antennas and the high-gain antenna were selected periodically, with performance equal to or greater than pre-flight predictions. The voice quality, both normal and backup, received throughout the mission was excellent. All modes of the high-gain antenna were used successfully.

The data quality of both high- and low-bit-rate telemetry was good. High-bit-rate telemetry was received through the 85-foot antennas at slant ranges of up to 160,000 nautical miles while the spacecraft was transmitting on omni antennas. The MSFN sites reported receipt of good-quality telemetry data during data storage equipment dumps.

Communications were satisfactory during entry until blackout. Air-to-ground voice contact was re-established at approximately 146:52 GET through the Apollo Range Instrumentation Aircraft. The USS YORKTOWN established voice contact during parachute descent. Although post-landing voice communications were momentarily interrupted when the spacecraft was in a stable II flotation attitude, the recovery operation was satisfactorily supported.

A total of six television transmissions were made during the flight. For the first telecast, the telephoto lens (100mm focal length) was used to view the earth. Because of camera motion and the higher than expected light intensity of the earth, the pictures were of poor quality. A procedure for use of the filters from the Hasselblad camera was developed and subsequent telecasts of the earth using the telephoto lens with a red filter were satisfactory. Excellent views of the lunar surface were taken in lunar orbit using the extra-wide-angle lens (9mm focal length) and suitable filters.

INSTRUMENTATION

The data storage equipment and instrumentation system performance was satisfactory throughout the mission, and only three measurements failed.

The fuel cell 2 radiator-outlet temperature indicated a temperature 6 to 12 degrees higher than expected. Proper system performance of the fuel cell and radiator was verified by other system measurements, thus indicating a failed sensor.

The radiator-outlet temperature measurement in the environmental control system failed at approximately 120 hours elapsed time and went to full-scale reading. Systems analysis verified proper radiator operation.

The measurement of potable water quantity in the ECS failed at approximately 144 hours elapsed time. Normal tank pressurization and water production data indicated the measurement to be questionable.

GUIDANCE AND CONTROL

Performance of the guidance and control system was excellent throughout the mission. All monitoring functions and navigation comparisons required during ascent, earth orbit, and translunar injection were normal. Platform alignments were performed during all coast phases with good results. Onboard midcourse navigation techniques were thoroughly exercised. Star-horizon measurements were made during translunar and transearth coast, and preliminary comparisons indicate close agreement with ground tracking. Onboard orbital navigation was performed in lunar orbit with nominal results.

Spacecraft attitude control was satisfactory using both the digital autopilot and the stabilization and control system. Service propulsion maneuvers were performed using the digital autopilot, with nominal results. Entry guidance and navigation was excellent.

Two guidance and control system problems occurred during the mission. The first involved abnormal shifts in the computer readout of the optics trunnion angle. Several times during periods of no optics activity, the read-out shifted from 0 to 45 degrees. In each case, the correct reading was restored with a normal optics zeroing procedure and no optics utilization capability was lost.

REACTION CONTROL SYSTEM

All command and service module reaction control system parameters were normal throughout the mission. The unplanned second CSM/S-IVB separation maneuver (see first item under FLIGHT CREW) resulted in lower than planned SM RCS propellant reserve, but still within acceptable limits. Due primarily to the need for only three of the seven scheduled midcourse corrections, the SM RCS propellant reserve converged on the planned curve for the remainder of the mission.

SERVICE PROPULSION SYSTEM

Four maneuvers were accomplished using the Service Propulsion System (SPS) and system operation was satisfactory in all cases. All maneuvers had "no-ullage" starts. The longest SPS burn was the 246.9-second lunar orbit insertion maneuver and the shortest was the 2.4-second first midcourse correction.

Early in the first SPS maneuver, a momentary drop in chamber pressure was experienced which was attributed to the presence of a small helium bubble in the oxidizer feed line. This bubble resulted from an inadequate bleed of the oxidizer system during pre-flight servicing. The chamber pressure was satisfactory throughout the remainder of the burn and for the three subsequent SPS maneuvers.

ENVIRONMENTAL CONTROL SYSTEM

Performance of the environmental control system was satisfactory. The radiators satisfactorily rejected the spacecraft heat loads during the translunar and transearth coasts, maintaining water/glycol temperatures below the evaporator turn-on level. The evaporators were therefore turned off during this time. The primary evaporator was used in the automatic mode during lunar orbit. Evaporator dryout occurred several times; however, the dryout did not impose any restraints on the mission. Evaporator dryout occurred on Apollo 7 at low loads and was expected to occur on Apollo 8 under similar load conditions. The evaporator was reserviced at the end of the first lunar orbit and operated satisfactorily until evaporator dryout recurred during the fourth lunar orbit. The evaporator was again reserviced and operated satisfactorily for the remainder of lunar orbital flight. Primary evaporator dryout occurred again during entry; however, the crew activated the secondary coolant loop, which operated properly throughout entry and maintained normal cabin temperatures near 61°F and the suit heat-exchanger outlet gas temperatures near 44°F.

The cabin fans, which were not needed during the mission, were noisy when activated at approximately 127 hours elapsed time to circulate the cabin atmosphere for a cabin temperature reading.

CREW PROVISIONS

All crew equipment operated satisfactorily during the mission. Excessive noise on the Lunar Module Pilot's electrocardiogram was corrected when he swapped the leads on his harness. The astronauts' boots were reported to be frayed but usable.

FLIGHT CREW

The Apollo 8 mission was accomplished essentially in accordance with the nominal flight plan, with the following minor exceptions.

The S-IVB separation rate from the spacecraft was judged to be less than predicted, and the crew spent a longer time in keeping the S-IVB in sight and eventually used an additional Reaction Control System maneuver to increase separation distance.

Because of the heavy workload in lunar orbit, the orbital activities after the eighth revolution were sharply reduced to allow additional crew rest. Normal activities were resumed in preparation for the transearth injection, after which the flight plan was again modified to allow for additional crew rest. At about 100 hours the mission returned to the nominal flight plan with only minor rescheduling of rest and meal periods.

Despite the long duty hours, crew performance was sharp throughout the mission, and many valuable observations of the lunar surface and its environment were made.

Entry and landing were performed in darkness with no apparent problems. Due to a small amount of water entering the command module at splashdown, the crew's attention was diverted temporarily. The resulting delay in releasing the main parachutes caused the command module to assume a stable II (apex down) flotation attitude for about 4.5 minutes before being uprighted by the crew. A decision had previously been made to delay the deployment of swimmers until daylight; therefore, crew transfer to the prime recovery ship by helicopter occurred about 80 minutes after landing.

MISSION SUPPORT PERFORMANCE

FLIGHT CONTROL

Flight control support was excellent during the Apollo 8 mission.

NETWORK

Network performance was excellent for this mission. All communications, tracking, command, telemetry, and the real-time computation functions supported the mission satisfactorily with no significant loss of data at any time.

RECOVERY

Recovery of the Apollo 8 spacecraft and crew was successfully completed in the Pacific Ocean by the prime recovery ship, the USS YORKTOWN. The major recovery events on 27 December 1968 are listed in the following table:

EST, HR:MIN: (27 December)	EVENT
10:41	First visual sighting of spacecraft by Rescue 1
10:43	Radar contact by USS YORKTOWN
10:49	First sighting of CM flashing light by YORKTOWN
10:52	Landing
11:48	Flotation collar installed and inflated
12:20	Astronauts onboard recovery ship
13:18	CM onboard recovery ship

Both S-band and VHF contacts were established with the recovery forces. Visual contact with the flashing light and voice contact with the flight crew ceased at landing, indicating that the Command Module went into a stable II position before uprighting. The uprighting bags were inflated, with one bag reported to be only partially inflated. Although a recovery helicopter was directly over the spacecraft as early as 11:08 EST, it was decided to wait until daylight before deploying swimmers, as previously planned.

The pertinent location data for the recovery operation are listed below:

Predicted target coordinates	08°08'N, 165°02'W
Ship position at landing*	08°09.3'N, 165°02.1'N
Estimated range to spacecraft at landing	5200 yards
Splashdown coordinates	08°07.5'N, 165°01.2'W

* As determined aboard the recovery ship

LAUNCH COMPLEX

Quick-look assessment indicates that the launch complex and supporting GSE performed satisfactorily with only minor anomalies occurring.

Damage to GSE and pad facilities was minimal and considered less than for previous launches. Refurbishment will not be extensive and Pad A will be ready to support the Apollo 9 mission.

GPO 873 285