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# APOLLO SOYUZ MISSION

# 5-DAY REPORT



*National Aeronautics and Space Administration*
***LYNDON B. JOHNSON SPACE CENTER***
***Houston, Texas***
August 1975

# PREFACE

This report is based on an evaluation of preliminary data, and the stated values are subject to change in the final mission evaluation report. Elapsed times are referenced to the time of Soyuz lift-off, 12:20:00 G.m.t., July 15, 1975. References to mission days are based upon each day ending at 24:00 G.m.t.

## SUMMARY

The Apollo Soyuz mission was the first manned space flight to be conducted jointly by two nations - the United States and the Union of Soviet Socialist Republics. The primary purpose of the mission was to test systems for rendezvous and docking of manned spacecraft that would be suitable for use as a standard international system, and to demonstrate crew transfer between spacecraft. The secondary purpose was to conduct a program of scientific and applications experimentation. With minor modifications, the Apollo and Soyuz spacecraft were like those flown on previous missions. However, a new module was built specifically for this mission - the docking module. It served as an airlock for crew transfer and as a structural base for the docking mechanism that interfaced with a similar mechanism on the Soyuz orbital module.

The Soyuz spacecraft, manned by Alexei A. Leonov, Commander, and Valeri N. Kubasov, Flight Engineer, was launched atop a Soyuz Rocket Booster from the Baikonur Cosmodrome in Kazakhstan on July 15, 1975, at 12:20:00 G.m.t. and the spacecraft was inserted into an orbit of 222 by 186 kilometers. Two maneuvers were performed to circularize the orbit, the first near the end of the fourth orbit with a resulting altitude of 226 by 192 kilometers, and the second during the 17th orbit. The second maneuver placed the Soyuz spacecraft in a near-circular orbit of about 223 kilometers in preparation for docking with the Apollo spacecraft.

The Apollo spacecraft, manned by Thomas P. Stafford, Commander, Vance D. Brand, Command Module Pilot, and Donald K. Slayton, Docking Module Pilot, was launched by a Saturn IB launch vehicle from Pad B of Complex 39 at the Kennedy Space Center 7 1/2 hours after the Soyuz launch. The time of launch was 19:50:01 G.m.t. and approximately 9 minutes and 56 seconds later, the spacecraft and S-IVB stage were inserted into a 168 by 150 kilometer orbit. All launch vehicle systems performed normally.

The Apollo spacecraft was separated from the S-IVB stage approximately 1 hour and 14 minutes after lift-off. The spacecraft was then docked with the docking module which was attached to the S-IVB, and the docking module was extracted. These operations were normal; however, the removal of the docking probe was hindered by a misrouted pyrotechnic connector cable. The corrective procedure given to the crew was used successfully to remove the probe.

The Apollo circularization, phasing, and rendezvous maneuvers were performed as planned and the first docking was performed on July 17, 1975, at 16:09:09 G.m.t. (51:49:09 g.e.t.). Upon opening hatch 1, the Apollo crew smelled an odor like "burnt glue" or "acetate" which, upon investigation, proved to be of no consequence. The first transfer between the

American and Russian spacecraft was made by the Apollo Commander and the Docking Module Pilot. All planned activities were conducted including connection and checkout of communications cables, and experiment operations. Messages of congratulations were received by all crewmen from the heads of state of both nations. Second and third transfers were made so that each crewman could visit the other spacecraft. Activities during these periods included: television tours of the two spacecraft and of parts of the United States and the Soviet Union during overflight; a press conference in which all crewmen participated; experiment activities; eating; exercising; and exchanges of symbolic items to commemorate the successful docking and transfer. The fourth transfer returned all crewmen to their own spacecraft.

The first undocking was performed normally, with the Apollo docking system active, after the two spacecraft had been docked for almost 44 hours. A joint artificial solar eclipse experiment (MA-148) was performed following undocking and the spacecraft were docked a second time to test the docking mechanisms with the Soyuz docking system active. The docking was performed at 96:14 g.e.t. Final undocking was at 99:06 g.e.t. after which the ultraviolet absorption experiment (MA-059) was conducted. Upon completion of the joint activities, unilateral experiments were performed.

The Soyuz deorbit maneuver was performed at 141:51 g.e.t. and the Soyuz reentry vehicle was brought to a safe landing at approximately 50 degrees 18 minutes north, 67 degrees 36 minutes east in Kazakhstan on July 21, 1975, at 10:50:54 G.m.t. after a flight of 142 hours 30 minutes and 54 seconds. The Apollo spacecraft continued in orbit for four additional days. Experiments accomplished during this time were conducted essentially according to plan. One finding of special significance was the first known detection of a cosmic source of extreme ultraviolet radiation. The source was found with the extreme ultraviolet telescope (MA-083). Some experiment hardware problems were experienced but, in general, the hardware performed very well and excellent scientific data were obtained.

The docking module was jettisoned at 199:27 g.e.t. in preparation for the doppler tracking experiment (MA-089) which required a 300 kilometer separation of the command and service module from the docking module. The maneuvers to accomplish the separation and to maintain a constant range were performed as planned and good data were received from the doppler measurements. All experiment operations were concluded during Apollo revolution 136 and preparations were begun for deorbit and landing.

The deorbit maneuver was performed at 224:18 g.e.t. and the command module landed about 1.3 kilometers from the target point on July 24, 1975, at 21:18:24 G.m.t. after a flight of 217 hours 28 minutes and 23 seconds.

The coordinates of the landing point are 22 degrees 0 minutes 36 seconds north and 163 degrees 0 minutes 54 seconds west. The command module went to the stable II attitude for about 4 1/2 minutes after landing. The crew remained in the spacecraft during recovery and were aboard the U.S.S. New Orleans about 41 minutes after landing.

During shipboard ceremonies, the crew appeared to be in good physical condition but it was later learned that the crew had been exposed to oxidizer vapors in the cabin for several minutes. The situation arose from missing an arming function and a manual backup function.

## TRAJECTORY

Soyuz lift-off occurred on time at 12:20:00 G.m.t. on July 15, 1975. The Soyuz ascent resulted in an insertion orbit of 221.5 by 186.3 kilometers. The inclination of the orbital plane was a near nominal 51.75°. Soyuz performed a 3.1 m/sec maneuver on the fourth revolution at 5:31:40 g.e.t. to correct the phasing and altitude for the 17th revolution circularization maneuver. The circularization maneuver was performed at 24:23:35 g.e.t. and the 11.6 m/sec velocity change placed the Soyuz in an assembly orbit of 223.0 by 222.2 kilometers.

The Apollo lifted off at 19:50:00.6 G.m.t. (7:30:00.6 g.e.t.) on July 15. The ascent resulted in an insertion orbit of 168.2 by 150.8 kilometers. After the docking module was extracted on the second revolution, the Apollo orbit was circularized at 167.4 by 167.2 kilometers. From this orbit, the first Apollo phasing maneuver was executed to provide the proper catch-up rate so that docking with the Soyuz spacecraft could occur on the 36th Soyuz revolution. The 20.5 m/sec phasing maneuver at 13:08:30 g.e.t. placed the Apollo spacecraft in a 232.8 by 168.7 kilometer orbit. A small phase and plane correction maneuver of 2.7 m/sec was executed on the 16th revolution.

The final rendezvous sequence began at 48:31:00 g.e.t. with the Apollo spacecraft performing a series of maneuvers which placed it in a 224.8 by 205.2 kilometer intercept orbit with Soyuz. After braking and stationkeeping, the docking was initiated at 51:49:09 g.e.t., about 6 minutes earlier than the nominal time. The duration of the first docked phase was 43 hours 54 minutes. The orbit was 223.5 by 222.8 kilometers after first docking and 220.9 by 219.1 at first undocking.

First undocking occurred at 95:43:20 g.e t., about 1 1/4 minutes after sunrise. Fifteen seconds later, Apollo began the first of two reaction control system maneuvers to back away from the Soyuz spacecraft to provide an artificial eclipse of the sun. These maneuvers were executed as planned and the solar eclipse experiment ended at approximately 95:48 g.e.t. The Apollo spacecraft then reapproached the Soyuz spacecraft and the second docking occurred at 96:13:39 g.e.t. Final undocking occurred about 3 hours later, at 99:06:12 g.e.t. The Apollo maintained a distance from the Soyuz of about 25 meters until the first ultraviolet absorption experiment maneuver occurred at approximately 99:22 g.e.t. This began a series of Apollo out-of-plane maneuvers to accomplish 150-meter and 500-meter data-takes during the next 3 hours. At 102:14:27 g.e.t., the Apollo spacecraft performed a small in-plane maneuver to set up the geometry for Soyuz photography of Apollo. Eight minutes later, the Apollo executed the final separation maneuver of 0.6 m/sec in-plane.

This caused the Apollo spacecraft to pass directly above the Soyuz at 102:49 g.e.t. for the 1000-meter data-take which terminated the joint phase of the mission. The Apollo orbit at this time was 222.1 by 220.9 kilometers with the Apollo trailing the Soyuz at an increasing range rate of approximately 9.3 kilometers per orbit.

At 118:21 g.e.t., the Soyuz spacecraft performed a 1.5 m/sec retrograde engine test firing which lowered the orbit to 215.8 by 213.5 kilometers and caused the Soyuz to move away from the Apollo, which was trailing by 209 kilometers, at a rate of approximately 50 kilometers per orbit. At the time of Soyuz deorbit, 141:50:30 g.e.t., the Apollo trailed the Soyuz by about 833 kilometers. After the Soyuz deorbit maneuver, the Soyuz landed at 142:30:54 g.e.t. in Kazakhstan. The approximate landing location was latitude 50 degrees 18 minutes north and longitude 67 degrees 36 minutes east.

An Apollo trim maneuver was executed at 146:38 g.e.t. to shift the end-of-mission ascending node 1.1° to the east to assure that the entry ground track would be near the nominal recovery area. The ground track had shifted to the west during the mission because of the initial Soyuz plane position and slightly higher than nominal orbits. The retrograde trim maneuver was 2.2 m/sec and placed the Apollo in a 219.1 by 211.3 kilometer orbit.

The docking module was jettisoned at 199:27 g.e.t. with an estimated orbital lifetime of 18 days. Thirty-five minutes later, the command and service module performed a 9.5 m/sec service propulsion system maneuver, placing it in a 227.2 by 218.2 kilometer orbit. This was the first of two service propulsion system maneuvers to set up a 300 kilometer range between the docking module and the command and service module for the doppler tracking experiment. The second service propulsion system maneuver occurred at 204:14 g.e.t. and this retrograde maneuver of 8.1 m/sec placed the command and service module in a 219.6 by 206.5 kilometer orbit.

The Apollo deorbit maneuver of 57.9 m/sec occurred on revolution 138 at 224:17:47 g.e.t. and entry interface (122 000 m) was 21 minutes 13 seconds later. The command module landed at 21:18:24 G.m.t. on July 24 in the Pacific Ocean at 22 degrees 0 minutes 36 seconds north and 163 degrees 0 minutes 54 seconds west, which was only 1.3 kilometers from the target point.

The times of the major events are given in table I and the major maneuver parameters are given in table II.

TABLE I.- SEQUENCE OF EVENTS

| Event | Time, g.e.t. Hr:min:sec | Time, G.m.t. Day:hr:min:sec |
|---|---|---|
| Soyuz lift-off | | 196:12:20:00 |
| Apollo lift-off | 7:30:01 | 196:19:50:01 |
| Earth orbit insertion | 7:39:56 | 196:19:59:56 |
| CSM/S-IVB separation | 8:44:01 | 196:21:04:01 |
| CSM/DM docking | 9:08:00 | 196:21:28:00 |
| Docking module extraction | 10:04:00 | 196:22:24:00 |
| Apollo evasive maneuver | 10:04:01 | 196:22:24:01 |
| Apollo circularization maneuver | 11:11:02 | 196:23:31:02 |
| First phasing maneuver | 13:08:30 | 197:01:28:30 |
| Soyuz circulatization | 24:23:35 | 197:12:43:35 |
| Phasing correction maneuver | 31:58:00 | 197:20:18:00 |
| Second phasing maneuver | 48:31:00 | 198:12:51:00 |
| Corrective combination | 49:15:05 | 198:13:35:05 |
| Coelliptic maneuver | 49:52:05 | 198:14:12:05 |
| Terminal phase initiation | 50:56:42 | 198:15:16:42 |
| Braking | 51:26:00 | 198:15:46:00 |
| Apollo/Soyuz docking no. 1 | 51:49:09 | 198:16:09:09 |
| Apollo/Soyuz undocking no. 1 | 95:43:20 | 200:12:03:20 |
| Apollo/Soyuz docking no. 2 | 96:13:39 | 200:12:33:39 |
| Apollo/Soyuz final undocking | 99:06:12 | 200:15:26:12 |
| Separation from Soyuz maneuver | 102:22:27 | 200:18:42:27 |
| Soyuz deorbit maneuver | 141:50:30 | 202:10:10:30 |
| Soyuz landing | 142:30:54 | 202:10:50:54 |
| Apollo trim maneuver | 146:38:00 | 202:14:58:00 |
| Docking module jettison | 199:27:00 | 204:19:47:00 |
| Apollo/docking module separation maneuver | 200:02:00 | 204:20:22:00 |
| Apollo stable orbit maneuver | 204:13:42 | 205:00:33:42 |
| Apollo deorbit maneuver | 224:17:47 | 205:20:37:47 |
| Command/service module separation | 224:24:09 | 205:20:44:09 |
| Entry interface | 224:39:00 | 205:20:59:00 |
| Begin blackout | 224:45:16 | 205:21:05:16 |
| End blackout | 224:50:21 | 205:21:10:21 |
| Drogue parachute deployment | 224:54:37 | 205:21:14:37 |
| Main parachute deployment | 224:55:17 | 205:21:15:17 |
| Landing | 224:58:24 | 205:21:18:24 |
| Command module on ship | 225:38:44 | 205:21:58:44 |
| Crew on deck | 225:45:40 | 205:22:05:40 |

TABLE II.- MANEUVER SUMMARY

| Maneuver | Time, g.e.t., hr:min:sec | System | Firing time, sec | Velocity change, m/sec | [a]Resultant orbit, km | |
|---|---|---|---|---|---|---|
| | | | | | Apogee | Perigee |
| Soyuz maneuver 1 | 5:31:40 | -- | [b]05.7 | [b]3.1 | [b]226.3 | [b]192.1 |
| Apollo evasive maneuver | 10:04:01 | RCS | 08.7 | 0.9 | 167.6 | 150.0 |
| Apollo circularization | 11:11:02 | SPS | 00.8 | 5.5 | 167.4 | 167.2 |
| First phasing maneuver | 13:08:30 | SPS | 03.2 | 20.5 | 232.8 | 168.7 |
| Soyuz circularization | 24:23:35 | -- | [b]21.0 | [b]11.6 | [b]223.0 | [b]222.2 |
| Apollo phase correction maneuver | 31:58:00 | RCS | 23.7 | 2.7 | 226.1 | 168.2 |
| Second phasing maneuver | 48:31:00 | SPS | 01.1 | 7.7 | 196.7 | 165.6 |
| Corrective combination maneuver | 49:15:05 | SPS | 01.5 | 10.6 | 203.3 | 189.8 |
| Coelliptic maneuver | 49:52:05 | SPS | 00.9 | 5.8 | 205.4 | 205.0 |
| Terminal phase initiation | 50:56:42 | SPS | 00.9 | 6.6 | 224.8 | 205.2 |
| Midcourse maneuver 1 | 51:08:42 | RCS | 01.6 | 0.2 | 225.2 | 205.0 |
| Midcourse maneuver 2 | 51:20:42 | RCS | 03.7 | 0.4 | 225.6 | 205.0 |
| Braking | 51:26:00 | RCS | 176.2 | 20.1 | 222.8 | 222.8 |
| Apollo/Soyuz first docking | 51:49:09 | RCS | 10.0 | 0.9 | 223.5 | 222.8 |
| Apollo/Soyuz first undocking | 95:43:20 | (c) | (c) | [b]0.1 | [b]220.9 | [b]219.1 |
| Apollo/Soyuz second docking | 96:13:39 | RCS | 5.0 | 0.5 | 219.8 | 219.1 |
| Apollo/Soyuz final undocking | 99:06:12 | (c) | (c) | [b]0.4 | [b]219.8 | [b]217.2 |
| Separation from Soyuz | 102:22:27 | RCS | 09.5 | 0.6 | 222.1 | 220.9 |
| Soyuz test maneuver | 118:21:00 | -- | [b]02.7 | [b]1.5 | [b]215.8 | [b]213.5 |
| Soyuz deorbit maneuver | 141:50:30 | -- | [b]194.9 | [b]120.0 | [b]214.1 | -- |
| Apollo trim maneuver | 146:38:00 | RCS | 36.1 | 2.2 | 219.1 | 211.3 |
| Docking module jettison | 199:27:00 | -- | 00.0 | 0.1 | 219.6 | 206.3 |
| Apollo/docking module separation | 200:02:00 | SPS | 01.0 | 9.5 | 227.2 | 218.2 |
| Apollo stable orbit maneuver | 204:13:42 | SPS | 00.9 | 8.1 | 219.6 | 206.5 |
| Apollo deorbit maneuver | 224:17:47 | SPS | 06.6 | 57.9 | 205.2 | -- |

[a]Above mean equitorial radius.

[b]Soyuz parameters.

[c]Data not available - small Soyuz thrusters.

## SPACECRAFT AND CREW SYSTEMS PERFORMANCE

### ASTP DOCKING SYSTEM

The docking systems used on the docking module and the Soyuz spacecraft performed properly. The Apollo spacecraft was the maneuvering vehicle for the two dockings. The time of capture for the first docking was 51:49 g.e.t. and the spacecraft remained docked for 43 hours and 54 minutes. The last docking, with the Soyuz docking system active, was at 96:14 g.e.t., and undocking was at 99:06 g.e.t.

### DOCKING MODULE SYSTEMS

#### Structures

From visual observation and crew comments, the docking module structural system performed satisfactorily. At 52:11 g.e.t., the crew reported a strong odor of "burnt glue" or "acetate" after opening the command module hatch 1 after docking. The crew performed normal procedures to verify the acceptability of the docking module atmosphere. Five minutes after the first report, the crew reported that the smell had "dissipated quite a bit." The crew could not find the source of the odor. The crew was advised that at least one crewmember should don his mask until the problem was better understood. Subsequently, mixing of the docking module and command module atmospheres was initiated and the odor dissipated following atmosphere mixing. The Command Module Pilot continued to use his mask until approximately 52:35 g.e.t. at which time the odor had dissipated. Postflight analysis of charcoal from the lithium hydroxide elements which were in use at the time and discussions with the crew will be conducted to attempt to identify the contaminants.

#### Thermal Control

Docking module temperature was monitored by two temperature sensors - one attached to the bulkhead at the Soyuz docking end and the other attached to the cylindrical wall. The docking module average internal wall temperature was maintained within allowable limits of 286° to 300° K throughout the mission.

## Communications

The docking module portion of the communications systems is discussed in conjunction with the command and service module communications system.

## Instrumentation

The oxygen partial pressure sensors appeared to operate 5 to 10 mm Hg low following the last crew transfer. This effect was probably caused by condensation on the teflon membrane resulting from high humidity associated with deactivation of the command module environmental control system evaporator. Otherwise, the 25 measurements in the docking module operated normally.

## Displays and Controls

The docking module displays and controls performed normally during the mission.

## Electrical Power Distribution

The docking module electrical power distribution system performed normally.

## Environmental Control System

The docking module environmental control system performance was normal and operations were such that the total and partial pressures were as predicted. No hardware problems were experienced.

Typically, during transfers, the docking module pressure was raised with nitrogen to 492 mm Hg. Per Soyuz crewman request, the partial pressure of nitrogen was increased by 20, 30 and 10 mm Hg during transfers 1, 2, and 4. The oxygen purge before depressurization was within 1 mm Hg of the desired 320 mm Hg oxygen partial pressure for the two transfers for which data were available. All transfer operations, both manual and automatic, were normal.

# COMMAND AND SERVICE MODULE SYSTEMS

## Structures

The command and service module structural system performed satisfactorily throughout the mission.

## Mechanisms

All command and service module mechanisms functioned properly except for one problem with the docking probe. The final step of probe removal required installation of the capture latch release tool in the aft end of the docking probe to release the probe capture latches from the drogue, thereby allowing removal of the probe from the tunnel. This could not be accomplished. The crewman then observed that one of the pyrotechnic electrical connectors was blocking the tool entrance hole. Workaround procedures were sent to the crew for the removal of the cover which was over the pyrotechnic connectors and removal of the interfering connector. (The connector was for the expended pyrotechnic initiator that was used for the probe retraction.) The connector was successfully disengaged and the pyrotechnic cover was reinstalled. The loose connector was then taped to the pyrotechnic cover and the probe was successfully removed in accordance with the checklist.

## Thermal Control

The thermal performance of the command and service modules was monitored by temperature sensors located on propellant tanks and lines, communications equipment, and experiments. All command and service module temperatures were maintained within allowable limits throughout the flight.

## Sequencing and Electrical Power Distribution

An abnormal sequence of events involving manual and automatic control of the earth landing system caused nitrogen tetroxide vapors to be drawn into the cabin. The following occurred: First, the proper arming time of the two earth landing system switches which arm the automatic landing sequence was missed. Second, the reaction control system command inhibit manual function was also missed. This set the stage. As a result, the reaction control system command inhibit function (effected through arming the two switches or through the manual backup) did not occur and allowed the reaction control system thrusters to respond vigorously the instant spacecraft motion was induced by the deployment of the drogue parachutes, which was done manually.

The two earth landing system switches were finally armed 30 seconds later and immediately stopped the reaction control system thruster commands. During this 30 second interval, all thrusters were very active and, for the first 6 seconds, expelled combustion products of monomethyl hydrazine with nitrogen tetroxide. The next instant, the reaction control isolation valves were manually closed. Consequently, instead of products of combustion, 3.4 kilograms of nitrogen tetroxide of the 4.1 kilograms trapped between the isolation valves and the thrusters boiled off and was expelled from the thrusters during the remaining 24 seconds before the reaction control system was inhibited.

The cabin pressure relief valve opens automatically prior to the deployment sequence to increase the cabin pressure to ambient conditions. Therefore, during the 30-second period of thruster activity, a mixture of air and combustion products, but primarily, a mixture of air and nitrogen tetroxide vapors were sucked into the cabin.

Functioning of the automatic and manual landing systems and associated hardware was all normal.

The electrical power distribution system performed normally. Power switching and sequential functions were also normal.

## Communications and Ranging

The performance of the communications and ranging system for all phases of the mission was very good.

One of the most significant accomplishments of the mission was the first use of a communications satellite to relay manned spacecraft signals to the ground. The satellite used was Applications Technology Satellite 6 (ATS-6). The ATS-6 system, including the power amplifier and high gain antenna in the service module, performed very well. Continuous coverage for approximately 50 minutes during each revolution was provided except for an occasional loss of signal because of spacecraft maneuvering past the antenna directional limits.

During the joint activities, two sources of external interference were encountered. The VHF/FM receiver frequency of 121.75 MHz is in the aircraft frequency band and received intermittent transmissions from the ground. The spacecraft was configured to relay the FM signals onto the S-band; therefore, these were heard on the downlink. During each pass over the U.S.S.R., periodic clicks occurred in both the voice and video signals. The most probable cause was interference from a ground radar.

Except for two apparent television camera failures, both real-time and played back television performed very well. During the joint activities, there was a periodic loss of color synchronization from one television camera. Color was lost from another camera about 28 hours after the joint activities were concluded.

## Instrumentation

The command and service module instrumentation system operated normally with the exception of two temperature measurements and an oxygen quantity measurement. The service module reaction control system quad A helium tank temperature measurement failed at 8:44 g.e.t. The command module primary coolant loop evaporator inlet temperature became erratic and failed at about 108 hours g.e.t. The quantity measurement for service module oxygen tank 1 failed at about 8:40 g.e.t.

## Displays and Controls

The displays and controls system performed normally during the mission except for one minor problem. At approximately 154 hours g.e.t., the crew reported a degradation in the caution and warning tone volume as heard in the headsets but there was no apparent degradation in the speaker box tone level.

## Guidance and Control Systems

The guidance and navigation, entry monitor, and stabilization and control systems performed well throughout the mission. One minor problem, however, was an intermittent failure in the guidance and navigation alarm sensing circuitry which occurred at approximately 43:30 g.e.t. and recurred numerous times thereafter at irregular intervals. This failure manifested itself as an inertial coupling data unit (ICDU) fail indication which results in an inertial subsystem (ISS) warning and activates the MASTER ALARM. The analysis of all system data revealed that these ICDU FAIL alarms were false and the system performance was normal.

To eliminate the nuisance which was created each time the alarm circuitry falsely triggered the MASTER ALARM and disturbed the crew, a bit was set in the system computer which prevented triggering for an ICDU FAIL indication.

Shortly before jettisoning of the docking module, when the crew was using the orbit rate display, they reported an intermittent difficulty when attempting to use the display with flight director attitude indicator 1. The crew was advised not to take the time to determine the source of the problem and to ignore the display for the remainder of the mission.

## Service Propulsion System

The service propulsion system was used nine times for a total duration of 17 seconds. The first firing was for the Apollo circularization maneuver; the next five uses of the system were maneuvers for the Apollo Soyuz rendezvous. After separation from Soyuz, two maneuvers were performed to position the command and service module behind the docking module for the doppler tracking experiment (MA-089). The final use of the system was for deorbit of the command and service module. Approximately 500 kilograms of propellant were used by the service propulsion system during the mission. System performance was normal.

## Service Module Reaction Control System

The performance of the service module reaction control system was normal throughout all phases of the mission. The total propellant consumed was 914 kilograms versus a predicted quantity of 738 kilograms. The propellant usage was greater than planned for three reasons: firing of the roll engines to purge a bubble introduced in the propellant storage module manifold during an off-nominal activation prior to launch, higher than expected usage associated with the second docking, and the performance of maneuvers required for the ultraviolet absorption experiment (MA-059). Pressurization and propellant feed systems operated properly and system temperatures were maintained within expected operating ranges throughout the mission. As discussed under Instrumentation, the quad A helium tank temperature was lost.

## Command Module Reaction Control System

The performance of the command module reaction control system was normal throughout system activation and entry. Total propellant consumption was 27 kilograms.

## Fuel Cells and Cryogenic Storage

The three Apollo fuel cells performed normally throughout the mission. Prior to lift-off, the fuel cells were configured with fuel cells 1 and 2 powering bus A and fuel cell 3 powering bus B. This configuration was maintained throughout the mission. From lift-off to command module/service module separation, the fuel cells provided 18 907 ampere-hours of energy at an average bus voltage of 28.5 volts.

The fuel cells consumed 22.1 kilograms of hydrogen during the mission, and 0.84 kilogram remained in each of the two tanks at command module/service module separation. The hydrogen storage system performance was normal throughout the mission.

Quantity remaining in oxygen tank 1 was determined after the failure of the tank quantity measurement by calculations based on pressure and temperature data. The fuel cells consumed 176.8 kilograms of oxygen during the mission, while 37.4 kilograms of oxygen were provided to the environmental control system leaving 36.3 kilograms in each tank at command module/service module separation. The oxygen storage system performance was as predicted throughout the mission.

## Batteries

The performance of the entry and postlanding batteries and the pyrotechnic batteries was normal.

## Environmental Control System

The environmental control system performed satisfactorily throughout the mission, providing an acceptable environment for the crew and adequate thermal control of the spacecraft equipment. System performance during the joint operations was normal.

Suit Circuit.- During the prelaunch countdown, the suit-to-cabin differential pressure fluctuated such that, in part of the suit loop, the pressure was negative with respect to the cabin. This negative pressure differential caused the suit demand regulator to flow oxygen into the suit circuit on several occasions. This condition was experienced during the countdown demonstration test and, as a result, a test was performed which indicated that the amount of nitrogen that would leak into the suit circuit from the cabin atmosphere would not violate the 95-percent oxygen requirement.

Thermal Control.- The primary evaporator was deactivated at 119:45 g.e.t. during the operation of an experiment as required by the flight plan. Data indicates that the evaporator filled with water because the water switch was placed into the "on" rather than the "off" position during deactivation. As a result, when the evaporator was turned on again, the excess water flowed into the steam duct and froze. The evaporator was deactivated and the ice allowed to sublimate until 149:31 g.e.t., when the evaporator was activated. Upon activation, there were still indications of steam duct ice and excess water in the evaporator. Therefore, the evaporator was deactivated after 24 minutes of operation. The secondary coolant loop and evaporator were activated at 168:36 g.e.t. and no symptoms of steam duct ice were observed. The secondary loop was operated for the remainder of the mission except during experiment periods to prevent contamination, and during cooler cabin periods to conserve water.

System operation during entry was normal except that the primary evaporator was not activated.

Atmospheric Pressure and Composition Control.- At docking module depressurization, the command module pressure began to decrease as the docking module pressure reached the command module pressure. Both pressures decayed to 223 mm Hg where the command module emergency regulator maintained the pressure. Apparently, the hatch 2 equalization valve was opened before the docking module vent valves were closed.

In order to insure that the cabin oxygen partial pressure would be above 147 mm Hg during the sleep period (to preclude the oxygen partial pressure caution and warning alarm from activating), the crew followed a procedure at 84:20 g.e.t. to raise the cabin oxygen partial pressure above 165 mm Hg by opening the docking module low pressure relief valve to purge the cabin of nitrogen by adding oxygen through the docking module oxygen purge valve. About 44 minutes after the procedure was completed, the crew elected to reinitiate the procedure for some reason, and the docking module low pressure relief valve was opened for 3 minutes causing cabin pressure to decrease from 278 to 243 mm Hg before the oxygen purge valve was opened. These purge procedures resulted in an oxygen use of 9.3 kilograms.

Prior to docking module jettison, the crew used the remaining docking module oxygen to raise the cabin oxygen partial pressure so that nitrogen boiloff from the electrophoresis experiment would not reduce the oxygen partial pressure to an unacceptable level. At the completion of the procedure, the oxygen partial pressure was 230 mm Hg and the total pressure was 282 mm Hg.

## CREW EQUIPMENT

### Suits

The suits for this mission were similar in configuration to the Command Module Pilots' suits used in the Apollo 15 through 17 missions with the exception of extravehicular activity provisions. In addition, a Tygon tube insert was incorporated in the crotch area between the pressure sealing and restraint entry closures (zippers) of the suits to prevent recurrence of the low pressure leakage problem encountered with the Command Module Pilot's suit during the countdown demonstration test. (See Environmental Control System section.)

Suit performance through lift-off, orbit insertion, and docking was normal. Helmets and gloves were doffed after orbit insertion, and the suits were doffed and stowed at 11:20 g.e.t. after extraction of the docking module. The suits remained stowed until 198:00 g.e.t. when they were again donned in preparation for docking module jettison. After docking module jettison, the suits were doffed and stowed for the remainder of the mission.

## Crew Provisions

The crew provisions for this mission were similar to those used in previous Apollo and Skylab missions and were satisfactory.

## Stowage

Stowage of all crew equipment in its proper locations for launch, on-orbit activities, and docking module jettison was accomplished.

The cosmonauts forgot their four data acquisition camera film magazines upon departing from the docking module. The magazines were stowed in the command module for return.

Used lithium hydroxide elements 5 and 6 replaced elements 15 and 16, and were returned for odor analysis.

## JOINT FLIGHT ACTIVITIES

Following a nominal rendezvous, docking with the Soyuz spacecraft was successfully achieved. After placing the Apollo spacecraft systems into a post-docked configuration, the Apollo Commander and the Docking Module Pilot prepared for the first transfer into the Soyuz orbital module. Upon entering the docking module, the crew smelled a pungent odor likened to that of acetate. Oxygen masks were donned until an assessment of possible sources of the odor indicated that it was safe to proceed. The atmosphere mixing system subsequently dispersed the odor.

Hatches 3 and 4 were opened on schedule and all planned operations for the first joint activity period in the Soyuz spacecraft were completed. The activities included the exchange of each nation's flags, exchange of the United Nations flag, connections and checkout of the cable communication system between the two spacecraft, setup of Apollo television and data acquisition camera equipment, signing of joint flight certificates, eating, exchange of zone forming fungi and microbial exchange experiment devices, and insertion of experiment cartridges into the multipurpose furnace for subsequent heat-up. In addition to the planned activities, messages of congratulations were received by all crewmembers from the heads of state of both countries.

At the end of the first day's joint activities in the Soyuz spacecraft, the Apollo Commander and Docking Module Pilot began their return to the command module. Following the depressurization of tunnel 2, the cosmonauts reported that their integrity check of the orbital module/docking module hatches 3 and 4 had failed and one of the two hatches appeared to be leaking into the tunnel at a rate of 1 mm Hg/min. The tunnel was repressurized by the Apollo crew, hatches 3 and 4 were reopened, and their respective seals checked. A second integrity check subsequently failed. A decision was made to have the Apollo crew continue docking module depressurization procedures enroute to the command module in the belief that the apparent hatch leakage was actually thermal instability in the tunnel following its rapid depressurization. Further checks on the tunnel by the Soyuz crew during the ensuing sleep period convinced both sides that there was no problem and the Soyuz integrity check go/no-go tolerances were biased to reflect the thermal condition.

The second day's crew transfer activities were begun on time with the Command Module Pilot transferring into Soyuz and the Soyuz Commander transferring into the command module. Milestones accomplished in Soyuz during the second joint activity period included an orbital module and descent vehicle television tour conducted by the Flight Engineer, the Command Module Pilot's signing of the joint flight certificates, the joining of a commemorative plaque, an exercise period for the Command Module Pilot using Soyuz equipment, a visual tour of the USSR conducted by the Flight Engineer, science demonstrations performed by the Command Module Pilot, a joint meal - with comments on Russian space food by the Command Module Pilot, and television and photographic requirements associated with the activities. Milestones accomplished in Apollo during this time included a television tour of the command module conducted by the Apollo Commander, signing of the joint flight certificates, the joining of a commemorative plaque, television camera support of the tour of the USSR conducted in Soyuz, an exercise period for the Soyuz Commander using Apollo equipment, a joint meal - with commentary from the Soyuz Commander on American space food, orbital science, and television and photographic requirements associated with the activities.

Following the third crew transfer - with the Soyuz Commander and Apollo Commander in the Soyuz spacecraft and the Docking Module Pilot, Command Module Pilot and Flight Engineer in the Apollo spacecraft - the milestones accomplished in Soyuz included a joint press conference, microbial exchange experiment sampling, presentation of tree seeds as a symbolic gift to the Soviet people, joining of two Apollo Soyuz Test Project medallion halves, and planned television and photographic operations of these activities. Simultaneously in Apollo, a joint press conference, microbial exchange experiment sampling, presentation of tree seeds as a symbolic gift to the American people, joining of two Apollo Soyuz Test Project medallion halves and a television tour of Florida were accomplished along with earth observations and planned television photographic operations of these activities. The fourth transfer returned all crewmembers to their own spacecraft on schedule.

The complex network of communications between the two vehicles and their respective ground stations led to numerous small communications problems during the duration of the joint phase. In most instances, switches in one vehicle or the other were out of configuration for the particular mode desired and the problem was solved by reconfiguration. (The Apollo speaker boxes in each vehicle caused a feedback squeal when operated simultaneously with the crew headsets.) Planned television procedures went very well with good quality coverage of the activities.

# EXPERIMENTS

## SPACE SCIENCES

### Stratospheric Aerosol Measurement

The stratospheric aerosol measurement (MA-007) photometer performed normally and sufficient data were produced to satisfy all the experiment mission objectives. Photometer data were collected per the flight plan for two sunsets and two sunrises.

Photographs of the sun were taken simultaneously with photometer data on three of the four planned passes. On the first sunset pass, an improperly configured lens of the 70 mm reflex camera caused the film not to advance. This was corrected and photographs were taken on the remaining three passes.

Ground truth measurements using a balloon-borne dust sonde and a ground-based LIDAR (light detection and ranging) system were made at the Richards-Gebaur AFB in support of the second sunset pass.

### Soft X-Ray

The soft X-ray experiment (MA-048) instrument was first turned on during activation of the three experiments in the scientific instrument module bay of the service module on the second day of flight and the detector was purged as scheduled. During the initial operation, high count rates were observed on all data channels. This operation occurred with the spacecraft passing through the South Atlantic Anomaly, an area of known high radiation. Consequently, the instrument was believed to be operating properly.

The X-ray experiment was next operated during the raster scan for the extreme ultraviolet survey experiment (MA-083). The count rates again went full scale and a gas purge was scheduled in anticipation of a possible instrument problem. After purging, the instrument was operated on the sixth day of flight and 25 minutes of good data were obtained before the problem reappeared. On day 7, a test was performed in which the instrument was operated with the high voltage on for 2 minutes and then off for 2 minutes. The instrument operated properly for approximately 3 minutes out of the 5 minutes during which the high voltage was on. The experiment operation procedure for day 8 was revised to incorporate the 2-minute-on mode of operation and at least 30 more minutes of good data were obtained.

The detector was allowed to pump down to vacuum and was activated while evacuated prior to entry. The detector count rates showed no evidence of discharge for an operational period of approximately 25 minutes. This would imply that the source of the problem was the detector. The high voltage was subsequently turned off, the detector was filled to 11 newtons/sq cm, and the high voltage was turned back on. Two minutes later, the discharge problem reappeared.

For the total mission, approximately 1 hour of discrete source data were obtained. Data were obtained on Cyg X-2, SMC X-1, the large Magellanic cloud, Her X-1, and Vela X. The X-ray instrument also obtained good low energy data on the source in Coma which was observed by the extreme ultraviolet telescope (MA-083). The scan requirements of the experiment were not accomplished.

## Ultraviolet Absorption

The ultraviolet absorption experiment (MA-059) was performed on days 2 and 5. Preliminary data indicates successful operation of the experiment and good data were obtained.

The calibration of the crew optical alignment sight and the star tracker on the star Vega was carried out successfully. However, the pilot indicated that the star tracker field-of-view was wider than expected. Subsequent tests on the backup star tracker indicated that this was due to a modification made when the star tracker linearity was adjusted.

During the 150-meter data-take the experiment apparently obtained only atomic oxygen resonance fluorescence data. Analysis indicates that either the side retroreflector on the Soyuz had low ultraviolet reflectivity or that the star tracker was locked on a window. Later, the crew reported that the retroreflector was four or five times brighter than the Soyuz window. Hence, a decision was made to obtain the 500-meter data from the aft retroreflector. The result was an excellent data run, from which the full objectives of the experiments at this time appear to have been achieved.

A malfunction occurred prior to the 1000-meter data-take during the lamp warmup period. The closed-door ultraviolet calibration signal showed a sharp decrease in signal level. The decrease occurred during a time for which no real-time data were available. Background ultraviolet data indicate no decrease in spectrometer sensitivity. Therefore, there may have been no effect on the experiment. The top retroreflector on the Soyuz was only sporadically acquired during the 1000-meter in-plane data-take.

The two subsequent data-takes, out-of-plane fluorescence and roll maneuver, were successful. Excellent data were obtained showing gas pileup during the roll maneuver. Another malfunction was apparently caused by oscillation on the nitrogen intensity monitor channel. There was no effect on the lamp output by this malfunction, as indicated by closed door ultraviolet calibration data obtained at the end of the data run.

## Extreme Ultraviolet Telescope

The extreme ultraviolet telescope (MA-083) was initially operated on day 2 for 13 minutes. All data indicated that the instrument was performing normally. The first planned raster scan for the extreme ultraviolet telescope was cancelled; however, the second planned raster scan went as planned on day 5 for 12 minutes. The instrument operation for this event was normal. Data operations began on day 6 and ran very close to the planned schedule through day 10. During this time, approximately 37 hours and 28 minutes of data were obtained. The instrument performed well throughout the mission. Data taken should be sufficient for accomplishing the planned experiment objectives.

The most significant achievement of the observing program was the detection of an intense extreme ultraviolet source on day 8. This is the first known detection of a cosmic source of extreme ultraviolet radiation. The object appeared very strongly in the parylene and beryllium filters.

## Helium Glow

The helium glow detector (MA-088) was initially turned on at the same time as the extreme ultraviolet telescope (MA-083). The detector was left on for 13 minutes and all data indicated that the instrument was performing normally. Data operations began on day 6 and ran very close to the planned schedule through day 10. During this time, approximately 29 hours and 36 minutes of data were taken. There was some concern over possible excessive background noise on detector 3. Otherwise, the instrument performed well throughout the mission.

The experiment is expected to provide significant new information concerning the local distribution of both neutral and ionized helium of terrestrial, solar, and interstellar origin. Specifically, a number of roll scans of the sky were obtained and these will allow preparation of a coarse all-sky map of the intensity and spectral characteristics of the local helium resonance radiation.

Additional data were obtained on day 8, including a 30° by 60° wide-angle raster scan. Good spectroscopic absorption cell data were obtained using the helium glow detector, although the extreme ultraviolet telescope (MA-083) was inadvertently left switched off with the consequence that the morphology of this complex region was not mapped.

Supplementary data on the daytime and nighttime earth helium glow were obtained on day 8. Again, the data were of excellent quality.

## Doppler Tracking

The doppler tracking experiment (MA-089) was operated in the warmup mode to achieve oscillator stabilization. This was started on day 6. After nearly 50 hours of warmup, the transmitter was inadvertently turned off for about 10 minutes. No degradation is expected in the data taken during prime time which started 8 hours later.

A second problem appeared at receiver turn-on. No tape motion was observed on either of the two (redundant) tape recorders and no telemetry was received. This condition could have been caused by a data processor lock-up and was corrected by recycling the control switch. The system appeared normal except that one of the two tape recorders did not operate.

A preliminary analysis of the data has shown that the spacecraft-to-spacecraft data were collected.

## Geodynamics

The geodynamics experiment (MA-128) was performed to demonstrate the feasibility of detecting and recovering high-frequency components of the geopotential by use of a synchronous relay satellite tracking a low altitude spacecraft. Detectability will be demonstrated by an analysis of the residual patterns in the relay doppler data (satellite-to-satellite tracking data) and comparing these patterns with previously predicted signatures due to assumed gravity anomalies.

Signals originating at the Spaceflight Tracking and Data Network (STDN) Madrid tracking station were relayed to the Apollo spacecraft via Applications Technology Satellite 6 (ATS-6). The prime area for collecting MA-128 experiment data, the Indian Ocean Depression, was within the ATS-6 visibility of Apollo, centered at approximately 3° N latitude and 75° E longitude.

The MA-128 experiment data collection phase was very satisfactory. Originally, 28 experiment revolutions were planned with the spacecraft passing through the center of the Indian Ocean Depression on ten of these. The experiment relay doppler data and all supporting data were collected for all of the 28 planned ATS-6 passes. Additional unscheduled data were collected during parts of four other passes through the anomaly center, fourteen passes near the center, and fifty-six passes through the outer periphery of the anomaly.

## Earth Observations and Photography

All earth observations and photography experiment (MA-136) objectives were successfully accomplished. Mapping camera operations and real-time visual observations were performed during 25 revolutions. Eleven mapping passes were scheduled; only the first one was not accomplished. Sixty visual observation sites were scheduled. About 20 percent of the 100 planned observations of these sites were not performed because of bad weather. Two extra passes were added for the observation of possible red tide blooms off the coast of Maine. Coordination with ground truth parties went well.

Television transmissions were acquired over several tracking stations and images of the daylight portion of revolution 124 were recorded on the video tape recorder.

## Artificial Solar Eclipse

The artificial solar eclipse experiment (MA-148) was performed immediately after the first undocking from the Soyuz. The maneuver was viewable on television, but the bloom over the image from the sunlit portions of the Soyuz precluded assessment of the shadow conditions on the orbital module hatch window. The shadow conditions and the corona detection will be assessed respectively from Apollo photographs and Soviet photographs.

## Crystal Activation

The crystal activation experiment (MA-151) consisted of crystals of germanium and sodium iodide stowed in the command module during the mission to determine radiation effects. Recovery, early measurements, and distribution of materials to laboratories were accomplished with no problems.

# LIFE SCIENCES

Five life sciences experiments were conducted during orbital flight. With the exception of the light flash experiment (MA-106) and the Killifish hatching and orientation experiment (MA-161) no real-time or near-real-time information was required during flight. Experiment samples and data have been returned for analyses.

## Microbial Exchange

The microbial exchange experiment (AR-002) was a joint USA-USSR experiment which involved sampling of potential microbial growth from each astronaut and each cosmonaut. Additionally, microbial growth samples were made from preselected sites in both the Soyuz and Apollo spacecraft. All samples were packaged and stowed in the Soyuz descent vehicle and returned with the cosmonauts. Cellular immune response (MA-031) and polymorphonuclear leukocyte response (MA-032) experiments are being conducted which deal with preflight and postflight analysis of blood samples extracted from each crewman. In both cases blood samples were taken and analyses are in progress.

## Light Flash

The light flash experiment (MA-106) was conducted in two parts. Ninety minutes of unmanned data were recorded by the experiment self-contained recorder and a manned portion was accomplished utilizing the Command Module Pilot and Apollo Commander as subjects. Magnetic tape cassettes, masks and active silver chloride detector modules have been returned with the command module for analysis.

## Biostack

The active biostack module for the biostack experiment (MA-107) collected high-energy particle data for 13 hours and 20 minutes prior to initial docking. Subsequent to final undocking, the module was powered on for a second time and acquired 22 hours and 25 minutes of data. Both the active and passive biostack modules were returned in the command module and have been delivered to the principal investigator for analysis.

### Zone Forming Fungi

The zone-forming fungi experiment (MA-147) was a joint USA-USSR experiment. It was conducted by photographing two sample packages twice a day at 12-hour intervals. The command module and the Soyuz carried two samples each, one of which was exchanged in flight for return. Analyses of the samples have begun by the respective countries.

### Killifish Hatching and Orientation

The Killifish hatching and orientation experiment (MA-161) involved inflight observation and photography of the orientation behavior of Killifish fry in one plastic film package and hatching of Killifish eggs in a second package. Inflight television was utilized to allow principal investigator observation on the ground. Both fish packages were returned. Orientation behavior was recorded photographically, and samples were killed and fixed for microscopic analysis.

## TECHNOLOGY

### Multipurpose Furnace

The multipurpose furnace (MA-010) system operation was satisfactory. The principal investigator believes that good data can be obtained from the MA-041 samples even though the cooldown period was longer than expected. Telemetry data of the other six experiment operations indicated that operations were nominal in all respects and followed predicted temperature profiles.

### Electrophoresis Technology

The electrophoresis apparatus operated successfully on seven of eight columns. Column 7, containing kidney cells, leaked and was returned for failure analysis.

### Electrophoresis - German

The German electrophoresis experiment (MA-014) unit operated normally. The tape recorded data will be returned to the Max Planck Institute for analysis.

## Crystal Growth

The crystal growth experiment (MA-028) observations were made and photographs taken by crewmen at approximately 12 hour intervals starting on day 5 and continuing through the flight. Observations indicate that the experiment proceeded as planned.

## INFLIGHT DEMONSTRATIONS

Four inflight demonstrations were performed and filmed: capillary wicking, liquid spreading, chemical foams, and physics demonstrations.

## BIOMEDICAL

The crew was exposed to toxic gases (mostly nitrogen tetroxide) from unplanned reaction control system firings during the landing phase. The nitrogen tetroxide gas entered the command module through the cabin pressure relief valve which was open during the landing sequence. (See the Sequencing and Electrical Power Distribution section for detailed discussion of this problem.)

The initial reaction of all crewmembers was coughing and eye irritation. Of the three crewmen, the Command Module Pilot probably received the largest dose because of his proximity to the cabin pressure relief valve. This contributed to his unconsciousness while in stable II, although the feet-lower-than-the-head position reduces orthostatic tolerance and favors fainting.

Postflight symptoms were primarily eye irritation (which subsided quickly), coughing, and substernal burning on taking deep breaths (which was still minimally present 4 days after recovery). Steroid treatment was initiated the first day following recovery and was probably instrumental in controlling the pulmonary infiltrates (collections of fluid and tissue thickening) which first appeared on the second set of X-rays, taken the day following recovery. The crew will be tapered off medications and closely monitored for delayed effects of the toxic exposure.

Until the time of exposure to the toxic gases, the health of the Apollo crew was good and all physiological parameters obtained from the crew were within the expected range.

Two scopolamine/dextroamphetamine tablets were taken by the Command Module Pilot shortly after insertion into orbit as a deterrent to motion sickness. Lomotil tablets were taken several times by the Commander. Caloric intake for all three crewmen was approximately as expected.

All medical operational equipment functioned properly throughout the mission with the exception of intermittent biomedical data involving the Apollo Commander's electrocardiogram during exercise on day 8. The data were noisy to the point of being unreadable.

Leg circumference measurements were accomplished on all crewmen on mission days 2, 5, 6, 7, and 9. Data were recorded and returned for evaluation.

# MISSION SUPPORT PERFORMANCE

## FLIGHT CONTROL

Flight control provided satisfactory operational support during the mission. Since most of the problems that were encountered are discussed elsewhere in this report, only those problems that are unique to flight control or have operational considerations not previously mentioned are present in this section.

Prelaunch activities followed the planned schedule. Because of a non-nominal Soyuz orbital inclination, the Apollo launch azimuth was changed from 45.16° to 44.85° to adhere to the nominal launch time of 19:50:00 G.m.t.

Docking module checkout required more time than planned, and the crew was 1-1/2 hours behind at lunch on the second day. To recover lost time, several activities were deleted. These included the first visual observations pass, the extreme ultraviolet survey (MA-083) raster scan, and the visual observations portion of the second earth observations experiment period. All other planned activities for the second day were accomplished.

A switching device in the Soyuz television system failed. The cosmonauts performed a corrective procedure which recovered use of two interior color television cameras.

Numerous operating instruction changes were made for the experiments located in the scientific instrument module bay of the service module. Most of the changes were due to the failure in the X-ray experiment (MA-048) hardware. Several alternate/contingency pads were utilized.

The spacecraft attitude for visual observations passes were modified at crew request. The premission attitude was heads down, posigrade, local horizontal. The new attitude pitched the docking module 30° toward the earth.

## NETWORK

Network support of the Apollo Soyuz mission was satisfactory. There were no noteworthy problems.

## RECOVERY

The Apollo command module landed approximately 1.3 kilometers from the target and about 7 kilometers from the primary recovery ship, the U.S.S. New Orleans. The landing point was latitude 22 degrees 0 minutes 36 seconds north and longitude 163 degrees 0 minutes 54 seconds west, as determined by the recovery ship. The time of landing was 21:18:24 G.m.t. on July 24, 1975.

The command module went to the stable II attitude after landing and was righted in 4 minutes and 24 seconds by the uprighting system. The Apollo crew opened the hatch after flotation collar installation to get more fresh air into the cabin. The crew remained in the command module while it was hoisted aboard the ship and they were on the ship about 41 minutes after landing. All three main parachutes and the forward heat shield (apex cover) were recovered.

TABLE III.- SUMMARY OF MISSION OBJECTIVES AND TECHNICAL INVESTIGATIONS

| Objectives/Investigations | Achievement status |
|---|---|
| Primary Objectives: | |
| 1. Spacecraft Rendezvous | Yes |
| 2. Spacecraft Docking and Undocking | Yes |
| 3. Intervehicular Crew-Transfer | Yes |
| 4. Interaction of Control Centers | Yes |
| 5. Interaction of Spacecraft Crews | Yes |
| Supplementary Objectives: | |
| 1. Docked Spacecraft Attitude Control | Yes |
| 2. Radio and Cable Communications | Yes |
| 3. Test Docking and Undocking | Yes |
| 4. Onboard Documentary Photography | Yes |
| 5. Television Transmission | Yes |
| 6. Joint Experiments (see Experiments) | Yes |
| Experiments: | |
| AR-002 Microbial Exchange (Joint) | Yes |
| MA-007 Stratospheric Aerosol Measurement | Yes |
| MA-010 Multipurpose Furnace (Joint[a]) | Yes |
| MA-011 Electrophoresis Technology | [b]Partial |
| MA-014 Electrophoresis - German | Yes |
| MA-028 Crystal Growth | Yes |
| MA-048 Soft X-Ray | [c]Partial |
| MA-059 Ultraviolet Absorption (Joint) | Yes |
| MA-083 Extreme Ultraviolet Survey | Yes |
| MA-088 Helium Glow | Yes |
| MA-089 Doppler Tracking | Yes |
| MA-106 Light Flash | Yes |
| MA-107 Biostack | Yes |
| MA-128 Geodynamics | Yes |
| MA-136 Earth Observations and Photography | Yes |
| MA-147 Zone-Forming Fungi (Joint) | Yes |
| MA-148 Artificial Solar Eclipse (Joint) | Yes |
| MA-161 Killifish Hatching and Orientation | Yes |

TABLE III.- SUMMARY OF MISSION OBJECTIVES AND TECHNICAL INVESTIGATIONS (Concluded)

| Objectives/Investigations | Achievement status |
|---|---|
| Detailed Objectives: | |
| Lower Limb Volume Measurements | Yes |
| Crew Height Measurements | [d]Partial |
| Orbital Navigation via Synchronous Satellite Relay Data | Yes |
| Inflight Demonstrations: | |
| Capillary Wicking in Zero Gravity | Yes |
| Liquid Spreading in Zero Gravity | Yes |
| Chemical Foams in Zero Gravity | Yes |
| Physics Demonstrations | Yes |

[a]One of seven sets of samples was a joint experiment.

[b]One of 8 samples leaked and was not completed.

[c]Degraded instrument operation significantly reduced data collection.

[d]All scheduled measurements were not obtained.