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STS-64
SPACE SHUTTLE
MISSION REPORT

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NOTE

The STS-64 Space Shuttle Mission Report was prepared from inputs received from the Orbiter Project Office as well as other organizations. The following personnel may be contacted should questions arise concerning the technical content of this document.

Kenneth L. Brown, JSC 713-483-3891	Orbiter and subsystems
C. A. Snoddy, MSFC 205-544-0391	MSFC Elements (SRB, RSRM, SSME, ET, SRSS, and MPS
Dianne J. Murphy, JSC 713-483-1055	Payloads/Experiments
G. P. Buoni, JSC 713-483-0639	DTOs and DSOs
F. T. Burns, Jr., JSC 713-483-1262	FCE and GFE

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SPACE SHUTTLE

MISSION REPORT

Prepared by

Robert W. Fricke, Jr.
LESC/Flight Evaluation Office

Approved by

Kenneth L. Brown
STS-64 Lead Mission Evaluation Room Manager

David W. Camp
Manager, Flight Engineering Office

Phillip C. Glynn
Deputy Manager, Orbiter Project

Brewster H. Shaw
Director, Space Shuttle Operations

Prepared by
Lockheed Engineering and Sciences Company
for
Flight Engineering Office

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

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INTRODUCTION

The STS-64 Space Shuttle Program Mission Report summarizes the Payload activities as well as the Orbiter, External Tank (ET), Solid Rocket Booster (SRB), Redesigned Solid Rocket Motor (RSRM), and the Space Shuttle main engine (SSME) systems performance during the sixty-fourth flight of the Space Shuttle Program and the nineteenth flight of the Orbiter vehicle Discovery (OV-103). In addition to the Orbiter, the flight vehicle consisted of an ET that was designated ET-66; three SSMEs that were designated as serial numbers 2031, 2109, and 2029 in positions 1, 2, and 3, respectively; and two SRBs that were designated BI-068. The RSRM's that were installed in each SRB were designated as 360L041A for the left SRB, and 360L041B for the right SRB.

This STS-64 Space Shuttle Program Mission Report fulfills the Space Shuttle Program requirement as documented in NSTS 07700, Volume VIII, Appendix E. The requirement stated in that document is that each major organizational element supporting the Program will report the results of their hardware and software evaluation and mission performance, plus identify all related in-flight anomalies.

The primary objective of this flight was to successfully perform the planned operations of the Lidar In-Space Technology Experiment (LITE), and to deploy the Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) -201 payload. The secondary objectives were to perform the planned activities of the Robot Operated Materials Processing System (ROMPS), the Shuttle Amateur Radio Experiment - II (SAREX-II), the Solid Surface Combustion Experiment (SSCE), the Biological Research in Canisters (BRIC) experiment, the Radiation Monitoring Equipment-III (RME-III) payload, the Military Application of Ship Tracks (MAST) experiment, and the Air Force Maui Optical Site Calibration Test (AMOS) payload.

The STS-64 mission was planned with a 9-day duration plus 1 extension day plus 2 contingency days, which were available for weather avoidance or Orbiter contingency operations. The sequence of events for the STS-64 mission is shown in Table I, and the Orbiter Project Office Problem Tracking List is shown in Table II. The official Government Furnished Equipment (GFE) Problem Tracking List is shown in Table III, and the Marshall Space Flight Center (MSFC) Problem Tracking List is shown in Table IV. In addition, the integration and payload in-flight anomalies are referenced in applicable sections of the report. Appendix A lists the sources of data, both formal and informal, that were used in the preparation of this report. Appendix B provides the definition of acronyms and abbreviations used in this document. All times are given in Greenwich mean time (G. m. t.) as well as mission elapsed time (MET).

The six-person crew for STS-64 consisted of Richard N. Richards, Capt., U. S. Navy, Commander; Blaine L. Hammond, Col., U. S. Air Force, Pilot; Jerry M. Linenger, M. D., Ph. D., Cdr., Medical Corps, U. S. Navy, Mission Specialist 1; Susan J. Helms, Lt. Col,

U. S. Air Force, Mission Specialist 2; Carl J. Meade, Col., U. S. Air Force, Mission Specialist 3; and Mark C. Lee, Col., U. S. Air Force, Mission Specialist 4. STS-64 was the fourth space flight for the Commander, the third flight for Mission Specialist 3 and Mission Specialist 4; the second space flight for the Pilot and Mission Specialist 2; and the first space flight for Mission Specialist 1.

MISSION SUMMARY

The STS-64 Space Shuttle Vehicle was launched successfully on a 57-degree launch azimuth at 252:22:22:54.982 G.m.t., 1 hour, 52 minutes, and 55 seconds later than planned because of unsatisfactory weather in the Return-to-Launch-Site (RTLS) landing area. All SSME and RSRM start sequences occurred as expected and the launch phase performance was satisfactory in all respects. First stage ascent performance was as expected. SRB separation, entry, deceleration, and water impact occurred as anticipated. Both SRBs were recovered. Performance of the SSMEs, ET, and main propulsion system (MPS) was normal. The Orbiter ascent performance was also nominal with the planned orbit of 137 by 23 nmi. achieved at main engine cutoff (MECO). S-band communications were lost for four minutes after MECO during the handover from Wallops Island to the Tracking and Data Relay Satellite (TDRS). Analysis shows that this loss of communications was not caused by the Orbiter vehicle subsystems. Postflight troubleshooting of the TDRS network was performed to determine the cause of the unexpected loss of signal (LOS).

No orbital maneuvering subsystem (OMS) -1 maneuver was required because of the satisfactory direct insertion trajectory flown. The OMS-2 maneuver was initiated at 252:22:59:03.8 G.m.t. (00:36:04.8 MET). The maneuver was 125.4 seconds in duration with a differential velocity (ΔV) of 208.7 ft/sec. The orbit achieved as a result of this maneuver was 140.8 by 139.9 nmi.

The SSME vacuum inerting process was initiated by the OI-23 software. A predicted pressure rise of approximately 30 psi in the hydrogen manifold was exceeded by approximately 3 psi. This was similar to the previous flight of OI-23 software on STS-65, although the pressure rise was greater on this flight. Because of this pressure rise, the crew manually performed a second vacuum-inerting procedure.

A determination of overall Space Vehicle performance during ascent was made using vehicle acceleration and preflight propulsion prediction data. From these data, the average flight-derived engine Isp, determined for the period between SRB separation and start of 3g throttling, was 452.5 seconds, and that value was very near the planned level.

Payload bay door (PLBD) operations were delayed due to the motor controller assembly (MCA) logic Main C Mid 4 switch being off. Data indicate the switch was moved to off at 252:23:39 G.m.t. (00:01:17 MET). The crew restored the switch to on at 252:23:44 G.m.t. (00:01:22 MET), and the door opening operations were completed with no further delay at 252:23:53:36 G.m.t. (00:01:30:41 MET).

During ascent, auxiliary power units (APUs) 1, 2 and 3 operated for 21 minutes 26 seconds, 21 minutes 31 seconds, and 21 minutes 17 seconds with fuel usages of 54, 59, and 56 lb, respectively. The APUs were shutdown in the order (3-1-2) desired to fulfill the requirements of Development Test Objective (DTO) 414, APU Shutdown Test (Sequence A). Analysis of the data from the shutdown sequence revealed no back-driving of the power drive units (PDUs).

Following the completion of post-insertion procedures, the crew reported that the side-hatch locking device could not be installed because of an obstruction. The crew downlinked video of the area involved, and analysis of the video did not clearly show the cause of the obstruction. Postflight inspection and analysis showed that the locking device was oversized when compared to the drawing. This particular unit had not been flown previously; consequently, this error had not been found.

Two reaction control subsystem (RCS) trim firings were performed with nominal subsystem operation. The first RCS trim firing was initiated at 253:02:45:25 G.m.t. (00:04:22:31 MET) using multiple thrusters. The firing was 5 seconds in duration with a ΔV of 1.4 ft/sec. The second firing was initiated at 253:03:33:09 G.m.t. (00:05:10:15 MET) using multiple thrusters. The +Z maneuver was approximately 10 seconds in duration with a ΔV of 3.7 ft/sec.

The crew reported that an advanced felt reusable surface insulation (AFRSI) blanket on the port OMS pod was partially detached near the AFRSI/low temperature reusable surface insulation (LRSI) interface. Downlinked video provided a detailed view of the AFRSI blanket damage. A small triangular tear in the blanket coating about 2 in. by 0.75 in. was seen at the interface between the tiles and the blanket. The batting beneath the torn cloth appeared to be intact. Similar damages to this particular blanket have occurred (ref. STS-50, OV-102, LP05), with no resulting damage to the underlying structure. The blanket is through-stitched on 1 in. centers to ensure that cover damage of this nature is minimized. The blanket damage seen in this view did not represent an on-orbit or entry concern.

The third RCS trim firing was performed at 254:02:37:55 G.m.t. (01:04:15:00 MET) using thrusters L3A and R3A. The firing duration was approximately two seconds and the resultant ΔV was 0.2 ft/sec.

The Shuttle Plume Impingement Flight Experiment (SPIFEX) payload was grappled and unberthed at 253:20:41:32 G.m.t. (00:22:51:37 MET), and the SPIFEX planned data takes were completed. The SPIFEX operations and the remote manipulator system (RMS) operations were nominal.

During the second day of RMS/SPIFEX operations, all RMS operations were nominal. One wrist pitch brake slip message occurred during one of the primary RCS firings; however, this was an expected phenomenon.

The flash evaporator system (FES) supply water system A accumulator temperature began cycling between 48 °F and 55 °F at approximately 253:02:00 G.m.t. (00:03:38 MET). The normal control range for the thermostat is between 55 °F and

75 °F. A comparison with the B supply accumulator temperature indicated that the temperature sensor was partially or totally debonded. The temperature cycles indicate that the heater was operating properly. There was no impact for this condition as the temperature never approached 32 °F. A heater reconfiguration was performed at 257:12:52 G.m.t. (04:14:30 MET), and data from the B heaters support the theory that the temperature sensor was partially or totally debonded. A postflight inspection is required to verify the sensor condition.

The launch/entry suit (LES) thermoelectric (TE) cooling unit data logger displayed a spurious flashing signature on its liquid crystal display (LCD) during deactivation on-orbit. During the deactivation, two resets were performed and the recorder was powered down in accordance with the instructions located on the data logger. The data logger is a secondary objective of DTO 674 and was used to gather performance data from the cooling system. The spurious flashing signature most probably resulted from completely depressing only one of two membrane-type buttons that should have been pressed simultaneously for proper operation of the logger.

The fourth RCS trim firing was performed at 254:15:25:37.95 G.m.t. (01:17:02:42 MET) using thrusters L3A and R3A. The firing consisted of seven +X pulses over a 25-second period and resulted in a ΔV of 1.5 ft/sec. Vernier RCS thrusters F5R, F5L, and R5R were also fired for three pulses each during this maneuver.

At 254:11:55:42 G.m.t. (01:13:32:47 MET), the MCA 1 operational status bit 4 transitioned from a 1 to a 0. At 254:15:03:37 G.m.t. (01:17:41:42 MET), the status bit transitioned back to a 1. No drive currents were detected on the supplying ac bus, nor were any position changes noted in the controller motors. Also, no change in the aft power controller 4 voltage or current measurements occurred during the transition times. The measurement (V76X2254E) is downlinked at one sample per second through multiplexer/demultiplexer (MDM) OA1, card 7, channel 00, and no other measurements on that channel changed states during the period in question. Had the indication remained, at least one additional failure would have been required before a function would have been lost or any corrective action required.

The left and right aft RCS were interconnected to the OMS at 255:03:08 G.m.t. (02:05:46 MET). The systems operated nominally. The interconnect operations were stopped at 260:15:31 G.m.t. (07:17:08 MET) with 10.76 percent of propellants from the left OMS and 9.47 percent of propellant from the right OMS used by the RCS.

At approximately 255:18:00 G.m.t. (02:19:38 MET), the Commander reported a problem when filling some of the drink bags. The problem drink bags have a restricted septum caused by excessive heat application during manufacture. Approximately 10 percent of the total of 746 drink bags stowed were suspected of having this problem. This restriction resulted in a smaller-than-normal quantity of water entering the bag. The crew was briefed on methods of dealing with this problem prior to the flight.

RCS trim firing 5 was performed at 256:15:14:24 G.m.t. (03:17:41:29 MET) with a duration of approximately 6 seconds. Thrusters L3A and R3A were used to provide a ΔV of 2.1 ft/sec. RCS trim firing 6 was performed at 256:16:00:34 G.m.t. (03:18:37:39 MET) with a duration of approximately 5 seconds. Thrusters L3A and R3A were used to provide a ΔV of 1.3 ft/sec. Subsystem operation during both firings was nominal.

Three major RCS separation maneuvers were performed after the SPARTAN deployment. RCS operation for the first two maneuvers was nominal. Thruster F4D had a low P_c indication of 70 psia at 256:16:01:22 G.m.t. (03:18:29:27 MET). Sixteen instances of the chamber pressure (P_c) being lower than the normal 150 psia on RCS thruster F4D were noted during the flight. Low P_c has occurred on the last five flights of F4D, with 3 instances on STS-60 and 11 instances on STS-51. In each case, the next firing of the thruster after a low P_c indication has been at the normal 150-psia level. This low P_c posed no problem for the flight.

A supply water dump was initiated at 256:12:35 G.m.t. (03:14:12 MET) and was terminated after 1 hour 15 minutes with 195.2 lb of supply water dumped. The dump was nominal; however, about 50 minutes after dump termination, the supply dump line temperature experienced an abrupt 8 °F temperature rise, which is indicative of a "burp." Review of the data for the first three supply dumps indicated that the line was not completely purged on the third dump. An extended post-dump purge for the duration of the nozzle bakeout (250 °F) was performed for the remaining supply dumps.

The Ku-band radar failed to lock on the SPARTAN payload following deployment at 256:21:29:57 G.m.t. (03:23:07:02 MET). The Ku-band passed several self-tests during the first hour after deployment with nominal results. Multiple searches were performed in both the general purpose computer (GPC) and automatic (Auto) modes with the output power in high and low and the range set in minimum and automatic, all without success. Approximately one hour after SPARTAN deployment, the Ku-band acquired the target, and remained locked on until the communications mode was selected. The Ku-band radar acquired the SPARTAN at 128,000 ft during retrieval activities, with lock remaining until 81 ft. All Ku-band operations during rendezvous were nominal.

During SPARTAN deployment operations, the berthing camera failed to operate. Analysis has shown that the label on the A7 panel that activated the SPARTAN berthing camera was placed over the wrong push-button. The PL3 button, which was labeled as a video tape recorder, was the correct button. The camera worked properly when the correct button was depressed.

During SPARTAN deployment operations, the Trajectory Control Sensor (TCS) (DTO 700-5), had problems acquiring SPARTAN as a target. The problem was traced to a Y-cable between the TCS and the payload and general support computer (PGSC). A plan was developed and uplinked to the crew to trade the connectors on the "Y" cable. This was done and the TCS was operational for SPARTAN retrieval.

On flight day 5, the consumables margin reached a level that was sufficient to support flight operations for 10 plus 2 days. As a result, the Mission Management Team authorized an extension day, which was inserted into the flight plan following the day during which the extravehicular activity (EVA) was performed.

At 258:22:51 G.m.t. (06:00:29 MET), the right OMS was used to perform the first of two orbit-adjust maneuvers. The first firing was 17.52 seconds in duration and the resultant ΔV was 15 ft/sec. The left OMS was used for the second firing, which was initiated at 258:23:36 G.m.t. (06:01:14 MET). The firing duration was 17.64 seconds and the resultant ΔV was 15 ft/sec. This maneuver placed the Orbiter in a 130 nmi. circular orbit.

The proximity operations (PROX OPS) camera did not come on when power was applied on flight day 6. The condition was caused by camera automatic light control (ALC) logic lock up. The crew performed malfunction procedure 2.4b to recover the camera. A power cycle was performed during this procedure and normal camera operations were restored.

On flight day 8, the crewmembers donned their extravehicular mobility units (EMUs) and performed a 50-minute in-suit prebreathe. The prebreathe period had been lengthened as the crew cabin had been at 10.2 psia slightly less than 24 hours. At the end of the prebreathe period, the airlock was depressurized to vacuum and the EVA began at 259:14:42:00 G.m.t. (06:16:20:55 MET). During the very successful EVA, seven nitrogen recharges of the simplified aid for EVA rescue (SAFER) unit were performed. The SAFER unit performed in an excellent manner throughout the EVA evaluation. The RMS was used extensively during the SAFER evaluation, and all systems performed nominally. After completion of the planned SAFER EVA activities, the crew members ingressed the airlock. The EMUs were connected to Orbiter power at 259:21:31:21 G.m.t. (06:23:08:26 MET). The total official EVA time of 6 hours 51 minutes.

Three EVA equipment anomalies were noted during the EVA. The articulating portable foot restraint (APFR) thermal cover interfered with the full insertion of the APFR simulator into the SPARTAN mission peculiar experiment support structure (MPESS) portable foot restraint (PFR) socket during the APFR load-limiter evaluation. The thermal cover was peeled back and the APFR simulator fitted properly. Also, two electronic cuff checklist (ECC) anomalies were noted during the EVA. The ECC-1 did not always respond when the upper middle sextant was depressed. Secondly, during an attempt to update the contents of ECC-2, a "WRITE ROM ERROR" message was displayed on the PGSC by the update application. The ECC-2 was still usable for the EVA as the crew proceeded with the update despite the error message.

On September 12, during a deorbit preparations training session on the Shuttle Mission Simulator (SMS), a backup flight system (BFS) display interface loss condition was discovered after the BFS was moded to halt following an initial program load (IPL).

When the BFS was later taken from halt to standby and assigned a cathode ray tube (CRT), the crew noted a big "X" without a "POLL FAIL" on the BFS CRT. During the simulation, the crew attempted to assign the BFS to other CRTs, but the big X was displayed on all CRTs to which an assignment was attempted. Analysis of the GPC dump collected following the anomaly showed that the BFS was halted while the module multifunction CRT display subsystem (MCDS) Update Module (MUM) was either active or suspended. The signature of this condition is clearly recognizable, the probability of occurrence was low, and the BFS can be recovered with a re-IPL procedure.

Analysis of the BFS software further revealed an additional scenario in which a big X with no POLL FAIL can occur on a BFS display. This scenario involves a transition back to OPS 0 where the MUM gets suspended prior to the initiation of the operations (OPS) transition. The transition back to OPS 0 makes the incompleted task MUM inactive and thus the flag MUM DONE is not properly set to continue display updating. This is the same type of problem described in the previous paragraph, but the window of exposure is considerably smaller. The corrective actions for both problems were identical.

Seven RCS maneuvers were performed during the SPARTAN rendezvous. These were the NC3 firing of 2.4 ft/sec; the NC4 firing of 2.2 ft/sec; the NCC maneuver of 1.1 ft/sec; the TI firing of 3.1 ft/sec; and three MC firings of 2.2, 0.59, and 0.74 ft/sec, respectively. The RCS performed satisfactorily during these maneuvers.

The TCS (DTO 700-5) operated flawlessly from 400 ft through SPARTAN retrieval. Likewise, the berthing and proximity operations cameras operated nominally.

The RMS operated satisfactorily during the retrieval and berthing of the SPARTAN payload. Some difficulty was experienced in obtaining the ready-to-latch indicators on the V-guides for the payload. The payload also had to be backed out of the guides for a primary RCS firing, during which the RMS brakes were applied. The berthing operation was then completed and the RMS was cradled and placed in the temperature monitoring mode.

The RMS elbow camera exhibited periodic horizontal jitter beginning at 259:15:12 G.m.t. (06:17:50 MET). At 259:16:34 G.m.t. (06:18:12 MET), the camera temperature had increased 5 °F and the camera was operating properly.

At 259:21:56 G.m.t. (06:23:34 MET), a "CRT BITE 1" message was annunciated indicating that the built in test equipment (BITE) had detected a problem. The BITE was attributed to a previously defined condition (User Note 55331) in which two key strokes are made in rapid succession.

The RMS was powered up at 260:13:12 G.m.t. (07:14:50 MET). It was uncradled, grappled the SPIFEX at 260:13:24 G.m.t. (07:15:02 MET), and maneuvered to the

SPIFEX extended park position. The RMS completed all SPIFEX operations nominally at 260:20:01 G.m.t. (07:21:39 MET). The RMS was cradled and the manipulator positioning mechanisms (MPMs) were stowed. No further RMS operations were planned or performed during STS-64.

The RCS hot-fire was performed at 261:14:53:56 G.m.t. (08:16:31:01 MET). At 261:14:56:05 G.m.t. (08:16:33:10 MET) during the hot-fire, RCS thruster L1A was deselected by the redundancy management (RM) software because of low chamber pressure (16 psia). This was the first firing of the L1A thruster during the mission. The oxidizer valve began leaking immediately after the failure, and the leak detector temperature continued to cycle after the firing attempt. No fuel leakage was detected. The most probable cause of the failure is nitrate contamination in the pilot and/or mainstage of the oxidizer valve, which resulted in a failure of the valve to fully open, thus creating a leak path. Thruster L1A remained deselected for the remainder of the mission. The remaining thrusters operated satisfactorily during the hot-fire.

The flight control system (FCS) checkout was performed satisfactorily at 261:13:29:07.48 G.m.t. (08:15:06:11.54 MET) and APU 3 ran for 6 minutes 35.61 seconds. The APU operated nominally with 20 lb of fuel used during the checkout. Hydraulic system 3, used for the FCS checkout, performed nominally. No water spray boiler (WSB) spray cooling was observed because of the short run-time of the APU.

There were two instances when the Orbiter return link was lost while the forward link remained operational. The first loss occurred when acquiring the TDRS West, and the second occurred several orbits later four minutes after an early handover to the TDRS East. The losses were caused by a software problem at the second TDRS ground terminal when the hourly vector was initiated too close to the service-start time, and time was not available for proper processing of the vector. A workaround was established to prevent an hourly vector from being accepted within 10 minutes of service-start time. Following this change, no additional occurrences of the anomaly were noted.

During deorbit preparations, when the FES checkout was performed at 262:14:24 G.m.t. (09:16:02 MET), the secondary high-load evaporator exhibited temperature oscillations before the temperature settled within the control band of 62 ± 2 °F. The secondary topping evaporator showed no oscillations when it was started. The primary B controller also showed some temperature oscillations before it reached its control band of 39 ± 1 °F. The first temperature oscillations were most likely caused by a slow response of the midpoint temperature sensor which controls the secondary high load evaporator. The second set of temperature oscillations was most likely caused by the midpoint temperature sensor, which controls the high-load evaporator using the primary B controller. No in-flight checkout requirements were violated as a result of these oscillations.

All deorbit preparations for the first and second Kennedy Space Center (KSC) landing opportunities on the first planned landing day (September 19) were completed, and the payload bay doors were closed at 262:14:50:32 G.m.t. (09:16:27:37 MET). Weather for both landing opportunities at KSC remained unacceptable, because thunderstorms were within 30 miles and lightning was being observed. As a result, landing was delayed until the first contingency day.

During the execution of procedures to back out of the deorbit configuration, the BFS was moded from halt to standby, and an "X" appeared on the CRT display. The crew performed a BFS IPL and restored normal BFS operation.

All deorbit preparations were again completed for the KSC and Edwards Air Force Base (EAFB) landing opportunities on the first contingency day (September 20) and the payload bay doors were closed at 263:14:41:35 G.m.t. (10:16:18:40 MET). Both landing opportunities at KSC were waived because of unacceptable weather conditions at the Shuttle Landing Facility (SLF), and the decision was made to land at Edwards Air Force Base concrete runway 04. The deorbit maneuver was initiated at 263:20:17:00.5 G.m.t. (10:21:55:05.5 MET), and was 181.3 seconds in duration with a ΔV of 323.6 ft/sec.

During landing just prior to tactical air navigation (TACAN) data being incorporated into the navigation, TACAN 1 experienced spurious 40-degree bearing movements, which was an expected condition for this TACAN. When TACAN data were selected, TACAN 1 bearing data exceeded RM-allowed dispersions, and TACAN 1 was deselected by the RM. Immediately after TACAN 1 bearing data were deselected, TACAN 1 bearing data recovered and were nominal for the remainder of the mission.

Main landing gear touchdown occurred at Edwards Air Force Base on concrete runway 04 at 263:21:12:52 G.m.t. (10:22:49:57 MET) on September 20, 1994. The Orbiter drag chute was deployed satisfactorily at 263:21:12:58.6 G.m.t., and nose landing gear touchdown occurred 4 seconds after drag chute deployment. The drag chute was jettisoned at 263:21:13:31.1 G.m.t. with wheels-stop occurring at 263:21:13:54 G.m.t. The rollout was normal in all respects. The flight duration was 10 days, 22 hours, 49 minutes, and 57 seconds.

PAYLOADS

The payloads flown on the STS-64 mission consisted of the following:

a. Lidar In-Space Technology Experiment;
b. Shuttle Pointed Autonomous Research Tool for Astronomy -210;
c. Robot Operated Materials Processing System;
d. Get-Away Specials (10);
e. Air Force Maui Optical Site;
f. Military Application of Ship Tracks;
g. Solid Surface Combustion Experiment;
h. Radiation Monitor Experiment - III;
I. Shuttle Amateur Radio Experiment-II; and
j. Biological Research in Canisters.

In addition to these 10 payloads, located in the payload bay and the middeck areas, hardware for three DTO experiments was also located in the payload bay. These were:

a. Shuttle Plume Impingement Flight Experiment (DTO 830);
b. Simplified Aid for EVA Rescue (DTO 661); and
c. Trajectory Control Sensor (DTO 700-5).

LIDAR IN-SPACE TECHNOLOGY EXPERIMENT

The STS-64 mission was the first flight of the LIDAR In-Space Technology Experiment (LITE) payload, which was developed by the Langley Research Center and flown as a technology test. The LITE provided an opportunity to collect valuable information about the Earth's atmosphere. Over the planned 9-day mission, the LITE was to collect atmospheric data during ten 4 1/2-hour sessions for a total of 45 hours of data.

The LITE instrument provided outstanding data during its 53 hours of operation, more than 8 hours longer than the premission plans. The extra hours became available with the addition of the energy-dependent extension day, as well as ground command operations during the crew stow-time period and the delay in stowing the Ku-band antenna on entry day. The scientists acquired more than 43.5 hours of high-rate data during operations, obtaining unprecedented views of cloud structures, storm systems, dust clouds, pollutants, forest burning and surface reflectance. Data images clearly indicated high cloud cover and dust storms over West Africa and dramatically outlined the structure of the super typhoon Melissa, including unprecedented details of the eye of the storm. Sixty-five teams from 20 countries performed validation measurements with ground-based and aircraft instruments around the Earth to verify LITE's data.

Several laser shutdowns occurred due to coolant loop problems that may have been the result of contamination. Adjustments were made to the monitored-sensor limits to enable proceeding with operations. The degradation of both lasers' output energy required swapping between the two lasers. Laser A was operated until 258:01:22:55 G.m.t. (05:03:00 MET) and again for the last three data takes.

Onboard recording of the high-rate data was corrupted. Replacement of the transport unit (TU) of the high data rate recorder (HDRR), inspection of the cable connections and power cycling the digital data handling unit (DDHU) were unsuccessful in correcting the problem. Further troubleshooting was accomplished after the flight.

The LITE system performed more effectively than originally expected, demonstrating the ability of a LIDAR system to penetrate multiple clouds and aerosol layers down to the Earth's surface. Operations of the instrument in the autonomous mode, accurate boresight of the laser beam, and command of the instrument in both real time and time-executable modes have all been demonstrated.

SHUTTLE POINTED AUTONOMOUS RESEARCH TOOL FOR ASTRONOMY

The Shuttle Pointed Autonomous Research Tool for Astronomy (SPARTAN) -201 studied the acceleration and velocity of the solar wind and measured aspects of the Sun's corona in an effort to explain how the solar wind is generated by the Sun. The solar wind originates in the corona, the outermost atmosphere of the Sun. SPARTAN-201 carried two separate telescopes to study the corona. One telescope, the White Light Coronagraph (WLC), measured the density distribution of electrons making up the corona. The second telescope, the Ultraviolet Coronal Spectrometer (UVCS), investigated the temperatures and distributions of protons and hydrogen atoms through the same layers of the corona.

The SPARTAN-201 was deployed using the RMS at 256:21:30 G.m.t. (03:23:07 MET). The release was extremely stable, with no discernible tip-off rates generated by the RMS. Following deployment, the pirouette maneuver was executed as planned, indicating a healthy attitude-control system. The SPARTAN-201 operated autonomously for approximately 47 hours, gathering data in accordance with its preflight planned program. The Orbiter rendezvoused with the SPARTAN-201 at 258:20:56 G.m.t. (05:22:33 MET), and the SPARTAN-201 was berthed in the payload bay at 258:22:28 G.m.t. (06:00:05 MET). The berthing process required three attempts to obtain all three ready-to-latch indications before the payload was latched.

ROBOT OPERATED MATERIALS PROCESSING SYSTEM

The Robot Operated Materials Processing System (ROMPS) used the microgravity environment to develop commercially valuable methods of processing semiconductor materials. Using the first United States robotics system in space, the ROMPS demonstrated that the use of robotics in space is viable and can reduce the costs of developing and manufacturing semiconductors. All primary mission objectives were accomplished.

The ROMPS flight hardware was contained in a pair of Getaway Special (GAS) canisters that were payload bay sidewall-mounted on a Hitchhiker carrier. One canister contained the samples, sample storage racks, the robot, two furnaces, and some electronics. The second canister contained the control electronics and Hitchhiker interface for power as well as ground links for telemetry and commands.

The ROMPS was activated shortly after launch at 253:00:38 G.m.t. (00:02:15 MET) and initially deactivated at 262:12:30 G.m.t. (09:14:08 MET) for the first landing attempt. After the wave-off of the first landing attempt, the ROMPS was reactivated and finally powered off at 263:13:14 G.m.t. (10:14:59 MET) for landing.

ROMPS successfully completed processing all 100 experimental samples including 32 critical samples processed without thruster firings. Engineering tests of the robot systems and the capaciflector were also accomplished. Operations were nominal except for the intermittent end-of-travel limit tripping on the robot radial axis. The last 22 samples were processed with an uplinked change to the radial arm calibration program that provided a workaround for the problem.

GET-AWAY SPECIALS

The GAS Program continues to provide a means whereby individuals and organizations may conduct experiments in space. A total of 117 GAS payloads have been flown since the beginning of the Space Shuttle Program. The 10 GAS payloads flown on STS-64 include 19 individual experiments as follows:

a. G-178 - Ozone Measurements of Earth's Upper Atmosphere in the Ultraviolet (UV) 200 to 400 Nanometer Spectral Range. This experiment is sponsored by Sierra College.

b. G-254 - Four experiments were flown in the G-254 GAS and they were sponsored by the Kinkaid School and Utah State University. The four experiments plus the power source were:

1. Spacepak 1 - Distillation Experiment;
2. Spacepak 2 - Float Zone Instability Experiment;
3. Spacepak 4 - Pachamama; and
4. Spacepak 5 - Bubble Interferometer Experiment.
5. Spacepak 3 - Power source for all four experiments;

c. G-325 - Sound Effects on Dust Particles in Near Zero Gravity. This experiment was sponsored by the Norfolk Public Schools of Norfolk, VA.

d. G-417 -Three experiments were flown in the G-417 GAS container, and they were sponsored by the Beijing Institute of Environmental Testing in Beijing, China. The three experiments were:

1. Reproduction of Parameciums;
2. Surface Interaction of Different Fluids; and
3. Survey of Surface Interaction of Solids and Liquids.

e. G-453 - Two experiments were flown in the G453 GAS container, and they were sponsored by the Society of Japanese Aerospace Companies, Inc. These experiments were:

1. Formation of Silicon-Lead (Si-Pb) Alloy; and
2. Boiling of Organic Solvent (Freon 113) under Microgravity and in the Absence of Convection.

f. G-454 - Two experiments were flown in the G-454 GAS container, and they were sponsored by the Society of Japanese Aerospace Companies, Inc. The two experiments were:

1. Crystal Growth of 3-Selenic-Niobium (NbSe3) from the Vapor Phase.
2. Crystal Growth of the Optoelectronic Crystal by the Diffusion Method.

g. G-456 - Electrophoresis Experiment. This experiment was sponsored by the Society of Japanese Aerospace Companies, Inc.

h. G-485 - Feasibility of Depositing Different Materials in a Vacuum Environment in Microgravity. This experiment was sponsored by the European Space Agency/ESTEC FTD, The Netherlands.

i. G-506 - Orbiter Stability Experiment. This experiment was sponsored by the Goddard Space Flight Center.

j. G-562 - QUEST-2 Materials Science Experiment. The three experiments were sponsored by the Canadian Space Agency and consisted of the following:

1. Droplet Growth in Liquid-Liquid Systems.
2. Metal-matrix composites for applications demanding high performance.
3. Distribution of Reinforcing Material Produced in Microgravity and in One Gravity.

AIR FORCE MAUI OPTICAL SITE

The AMOS is an electrical-optical facility on the Hawaiian island of Maui. No hardware is required onboard the Orbiter to support the experimental observations of thruster firings, water dumps, etc. The one opportunity planned for this flight on orbit 58 was canceled due to the elevation angle between the Orbiter and Maui being too low for the sensor to acquire and track the Orbiter.

MILITARY APPLICATIONS OF SHIP TRACKS

The Office of Naval Research (ONR) sponsored the MAST experiment on STS-64. MAST is a part of a five-year research program developed to examine the effects of ships on surrounding clouds and aerosols. The experiment was flown under the direction of the Department of Defense (DOD) Space Test Program. Nineteen target opportunities were uplinked to the crew during flight days 3, 4, 7, 9, and 10. The success of this experiment will be determined by postflight analysis.

SOLID SURFACE COMBUSTION EXPERIMENT

The SSCE was flown for the seventh time during the STS-64 mission. This experiment is used to study how flames spread in a microgravity environment. Conducting the flame spreading experiment in microgravity removes buoyant air motion, commonly observed as "hot gases rising", caused by gravity. A comparison made of the microgravity results with the normal-gravity-of-Earth results has provided detailed information about air motion and its effects on flame spreading. Between 255:23:48 G.m.t. (03:01:25 MET) and 256:00:22 G.m.t. (03:01:59 MET), two SSCE burns were completed. Nominal operations were reported; however, further conclusions await completion of the postflight analysis.

RADIATION MONITORING EXPERIMENT

The RME -III measured the crew exposure to ionizing radiation within the Orbiter cabin. The RME-III measured gamma ray, electron, neutron and proton radiation, and calculated the real-time exposure in RADS-tissue equivalent. The RME-III was set-up and stowed in accordance with the flight plan. The first two changes of the memory module occurred near the end of the life expectancy of the batteries, resulting in messages and incorrect times on the modules. The remaining memory module replacements were performed earlier to prevent similar events from recurring. The data were stored and will be analyzed postflight.

SHUTTLE AMATEUR RADIO EXPERIMENT

The SAREX is a joint project of NASA, the American Radio Relay League, and the Radio Amateur Satellite Corporation. This was the fifteenth flight of the SAREX, and the project encourages public participation in the Space Program and supports educational initiatives. All 10 school contacts were completed successfully, and the schools contacted were:

a. Grizzly Hill School, North San Juan, California;
b. Branson School, Ross, California;
c. Crystal Lake South Elementary, Crystal Lake, Illinois;
d. Morocco Elementary School, Morocco, Indiana;
e. Dwight D. Eisenhower Middle School, Laurel, Maryland;

f. Springfield Plains Elementary, Clarkston, Michigan;
g. Francis Howell North High School, St. Charles, Missouri;
h. Central Square Middle School, Central Square, New York;
i STEP/Star Schools - Young Astronauts, Spokane, Washington; and
j Middleton Grange School, Christchurch, New Zealand.

In addition, the crew made some random voice contacts, and once the power limitations were removed on flight day 9, robot packet contacts were also recorded as well as short conversations with personnel including Astronaut Bonnie Dunbar at Star City, Russia.

BIOLOGICAL RESEARCH IN CANISTERS

The Biological Research in Canisters (BRIC) -2 experiment was the facility for basic research on the development and differentiation of Orchard Grass, which is from a major food crop family that provides half of the world's caloric intake from plants. Orchard grass is part of the plant family that includes wheat, rice, and corn.

The BRIC-2 experiment was installed within 24 hours of the opening of the launch window and was removed within three hours of landing. The experiment did not require power or crew interaction. Postflight analysis is required to determine the success of this experiment.

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All SRB systems performed nominally. The SRB prelaunch countdown was normal with no Launch Commit Criteria (LCC) or Operational Maintenance Requirements and Specifications Document (OMRSD) violations.

Power-up and operation of all igniter and field joint heaters was accomplished routinely. For this flight, the low-pressure heated ground purge in the SRB aft skirt was used to maintain the case/nozzle joint temperatures within the required LCC ranges. At T-15 minutes, the purge was changed to high pressure to inert the SRB aft skirt.

Both SRB's were successfully separated from the ET at approximately T+122.6 seconds, and recovery area reports indicate that the deceleration system performed as designed. Both SRB's were observed during descent, and found floating near the retrieval ships.

During the postflight disassembly, a foreign material was found in connector X13W12RP1 of the right-hand aft integrated electronics cable assembly (Flight Problem STS-64-B-01). Analysis of the foreign material is continuing.

Also during the postflight disassembly, debris was found in connectors J4 and J21 of the right-hand forward integrated electronics assembly (Flight Problem STS-64-B-02). Analysis of the debris is continuing.

REDESIGNED SOLID ROCKET MOTORS

All RSRM systems performed nominally and no LCC or OMRSD violations were noted. All RSRM temperatures were maintained within acceptable limits throughout the countdown.

As a result of the very warm atmospheric temperatures present on the day of launch, field joint heaters operated for 13 hours 12 minutes, and this equates to power being applied 14 percent of the time during the LCC time-frame. Likewise, the igniter joint heaters operated for only 19 hours 31 minutes, and this equates to 25 percent of the time during the LCC time-frame. Also, because of the atmospheric temperatures present, aft skirt thermal conditioning was not necessary.

Data indicate that the flight performance of both RSRM's, as shown in the following table, was well within the allowable performance envelopes, and was typical of the performance observed on previous flights. The RSRM propellant mean bulk temperature (PMBT) was 82 °F. The table on the following page presents the performance data for the RSRMs.

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 82 °F		Right motor, 82 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	65.98	66.78	66.21	66.68
I-60, 10^6 lbf-sec	175.72	176.87	176.23	176.81
I-AT, 10^6 lbf-sec	296.85	297.13	296.85	296.64
Vacuum Isp, lbf-sec/lbm	268.6	268.9	268.6	268.4
Burn rate, in/sec @ 60 °F at 625 psia	0.3669	0.36811	0.3677	0.3684
Burn rate, in/sec @ 81 °F at 625 psia	0.3727	0.3739	0.3735	0.3742
Event times, seconds[a]				
Ignition interval	0.232	N/A	0.232	N/A
Web time[b]	109.2	109.0	108.8	108.6
Separation cue, 50 psia	118.9	117.4	118.5	117.5
Action time[b]	120.9	119.8	120.5	119.7
Separation command	123.8	122.5	123.8	122.5
PMBT, °F	82	82	82	82
Maximum ignition rise rate, psia/10 ms	90.4	N/A	90.4	N/A
Decay time, seconds (59.4 psia to 85 K)	2.8	3.1	2.8	2.9
Tailoff Imbalance Impulse differential, Klbf-sec	Predicted		Actual	
	N/A		208.4	

Impulse Imbalance = left motor minus right motor

[a] All times are referenced to ignition command time except where noted by a [2].

[b] Referenced to liftoff time (ignition interval).

EXTERNAL TANK

All objectives and requirements associated with the ET propellant loading and flight operations were met. All ET electrical equipment and instrumentation operated satisfactorily. ET purge and heater operations were monitored and all performed properly. No ET LCC or OMRSD violations were identified, nor were any in-flight anomalies identified.

Typical ice/frost formations were observed on the ET during the countdown. There was no observed ice or frost on the acreage areas of the ET. Normal quantities of ice or frost were present on the liquid oxygen (LO_2) and liquid hydrogen (LH_2) feedlines and on the pressurization line brackets, and some frost or ice was present along the LH_2 protuberance air load (PAL) ramps. These observations indicated acceptable conditions based on NSTS 08303. The Ice/Frost inspection team reported that no anomalous TPS conditions were noted.

The ET pressurization system functioned properly throughout engine start and the flight. The minimum LO_2 ullage pressure experienced during the ullage pressure slump was 13.9 psid.

A number of exposures were made; however, only one usable post-separation ET photograph was taken by the crew using a 35 mm camera with a 300 mm lens and a 2X multiplier. Lighting conditions that were present with the late afternoon launch prevented obtaining more than one image. This one photograph showed 12 divots approximately 6 inches in diameter in the +Y/-Z quadrant of the intertank-to-LH_2 flange closeout. These divots are typical of those observed on previous missions.

ET separation was confirmed. ET entry and breakup were within the predicted footprint, 98 nmi. uprange of the preflight predicted impact point.

SPACE SHUTTLE MAIN ENGINE

All SSME parameters appeared normal throughout the prelaunch countdown and were typical of prelaunch parameters observed on previous flights. Engine ready was achieved at the proper time, all LCC were met, and engine start and thrust buildup were normal.

Flight data indicate that SSME performance during mainstage, throttling, shutdown, and propellant dump operations was normal. High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures appeared to be well within specification throughout engine operation. MECO occurred 514.6 seconds after liftoff, and no failures or problems were noted during the ascent phase. The Isp was rated as 452.5 seconds based on trajectory data.

The SSME 1 high pressure oxidizer turbine (HPOT) intermediate seal pressure shifted upward at engine start minus 5500 seconds. This shift is within the experience base and was possibly due to nose-seal leakage. A similar shift was observed during the green run of this pump.

Also, SSME 1 HPFTP coolant liner pressure exhibited minor random shifts during mainstage operation. The shifts were within the experience base and possibly due to leakage past the static seals.

The SSME 2 and 3 HPOTP rotors slowed down at engine cutoff plus 2.5 seconds. This phenomenon has been observed five times in the past, and this was the second time it has occurred on the SSME 2 HPOTP. It is believed to be caused by interstage seal rubbing.

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the launch countdown, and the SRSS performed as designed throughout the ascent phase.

ORBITER SUBSYSTEMS

Main Propulsion System

The overall performance of the MPS was as expected. LO_2 and LH_2 loading were performed as planned with no stop-flows or reverts. Also, no LCC or OMRSD violations were identified.

Throughout the period of preflight operations, no significant hazardous gas concentrations were detected. The maximum hydrogen concentration level in the Orbiter aft compartment (occurred shortly after the start of fast fill) was approximately 130 ppm, and this compares favorably with previous data from this vehicle.

A comparison of the calculated propellant loads at the end of replenish with the inventory (planned) load results in a loading accuracy of +0.01 percent for LH_2 and +0.03 percent for the LO_2.

The LH_2 and LO_2 pressurization and feed systems performed nominally and satisfied all tank-ullage pressure and SSME inlet net positive suction pressure (NPSP) requirements. Analyses of the propulsion systems during start, mainstage and shutdown operations indicated that performance was nominal and all requirements were satisfied.

The LH_2 and LO_2 propellant dump operations were initiated at MECO + 120.4 seconds as planned. Postflight analyses indicated that the performance was nominal.

The vacuum inerting process was initiated by the OI-23 software. A predicted pressure rise of approximately 30 psi in the hydrogen manifold was exceeded by approximately 3 psi, and this was similar to the previous flight of OI-23 software on STS-65, although the pressure rise was greater on this flight. Because of this excessive pressure rise, the crew manually performed a second vacuum-inerting procedure.

Reaction Control Subsystem

The performance of the RCS was nominal with two in-flight anomalies identified. RCS propellant consumption was 5,111.1 lbm. The left and right aft RCS were interconnected to the OMS at 255:03:08 G.m.t. (02:05:46 MET). The systems operated nominally. The interconnect operations were stopped at 260:15:31 G.m.t.

(07:17:08 MET) with 10.76 percent of propellants from the left OMS and 9.47 percent of propellant from the right OMS (2,615.9 lbm total) used by the RCS.

Six RCS trim firings were performed with nominal subsystem operation. The first RCS trim firing was initiated at 253:02:45:25 G.m.t. (00:04:22:31 MET) using multiple thrusters. The firing was 5 seconds in duration with a ΔV of 1.4 ft/sec. The second firing was initiated at 253:03:33:09 G.m.t. (00:05:10:15 MET) using multiple thrusters. The +Z maneuver was approximately 10 seconds in duration with a ΔV of 3.7 ft/sec. The third RCS trim firing was performed at 254:02:37:55 G.m.t. (01:04:15:00 MET) using thrusters L3A and R3A. The firing duration was approximately two seconds and the resultant ΔV was 0.2 ft/sec. The fourth RCS trim firing was performed at 254:15:25:37.95 G.m.t. (01:17:02:42 MET) using thrusters L3A and R3A. The firing consisted of seven +X pulses over a 25-second period and resulted in a ΔV of 1.5 ft/sec. Vernier RCS thrusters F5R, F5L, and R5R were also fired for three pulses each during this maneuver. RCS trim firing 5 was performed at 256:15:14:24 G.m.t. (03:17:41:29 MET) with a duration of approximately 6 seconds. Thrusters L3A and R3A were used to provide a ΔV of 2.1 ft/sec. RCS trim firing 6 was performed at 256:16:00:34 G.m.t. (03:18:37:39 MET) with a duration of approximately 5 seconds. Thrusters L3A and R3A were used to provide a ΔV of 1.3 ft/sec.

Three major RCS separation maneuvers were performed after the SPARTAN deployment. RCS operation for the first two maneuvers was nominal. During the third maneuver, thruster F4D had a low P_c indication of 70 psia at 256:16:01:22 G.m.t. (03:18:29:27 MET). Sixteen instances of the chamber pressure (P_c) being lower than the normal 150 psia on RCS thruster F4D were noted during the flight (Flight Problem STS-64-V-09). Low P_c has occurred on the last five flights of F4D, with three instances on STS-60 and 11 instances on STS-51. In each case, the next firing of the thruster after a low P_c indication has been at the normal 150-psia level. This low P_c posed no problem for the flight.

The RCS hot-fire was performed at 261:14:53:56 G.m.t. (08:16:31:01 MET). At 261:14:56:05 G.m.t. (08:16:33:10 MET) during the hot-fire, RCS thruster L1A was deselected by the RM software because of low chamber pressure (16 psia) (Flight Problem STS-64-V-03). This was the first firing of the L1A thruster during the mission. The oxidizer valve began leaking immediately after the failure, and the leak detector temperature continued to cycle after the firing attempt. No fuel leakage was detected. The most probable cause of the failure was nitrate contamination in the pilot and/or mainstage of the oxidizer valve, which resulted in a failure of the valve to fully open, thus creating a leak path. Thruster L1A remained deselected for the remainder of the mission. The remaining thrusters operated satisfactorily during the hot-fire.

Orbital Maneuvering Subsystem

The OMS performed satisfactorily during the four maneuvers executed during the flight as are shown in the table on the following page. The total firing time for the left and right OMS engines was 324.2 and 324.1 seconds, respectively, and the total propellants used during the OMS maneuvers was 15,017 lbm.

OMS FIRINGS

OMS firing	Engine	Time, G.m.t./MET	Firing duration, seconds	ΔV, ft/sec
OMS-2	Both	252:22:59:03:8 G.m.t. 00:00:36:03.8 MET	125.4	208.7
OMS-3	Right	258:22:51:47.2 G.m.t. 06:00:28:52.2 MET	17.4	15.0
OMS-4	Left	258:23:36:46.4 G.m.t. 06:01:13:41.4 MET	17.5	15.0
Deorbit	Both	263:20:17:00.5 G.m.t. 10:21:55:05.5 MET	181.3	323.6

Five periods of RCS interconnect operations, for a total time of 4 days 0 hours 3 seconds, were completed during the mission. During the interconnect operation, a total of 20.23 percent of the OMS propellants was consumed by the RCS.

Power Reactant Storage and Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performance was nominal with no anomalies or problems noted. A total of 2502 lbm of oxygen and 315 lbm of hydrogen was provided to the fuel cells for power generation, and 91 lbm of oxygen was provided for crew breathing. At landing, a mission extension capability of 33 hours at an average power level of 13.9 kW remained.

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed nominally with a total of 3660 kWh of electricity generated at an average power level of 13.9 kW. The fuel cells consumed 2502 lbm of oxygen and 315 lbm of hydrogen, with 2817 lbm of water being generated. No fuel cell problems or anomalies were noted during the mission.

Auxiliary Power Unit Subsystem

The APU subsystem performed nominally throughout the STS-64 mission with only one anomaly noted. The APUs were shut down in the order 3, 1, 2 to fulfill the requirements of DTO 414. The results of DTO 414 are discussed in the Development Test Objective section of this report. The fuel consumption and run-time by APU position and serial number are shown in the table on the following page.

Flight phase	APU 1 (S/N 407)		APU 2 (S/N 304)		APU 3 (S/N 306)	
	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb	Time, min:sec	Fuel consumption, lb
Ascent	21:26	54	21:31	59	21:17	56
FCS checkout					6:35	16
Entry[a]	61:06	117	77:18	154	61:08	136
Total	82:32	171	98:49	213	89:00	208

[a] APUs ran for approximately 16 minutes 20 seconds after main gear touchdown.

Hydraulic load tests were performed on all three APUs after landing. The APU performance was nominal.

STS-64 was the first flight of the titanium thermal isolator sleeve located between the gear box and the APU fuel pump. The sleeve was incorporated in all three APUs to replace the previous ceramic sleeve that was incompatible with hydrazine. The fuel pump soak-back temperatures after ascent were 183 °F, 176 °F, and 175 °F for APUs 1, 2, and 3, respectively. These temperatures were well below the 210 °F limit.

Also, the APU 1 gearbox repressurized once during entry at approximately 263:21:00 G.m.t. (10:22:37 MET). The gearbox bottle pressure dropped from 187 psia to 172 psia, and the gearbox pressure increased from about 5.7 psia to 7.0 psia during the repressurization period. This repressurization did not affect any entry operations.

APU 3 exhaust-gas-temperature (EGT) 2 sensor showed erratic performance during entry (Flight Problem STS-64-V-04). The sensor was the most likely cause and it will be replaced prior to the next flight of this vehicle.

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/WSB subsystem performance was nominal during all phases of the mission. No PDU backdriving was observed in the data from the DTO 414 shut down test of the APUs after ascent. No problems or anomalies were identified from the data review. Hydraulics systems load tests were performed after landing, and the hydraulics systems performed nominally.

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performed nominally.

At 254:11:55:42 G.m.t. (01:13:32:47 MET), the aft motor control assembly (MCA) 1 operational status bit 4 transitioned from a 1 to a 0 (Flight Problem STS-64-V-01). At 254:15:03:37 G.m.t. (01:17:41:42 MET), the status bit transitioned back to a 1. No drive currents were detected on the supplying ac bus, nor were any position changes noted in the controller motors. Also, no change in the aft power controller 4 voltage and current measurements occurred during the transition times. The measurement (V76X2254E) is channelized through MDM OA1, card 7, channel 00, and no other measurements on that channel changed states during the period in question. Had the indication remained, at least one additional failure would have been required before a function would have been lost or any corrective action required. This status change did not impact the mission.

Environmental Control and Life Support System

The active thermal control system (ATCS) performed satisfactorily, and all temperatures were maintained within nominal limits.

The flash evaporator system (FES) supply water system A accumulator temperature began cycling between 47 °F and 55 °F at approximately 253:17:41 G.m.t. (00:19:19 MET) (Flight Problem STS-64-V-02). The normal control range for the thermostat is between 55 °F and 75 °F. A comparison with the B supply accumulator temperature indicated that the temperature sensor was partially or totally debonded. The temperature cycles indicate that the heater was operating properly. There was no impact from this condition as the temperature never approached 32 °F. A heater reconfiguration to the B heaters was performed at 257:12:52 G.m.t. (04:14:30 MET), and the same signature was noted, supporting the theory that the temperature sensor was partially or totally debonded. A postflight inspection is required.

The radiator coldsoak provided cooling during entry through touchdown plus 10 minutes when ammonia system B using the primary/GPC controller was activated. System B operated for 38 minutes and was deactivated when the cooling cart was connected to the vehicle. After verification of cooling cart operation was completed, the cooling cart was placed in bypass so it would not be cooling the vehicle. Since the freon coolant loops were still in radiator flow, vehicle cooling was accomplished by convective cooling of the radiator panels using the payload bay purge. The purge air temperature was lowered to 45 °F. The ground cooling cart was not used during this 5-day ferry flight preparation period as the radiator inlet temperature never exceeded 104 °F for 45 minutes (SPARTAN film constraint) and no other OMRSD temperature constraints were violated. All vehicle cooling requirements were satisfactorily met during this 5-day alternate cooling test.

The supply water and waste management systems performed adequately throughout the mission. By the completion of the mission, all of the waste water and supply water in-flight checkout requirements were performed and satisfied.

Supply water was managed through the use of the overboard dump system and the FES. Six supply water dumps were performed, of which two were simultaneous with waste water dumps. The supply water dumps were performed at an average dump rate of 1.56 percent/minute (2.57 lb/min). The supply water dump line temperature was maintained between 63 °F and 108 °F throughout the mission with operation of the line heater.

Waste water was gathered at approximately the predicted rate. Four nominal waste water dumps were performed at an average rate of 1.88 percent/minute (3.1 lb/min). The waste water dump line temperature was maintained between 56 °F and 86 °F throughout the mission, while the vacuum vent line temperature remained between 59 °F and 85 °F and the vacuum vent nozzle remained between 136 °F and 190 °F.

This was the first flight of the supply water dump line purge assembly (SWDLPA). The SWDLPA was designed to provide an automatic air purge of the supply water dump line at the completion of each water dump to prevent the dump valve from "burping." On previous missions of this vehicle, the burping has been known to occur up to 10 times. An air purge has been used to stop the burping condition on those flights. Despite the automatic air purge on STS-64, data indicate a singular event of internal leakage through the supply water dump valve after the third and sixth supply water dumps. Although this is significantly better than previous missions, some refinement to procedures will be necessary for future flights.

The waste collection system (WCS) performed nominally throughout the mission with no problems or anomalies identified.

The atmospheric revitalization system (ARS) performed satisfactorily, maintaining the crew compartment environment with the required specifications. Data were collected for DTO 664 - Cabin Temperature Survey.

The atmospheric revitalization pressure control system (ARPCS) system performed normally throughout the duration of the flight. The cabin pressure was allowed to bleed down to conserve GN_2 for a minimum SAFER recharge pressure requirement. At 258:14:32 G.m.t. (05:16:09 MET), the cabin was depressurized to 10.2 psia to support the planned SAFER EVA. The cabin was repressurized to 14.7 psia, using the 14.7-psia cabin regulators, at 259:21:33 G.m.t. (06:23:10 MET) after the EVA and redundant component check were performed. Both systems exhibited normal operation.

Airlock Support System

The airlock system performance was nominal throughout the flight. The airlock depressurization valve was used to depressurize the cabin from 13.15 psia to 10.2 psia. The depressurization valve was also used to depressurize the airlock to vacuum at 259:14:27 G.m.t. (06:16:04 MET) in support of the SAFER EVA. After the EVA, the equalization valve was used to equalize the cabin and airlock pressures, and the cabin pressure regulators were used to raise the cabin pressure to 14.7 psia. The active system monitor parameters indicated normal outputs throughout the flight.

Smoke Detection and Fire Suppression Subsystem

The smoke detection system showed no indications of smoke generation during the entire flight. Use of the fire suppression system was not required.

Avionics and Software Systems

The ascent and entry guidance, navigation and control (GN&C) subsystem performed nominally. The on-orbit GN&C was also nominal during operations in support of the SPARTAN deployment and retrieval, LITE operations, SPIFEX operations, and the EVA.

The FCS performed nominally. The touchdown and slapdown was nominal with a descent rate of less than 2.0 ft/sec at touchdown, and a slapdown rate of approximately 5.5 deg/sec with elevon limiting occurring at -2.5 degrees down. No unusual oscillations were observed either during the touchdown, slapdown, or rollout phases. During the landing phase, the Commander achieved the desired 2-second time period between derotation initiation and a steady-state pitch rate of 1.0 to 1.25 deg/sec before elevon limiting engaged to allow slapdown at a higher rate.

The high accuracy inertial navigation system (HAINS) inertial measurement units (IMUs) serial numbers 209, 212, and 216 in slots 1, 2, and 3, respectively, performed very satisfactorily. For the first time in the Space Shuttle Program, no gyroscope or accelerometer uplink compensations were required because of the accuracy of these units. Drift on all units never exceeded one sigma (0.006 deg/hr).

The performance of the star tracker was also nominal with no problems noted.

The OI-23 software was flown for the second time and its performance was nominal. The only software anomaly noted was found on September 12 during a deorbit preparations training session on the SMS. A BFS display interface loss condition was discovered after a BFS IPL followed by being moded to halt (Flight Problem STS-64-V-06). When the BFS was later taken from halt to standby and assigned a CRT, the crew noted a big "X" without a "POLL FAIL" on the BFS CRT.

The crew attempted to assign the BFS to other CRTs, but the BFS showed the same signature on all CRTs assigned to it. Analysis of the GPC dump collected during the simulation showed that the BFS was halted while the MUM was either active or suspended. The signature of this condition is clearly recognizable, the probability of occurrence is low, and the BFS can be recovered by a re-IPL.

Analysis of the BFS software revealed an additional scenario in which a "big X with no POLL FAIL" can occur on a BFS display. This scenario involves a transition back to OPS 0 where the MUM gets suspended prior to the initiation of the OPS transition. The transition back to OPS 0 makes the incompleted task MUM inactive and thus the flag

MUM DONE is not properly set to continue display updating. This is the same type of problem described earlier, but the window of exposure is considerably smaller. The corrective actions for both problems are the same.

The condition (Flight Problem STS-65-V-06) subsequently revealed itself during flight when, during the conduct of procedures to back out of the initial deorbit preparations, the BFS was moded from Halt to Standby and an X appeared on the CRT display. The crew performed an IPL and the BFS returned to normal operation.

At 259:21:56 G.m.t. (06:23:34 MET) a "CRT BITE 1" message was annunciated. The BITE was attributed to a previously defined condition (User Note 55331) in which two key strokes are made in rapid succession. The crew implemented the display electronic unit (DEU) malfunction procedures and reported no BITE indication in the contents of the BITE registers when the Item B of the operational test procedure (OTP) was executed. As specified in User Note, Item D should be used to view the contents of the BITE register buffer location where the error information is preserved. When a critical BITE occurs, the contents of the BITE registers are stored in a buffer area in the DEU memory. When the DEU is subsequently polled, the error information is returned in the poll response, and the registers are then cleared so that the registers only contain the information until the first poll following the occurrence of the error. Item B of the OTP displays the contents of the BITE registers, which have been cleared as a result of the GPC polling the DEU, and this explains why the BITE registers were nominal. The GPC polling indicates that the error condition seen in the poll response was a transient condition.

The displays and controls subsystem performed satisfactorily; however, one payload bay floodlight (mid starboard or aft port) showed evidence of arcing during the payload bay door closure for both landing attempts. The light appeared to be functioning properly.

Communications and Tracking Subsystem

The communications and tracking subsystem operated acceptably throughout the mission. A number of problems and anomalies were identified; however, none of these impacted the mission.

S-band communications were lost for four minutes after MECO during the handover from Wallops Island to the TDRS East. Analysis shows that the Orbiter vehicle subsystems were performing properly throughout this period. Similar losses of the Orbiter return link were also noted on STS-52 and STS-53. Postflight troubleshooting of the TDRS network was conducted after landing.

In addition, there were two instances when the Orbiter return link was lost while the forward link remained operational. The losses have been attributed to problems in the software at the second TDRS ground terminal.

The Ku-band radar failed to lock on the SPARTAN payload following deployment (Flight Problem STS-64-V-05). The Ku-band passed several self-tests during the first hour after deployment with nominal results. Multiple searches were performed in both the GPC and Auto modes with the output power in high and low and the range set in minimum and automatic, all without success. Approximately one hour after SPARTAN deployment, the Ku-band acquired the target, and remained locked on until the communications mode was selected. The Ku-band radar acquired the SPARTAN at 128,000 ft during retrieval activities, with lock-on remaining until 81 ft. All Ku-band operations during rendezvous were nominal.

During SPARTAN deployment operations, the berthing camera failed to operate (Flight Problem STS-64-F-03). Analysis has shown that the label on the A7 panel for the push-button that selects the SPARTAN berthing camera was placed on the wrong push-button. The PL3 button, which was labeled as a video tape recorder, was the correct button. The camera worked properly when the correct button was depressed.

There were two instances when the Orbiter return link was lost while the forward link remained operational. The first loss occurred when acquiring the TDRS West, and the second occurred several orbits later four minutes after an early handover to the TDRS East. The losses were caused by a software problem at the second TDRS ground terminal when the hourly vector was initiated too close to the service-start time and time was not available for proper processing of the vector. A workaround was established to prevent an hourly vector from being accepted within 10 minutes of service-start time. Following this change, no additional occurrences of the anomaly were noted.

During landing, just prior to navigation selecting TACAN data, TACAN 1 experienced a 40-degree bearing data shift and RM deselected TACAN 1 bearing data. Immediately after the TACAN 1 bearing data was deselected, TACAN 1 bearing data recovered and operated nominally for the remainder of landing.

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation (OI) and modular auxiliary data system (MADS) operated nominally.

The FES supply water system A accumulator temperature cycled between 48 °F and 55 °F for most of the mission. Analysis showed that this condition was most probably caused by a debonded temperature sensor. A more detailed discussion of this anomaly is contained in the Environmental Control and Life Support section of this report.

At approximately 256:13:54:00 G.m.t. (03:15:31:05 MET), the crew selected the "quiescent" format (17), which was then loaded into payload data interleaver (PDI) decommutator 4. The BITE bits for decommutator 4 went high and those for decommutator 1 went low as expected. About two minutes later, the crew selected the "regular" format; the BITE bits for decommutator 1 went high again as expected, but only the bit rate accuracy bit for decommutator 4 BITE went low (Flight Problem STS-64-V-07). The bit-lock, word-lock, and master-frame-lock bits for decommutator 4 went low approximately 22 minutes later at 256:14:20:00 G.m.t. (03:15:57:05 MET). No payload data were lost by this occurrence, nor was any data loss anticipated if the event should recur. Postflight troubleshooting is required to resolve this anomaly.

Structures and Mechanical Subsystems

The structures and mechanical subsystems performed nominally throughout the mission with no problems or anomalies identified. The drag chute was deployed nominally and performed as designed. The landing and braking data are shown in the following table.

Landing and Braking Parameters

Parameter	From threshold, ft	Speed, keas	Sink rate, ft/sec	Pitch rate, deg/sec
Main gear touchdown	3386	198.3	~ 1.0	N/A
Nose gear touchdown	7192	153.8	N/A	~5.8

Brake initiation speed	127.5 knots (keas)
Brake-on time	44.2 seconds
Rollout distance	9,656 feet
Rollout time	61.5 seconds
Runway	0433 (Concrete) EAFB
Orbiter weight at landing	212,179.5 lb

Brake sensor location	Peak pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	714	Left-hand outboard	9.29
Left-hand inboard 3	714	Left-hand inboard	12.20
Left-hand outboard 2	714	Right-hand inboard	23.62
Left-hand outboard 4	674	Right-hand outboard	18.96
Right-hand inboard 1	753		
Right-hand inboard 3	938		
Right-hand outboard 2	674		
Right-hand outboard 4	780		

Integrated Aerodynamics, Heating and Thermal Interfaces

The ascent and entry aerodynamics were nominal with no problems or anomalies identified. DTO 254 - Subsonic Aerodynamics Verification - was performed during final approach. The results are discussed in the Development Test Objective section of this report.

The aerodynamic and plume heating during the ascent phase were nominal, based on the evaluation of the vehicle telemetry data and the physical appearance of the plumes. The entry aerodynamic heating was also nominal; however, heating calculations and data evaluation are continuing.

The performance of the thermal interfaces was satisfactory with all temperatures and pressures maintained within limits. In addition, the aft compartment helium concentration showed that all leakages in that area were within the experience base.

Thermal Control Subsystem

The performance of the thermal control subsystem was nominal during all phases of the mission, and all Orbiter subsystem temperatures were maintained within acceptable limits.

Aerothermodynamics

The entry acreage heating, as well as local heating, were within nominal limits and indicated average heat loads. All structural temperatures were maintained within limits and thermal protection subsystem (TPS) damage was average. The structural-temperature rises were within the experience base, and the rises were symmetrical on the right and left wing.

Thermal Protection Subsystem

The TPS performed satisfactorily. Based on structural temperature response data (temperature rise), the entry heating was above average, but not beyond previous flight experience. Boundary layer transition from laminar to turbulent flow occurred 1270 seconds after entry interface (EI) on the forward centerline of the vehicle. At the aft right and left sides of the vehicle, transition occurred at 1255 seconds, and was symmetrical from right to left on the vehicle.

The crew reported that an AFRSI blanket on the port OMS pod was partially detached near the AFRSI/LRSI interface. Downlinked video provided a detailed view of the AFRSI blanket damage. A small triangular tear in the blanket coating about 2 in. by 0.75 in. was seen at the interface between the tiles and the blanket. The batting beneath the torn cloth appeared to be intact. Similar damages to this particular blanket have occurred (ref. STS-50, OV-102, LP05) with no resulting damage to the underlying structure. The blanket is through-stitched on 1-inch centers, so the area of the cover damage could not increase. The blanket damage seen in this view did not represent an on-orbit or entry concern.

Based on a runway and a Mate/Demate Device inspection of the TPS, overall debris damage was slightly above average. The number of hits on the lower surface greater than one inch was slightly higher than average. Data indicate that the Orbiter had a total of at least 173 hits of which 22 had a major dimension of one inch or greater. This total does not include the numerous hits on the base heat shield that are attributed to the flame arrestment sparkler system.

The Orbiter lower surface sustained a total of 116 hits of which 18 had a major dimension of one inch or greater. A total of 57 hits were found just aft of the liquid hydrogen umbilical door with four of the hits having a major dimension greater than one inch. The upper surface of the Orbiter had one hit, the right side had seven hits with one hit having a major dimension greater than 1 inch, the left side had two hits, the right OMS pod had 16 hits, and the left OMS pod had eight hits.

Two sections of the mechanically attached main-landing-gear door (MLGD) thermal barrier (18 inches in length), including the carrier panel, were missing from the aft inboard area of both the right and left main gear wells (Flight Problem STS-64-V-08) at landing. These items fell from the vehicle during main gear deployment and were found approximately 4,000 ft from the runway 04 threshold. Neither of the barriers showed any damage, and no carrier plate damage was evident. Each barrier assembly is normally clipped in place for flight; however, a review of the enlarged closeout photos taken prior to the mission show that the spring clips, which lock the thermal barriers in place, were not engaged on the right-hand thermal barrier. The loss of both thermal barriers is attributed to improper installation. The right-hand thermal barrier apparently caused five damage sites on the tile just aft of that location.

The nose cap and chin panel tile areas were in good condition. The nose landing gear door (NLGD) thermal barriers were in good condition with a 1-inch breach noted. A tile on the aft right-hand edge of the NLGD lost a 2.5 inch by 0.75 inch repair.

Light window hazing was reported on windows 3 and 4, with a number of streaks were evident on window 4. Debris hits were found on the peripheral tiles around windows 2, 3, 4, and 5.

The MLGD thermal barriers (new) were in good condition other than the two barrier segments that fell out. No thermal damage was noted in the area, supporting the postulation that the barriers fell out when the MLGDs were opened.

The damaged AFRSI blanket on the left-hand OMS pod showed little or no degradation. The ET door thermal barriers were in satisfactory condition; however, a 1.5-inch by 1.0-inch repair was missing from an ET door tile. The elevon/elevon gap tiles were in good condition, with a protruding gap filler on the right-hand side. The engine dome-mounted heat shield blankets looked good except for minor cover damage on SSME 1 at the 6 o'clock position. Base heat shield peppering was nominal. No damage occurred to tiles as a result of the drag chute deployment.

REMOTE MANIPULATOR SYSTEM

The remote manipulator system (RMS) performed very satisfactorily throughout the flight. The RMS checkout procedure was initiated at 253:17:29 G.m.t. (00:19:06 MET). The checkout, which required about 47 minutes to complete, verified that the RMS was functioning properly. At 253:20:22 G.m.t. (00:22:00 MET), the first day of SPIFEX operations began with the grappling and unberthing of the SPIFEX boom; however, experiment operations were delayed about 1 hour 20 minutes because of SPIFEX problems. A total of 34 test positions were completed before the RMS was placed in the overnight park position.

During several of the RCS firings for the SPIFEX operations, some small degree of brake slippage was noted. This slippage had been predicted prior to flight and was not considered a problem. However, in one instance, a brake slip annunciation was received because of the cumulative slip from two thruster firings. While each brake slip was about 0.3 degree, which does not trigger the alarm, the cumulative slip was greater than the 0.5-degree threshold of the annunciation. The preflight analysis had not considered that several test points required several thruster firings with the RMS in the same position, and that means that the brake slip function was not reset between thruster firings.

STS-64 was the first RMS flight with the OI-23 software, which also incorporated the position orientation hold select (POHS) mode of operation for the RMS. Although there were minimal manual augmented mode operations during the flight, the data indicate that the POHS behaved as expected. The steady-state position accuracy was well within the 1-inch and 0.5-degree requirement. A review of the data shows that the RMS performed as expected during the POHS operations.

On flight day 3, the RMS was again used to perform SPIFEX operations. A total of 33 additional test positions was completed. Brake slippage was noted during some RCS firings, but it was expected. The RMS was again parked for the night. Flight day 4 activities included the last two test positions prior to the SPARTAN-201 operations and the SAFER EVA. The SPIFEX was reberthed for later use during the extension day.

On flight day 5, the SPARTAN-201 activities were initiated in preparation for the release of the satellite. The SPARTAN-201 was released at 256:21:30 G.m.t. (03:23:07 MET), and the Orbiter performed two separation maneuvers.

After an uneventful rendezvous on flight day 7, the SPARTAN-201 was grappled at 258:21:01 G.m.t. (06:22:38 MET). On flight day 8, the RMS was used by the EVA crew members during an evaluation of the SAFER unit.

Flight day 9 was added to the mission as an experiments day because of the conservation of consumables during previous days of the mission. The remaining

SPIFEX test positions that were not completed on the fourth flight day were accomplished. The SPIFEX was berthed, the RMS was returned to the stowed position and cradled.

GOVERNMENT FURNISHED EQUIPMENT/FLIGHT CREW EQUIPMENT

The Government furnished equipment (GFE)/flight crew equipment (GFE/FCE) performed very satisfactorily except as discussed in the following paragraphs.

Following the completion of post-insertion procedures, the crew reported that the side-hatch locking device could not be installed because of an obstruction (Flight Problem STS-64-F-02). One of the crew members carries this device in the pocket of his/her suit, and the device is installed as one of the first activities after ascent. The crew downlinked video of the area involved, and analysis of the video did not clearly show the cause of the obstruction. Postflight inspection and analysis showed that the locking device was oversized when compared to the drawing. This particular device had not been flown nor fit-checked previously; consequently, this error had not been found.

At approximately 255:18:00 G.m.t. (02:19:38 MET), the Commander reported a problem when filling some of the drink bags (Flight Problem STS-64-F-01). The problem drink bags have a restricted septum caused by excessive heat application during manufacture that caused the partial collapse of the channel in the septum adapter assembly. Testing has shown that approximately 50 percent of the drink bags suspected of having this problem had a collapsed channel. This restriction resulted in a smaller-than-normal quantity of water entering the bag. The crew was briefed on methods for dealing with this problem prior to the flight.

During SPARTAN deployment operations, the berthing camera failed to operate (Flight Problem STS-64-F-03). Analysis has shown that the label on the A7 panel push-button that activates the SPARTAN berthing camera was placed on the wrong push-button. The PL3 button, which was labeled as a video tape recorder, was the correct button. The camera worked properly when the correct button was depressed.

During SPARTAN deployment operations, the TCS (Development Test Objective [illegible]-3), had problems acquiring SPARTAN as a target. The problem was traced to a Y cable between the TCS and the PGSC (Flight Problem STS-64-F-04). A plan was developed and uplinked to the crew to swap the connectors on the Y cable. This was accomplished, and the TCS was operational for SPARTAN retrieval.

The RMS elbow camera exhibited periodic horizontal jitter beginning at 259:15:12 G.m.t. (06:17:50 MET). At 259:16:34 G.m.t. (06:18:12 MET), the camera temperature had increased 5 °F and the camera was operating properly.

EXTRAVEHICULAR ACTIVITY

The EMU checkout was successfully completed on flight day 6 with no anomalies. During the checkout, both EMUs functioned properly, all communications modes were verified to be operational, and the EMUs were ready to support contingency EVA operations on flight day 6, but no contingency EVA was required.

The crewmembers donned their EMUs and power was applied at 259:12:00 G.m.t. (06:13:28 MET). The communications checks required about 25 minutes to complete, and biomedical data were being received on the ground, but the data were not being processed. After a change in the Mission Control Center to the correct telemetry format load (TFL), the Flight Surgeon verified that good data were received and processed. Because the cabin depressurization to 10.2 psia had occurred less than 24 hours earlier, the prebreathe period was increased from 40 minutes to 50 minutes. The 50-minute in-suit prebreathe period was completed and the hatch was opened at 259:14:39:28 G.m.t. (06:16:16:33 MET). The EVA officially began at 259:14:42:00 G.m.t. (06:16:19:05 MET) when the EMUs went on internal power. The two crewmembers began the first untethered EVA since 1984, and the twenty-eighth EVA of the Space Shuttle Program.

The main purpose of the EVA was to test the SAFER unit (DTO 661). This unit is an emergency rescue system designed by JSC to provide a return capability for an astronaut who may become separated from the Orbiter or Space Station. The SAFER unit is approximately 1/4 of the weight of the Manned Maneuvering Unit (MMU). It carries three pounds of nitrogen that can be fed through 24 thrusters for up to one minute at a time to move an adrift astronaut at up to 10 ft/sec.

After a short familiarization period for becoming accustomed to working in the space environment with the SAFER, each crew member performed an engineering evaluation, an EVA self-rescue demonstration, and finally an overall flight quality evaluation, which entailed a demonstration of precision flying by tracking the RMS arm. The final task of the EVA was the articulating portable foot restraint (APFR) evaluation. During the first engineering evaluation, spin rates as high as 40 deg/sec were imparted (30 deg/sec planned preflight) to the EV1 crewmember, and the crewmember was able to stabilize himself from this spin rate.

The EVA was conducted in a benign thermal environment, and the metabolic rates reflected this condition. During the crew debriefing, the EV2 crewmember reported that his feet got extremely cold.

During the EVA, seven nitrogen recharges of the SAFER unit were performed. The RMS was used extensively during the SAFER evaluation, and all systems performed nominally. After completion of the planned SAFER EVA activities, the crew members ingressed the airlock. The EMUs were connected to Orbiter power at

259:21:31:21 G.m.t. (06:23:08:26 MET) for a total official EVA time of 6 hours 51 minutes.

Two EVA equipment anomalies were noted during the EVA. The articulating portable foot restraint (APFR) thermal cover interfered with the full insertion of the APFR simulator into the SPARTAN mission peculiar experiment support structure (MPESS) portable foot restraint (PFR) socket during the APFR load-limiter evaluation (Flight Problem STS-64-F-05). The thermal cover was peeled back and the APFR simulator fitted properly. Also, two electronic cuff checklist (ECC) anomalies were noted during the EVA (Flight Problem STS-64-F-06). The ECC-1 did not always respond when the upper middle sextant was depressed. Secondly, during an attempt to update the contents of ECC-2, a "WRITE ROM ERROR" message was displayed on the payload general support computer (PGSC) by the update application. ECC-2 was still usable for the EVA as the crew proceeded with the update despite the error message.

A discussion of the SAFER unit evaluation is contained in the Development Test Objective section of this report.

CARGO INTEGRATION

All cargo integration hardware performed nominally and no anomalies or problems were noted.

DEVELOPMENT TEST OBJECTIVE/DETAILED SUPPLEMENTARY OBJECTIVE

A total of 24 Development Test Objectives (DTOs) and 17 Detailed Supplementary Objectives (DSOs) were assigned to the STS-64 mission. Data were collected on 22 of the 24 DTOs and on all 17 of the DSOs. The following paragraphs discuss the results of each DTO and DSO, if the results are known.

DEVELOPMENT TEST OBJECTIVES

DTO 254 - Subsonic Aerodynamics Verification - This DTO was performed during the final approach to runway 04 at Edwards Air Force Base, CA. Postflight data evaluation is required because the data are recorded on the MADS recorder which is dumped postflight. Data were given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 301D - Ascent Structural Capability Evaluation - This DTO was performed during the ascent phase of the mission. Postflight data evaluation is required because the data were recorded on the MADS recorder which is dumped postflight. The data were given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 305D - Ascent Compartment Venting Evaluation - This DTO was performed during the ascent phase of the mission. Postflight data evaluation is required because the data were recorded on the MADS recorder which is dumped postflight. The data were given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 306D - Descent Compartment Venting Evaluation - This DTO was performed during the entry phase of the mission. Postflight data evaluation is required because the data were recorded on the MADS recorder which is dumped postflight. The data were given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 307D - Entry Structural Capability - This DTO was performed during the entry phase of the mission. Postflight data evaluation is required because the data were recorded on the MADS recorder which is dumped postflight. The data were given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 312 - ET TPS Performance (Method 3) - Photography of the STS-64 ET (after separation) was attempted. Eleven exposures were made on magazine 1. The ET with the moon in the background is imaged on one frame (03). The +X/-Z side of the ET is visible. Approximately 10 divots are visible on the LH_2 tank/intertank closeout flange. A divot is also visible on the LH_2 tank acreage just aft of the intertank closeout flange. A white object (probably frozen hydrogen) is imaged on frames 4 and 5. The single exposure of the ET is good, and timing data are present on the film. There is a slight blurring of the image that was probably caused by soft focus or motion smear. The 11 exposures were taken over a 1-minute 44-second period.

Video of the STS-64 ET after separation was not acquired by the crew.

DTO 319D - Orbiter/Payload Acceleration and Acoustics Environment Data - Data were acquired at the planned times. Postflight data evaluation is required because the data were recorded on the MADS recorder which is dumped postflight. The data were given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 414 - APU Shutdown Test (Sequence A) - This DTO was performed to continue the investigation into an anomalous 40-second hydraulics system 3 supply pressure hang-up observed when APU 3 was shut down early during ascent on STS-54. The DTO was performed with an APU shutdown sequence of 3, 1, and 2,with at least 5 seconds between APU shutdowns. No anomalous pressure hang-ups or power drive unit (PDU) back-driving were noted.

DTO 520 - Edwards Lakebed Runway Bearing Strength and Rolling Friction Assessment for Orbiter Landings - This DTO was not performed as the landing was on concrete runway 04 at Edwards Air Force Base.

DTO 524 - Landing Gear Loads and Brake Stability Evaluation (Data Collection Only) - Data were collected for this DTO and have been given to the sponsor for later evaluation.

DTO 659 - EDO Treadmill Evaluation (Preflight plans require no power) (Configuration 2) - The Extended Duration Orbiter (EDO) treadmill performed well in the unpowered state as well as the powered configuration. After energy became available on flight days 9 and 10, treadmill operations were accomplished in the powered-up configuration.

DTO 661 - Simplified Aid for Extravehicular Activity Rescue - The SAFER unit was designed and developed by Johnson Space Center (JSC). The SAFER unit is a small, self-contained, propulsive backpack device that provided free-flying mobility for a space-walker. A stranded detached space-walker can perform a self-rescue in the event no other means of rescue are available.

The SAFER unit was attached to the space suit's portable life support system backpack and became, in essence, a scaled-down miniature version of the MMU flown on the Space Shuttle in 1984.

During the EVA, seven nitrogen recharges of the SAFER unit were performed. The RMS was used extensively during the SAFER unit evaluation, and all systems performed nominally.

DTO 664 - Cabin Temperature Survey - The planned measurements of cabin temperature were taken, and these data have been given to the sponsor for evaluation. Results of this DTO will be published in separate documentation.

DTO 671 - EVA Hardware for Future Scheduled EVA Missions - This hardware was tested during the SAFER EVA. Evaluations of each piece of hardware were given to the sponsors during postflight debriefings. The results will be published in separate reports.

DTO 672 - EVA Electronic Cuff Checklist - The ECC was used during the EVA. The ECC 1 touch-screen upper middle sextant did not consistently respond. However, during post-EVA activities, the screen responded normally. Secondly, only 1 of 6 pages were able to be transferred from the PGSC to ECC 2. Postflight inspections will be required to determine the cause of these problems.

DTO 673 - EDO Rower Ergometer Evaluation (Preflight plans require no power) (Configuration 2) - Data for this DTO have been given to the sponsor. The results of the evaluation will be reported in separate documentation.

DTO 674 - Thermo-Electric Liquid Cooling System Evaluation (for two crewmembers) - The launch/entry suit (LES) thermo-electric (TE) cooling unit data logger displayed a spurious flashing signature on its LCD during deactivation on-orbit. During the deactivation, two resets were performed and the recorder was powered down in accordance with the instructions located on the data logger. Checkout of the data logger was considered a secondary objective of DTO 674, and the logger was used to gather performance data from the cooling system. The problem that occurred during the deactivation of the data logger did not affect the performance of the cooling system. The spurious flashing signature most probably resulted from completely depressing only one of two membrane-type buttons that should have been pressed simultaneously.

DTO 700-2 - Laser Range and Range Rate Device - The Laser Range and Range Rate Device was used during the SPARTAN deployment and retrieval. The crew reported that the hand-held Light Distance and Ranging (LIDAR) data compared well with the radar and the navigation filter results. The results have been given to the sponsor for evaluation, and the results of the evaluation will be published in separate documentation.

DTO 700-5 - Payload Bay Mounted Rendezvous Radar - During SPARTAN deployment operations, the TCS) had problems acquiring the SPARTAN as a target. The problem was traced to a Y-cable between the TCS and PGSC (Flight Problem STS-64-F-04). A plan was uplinked to the crew to exchange the connectors on the Y cable. This was done and the TCS was operational for SPARTAN retrieval.

DTO 700-7 - Orbiter Data for Real-Time Navigation Evaluation - The Orbiter Data for Real-Time Navigation Evaluation experiment was used in conjunction with DTOs 700-2 and 836. Based on the response from the latter two DTOs, this DTO apparently performed as expected. The data have been given to the sponsor for evaluation and the results of that evaluation will be reported in separate documentation.

DTO 805 - Crosswind Landing Performance - The Crosswind Landing Performance was not performed as the winds were not of sufficient magnitude.

DTO 830 - The Shuttle Plume Impingement Flight Experiment - The Shuttle Plume Impingement Flight Experiment (SPIFEX) was designed and built at JSC, for the study of the characteristics and behavior of exhaust plumes during RCS thruster firings. The unit, when picked up by the RMS, was a 33-foot extension for the arm and contained a package of instruments that measured the near-field, transition, and far-field effects of thruster plumes. The plume information gathered by the experiment will assist planners in understanding the potential effects of thruster plumes on large space structures, such as the Russian Space Agency's Mir Space Station and the International Space Station, during future Shuttle docking and rendezvous operations.

The SPIFEX was moved by a series of complex mechanical RMS maneuvers to take measurements of 86 separate test firings of the RCS thrusters at 60 different locations.

The SPIFEX was first grappled at 253:20:40 G.m.t. (00:02:17 MET), with unberthing occurring three minutes later. Prior to the first berthing on flight day 4, 80 of 86 preplanned test points plus an additional two test points had been completed. As predicted, a dual thruster (F1F and F2F) firing caused the boom to move about 6 inches and the RMS wrist brake to slip. On the energy-dependent extension day, flight day 9, SPIFEX was again unberthed and an additional 18 test points were achieved before the boom was berthed for entry at 260:21:07 G.m.t. (07:22:44 MET).

On the initial start-up of the SPIFEX, communications with the data system were acquired and then were lost. Cycling the circuit breaker allowed communications to be re-established with the boom. This problem occurred a number of times, and each time the system was recovered with a power cycle. Health-monitoring data showed all systems were in excellent health. Data download interruptions interfered with the data transfer to the PGSC. The problem was believed to be caused by the high baud rate being shipped through the RMS. All data were eventually transferred to the PGSC. On the energy-dependent extension day, the system did not acquire power. Recovery of the power occurred after the PGSC was rebooted and connectors demated and mated.

DTO 832 - Target of Opportunity Navigation Sensors - Data were acquired at the planned times. Postflight data evaluation is required. The data have been given to the sponsor for evaluation, and the results will be published in separate documentation.

DTO 836 - Tools for Rendezvous and Docking Test 1 and 2 - The requirements of the Tools for Rendezvous and Docking (TRAD) DTO, for STS-64 only, were fulfilled by the requirements specified in DTO 700-2, 700-5, and 700-7. The data have been given to the sponsor for evaluation, and the results will be reported in separate documentation.

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 482 - Cardiac Rhythm Disturbances During Extravehicular Activity - Data collected during the EVA for the Cardiac Rhythm Disturbances during EVA have been given to the sponsor for evaluation. The results of the evaluation will be published in separate documentation.

DSO 483 - Back Pain Pattern in Microgravity - Data were collected for this DSO, and these data have been given to the sponsor for evaluation. The results of the evaluation will be reported in separate documentation.

DSO 487 - Immunological Assessment of Crewmembers - Data were collected for this DSO during the preflight and postflight periods. These data have been given to the sponsor for evaluation, and the results of the evaluation will be reported in separate documentation.

DSO 489 - EVA Dosimetry Evaluation - Data were collected during the EVA for this DSO, and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 491 - Characterization of Microbial Transfer Among Crewmembers - Data were collected during the preflight and postflight periods. These data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DSO 603 - Orthostatic Function During Entry, Landing, and Egress (603C Schedule) - Data were collected during the planned periods, and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 604 - Visual-Vestibular Integration as a Function of Adaptation [OI-3(b)] - Data were collected as planned, and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 605 - Postural Equilibrium Control During Landing/Egress - Data were collected during the preflight and postflight periods for this DSO. These data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 610 - In-Flight Assessment of Renal Stone Risk - In-flight samples were collected for this DSO. These samples were evaluated during postflight operations and the results have been given to the sponsor. The results of that evaluation will be reported in separate documentation.

DSO 612 - Energy Utilization - Data were collected for this DSO. These data have been given to the sponsor for evaluation, and the results of this experiment will be reported in separate documentation. The glucometer, Ketone sticks, and Metabolic Gas Analysis System were not flown on STS-64.

DSO 614 - The Effect of Prolonged Space Flight on Head and Gaze Stability During Locomotion (Protocol B) - Preflight and postflight data were collected, and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 621 - In-Flight Use of Florinef to Improve Orthostatic Intolerance Postflight - Data were collected during preflight and postflight operations in support of this DSO. These data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DSO 624 - Preflight and Postflight Measurement of Cardiorespiratory Responses to Submaximal Exercise - Data were collected during preflight and postflight exercise periods and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 626 - Cardiovascular and Cerebrovascular Responses to Standing Before and After Space Flight - Data were collected during the preflight and postflight operations, and these data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 901 - Documentary Television - Video was collected throughout the flight in support of this DSO. These data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

DSO 902 - Documentary Motion Picture Photography - Photographic data were collected as time permitted throughout the flight in support of this DSO. These data have been given to the sponsor for evaluation. The results of that evaluation will be reported in separate documentation.

DSO 903 - Documentary Still Photography - Photographic data were collected as time permitted throughout the flight in support of this DSO. These data have been given to the sponsor for evaluation, and the results of that evaluation will be reported in separate documentation.

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

On launch day, 22 videos of the launch activities were screened and no anomalous conditions were noted. The following day, 52 of 54 planned films of launch activities were also screened. Film from two cameras was lost because of camera problems. No anomalies were noted in the review of the launch film.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

An assessment was made of two items that were viewed on a downlink of video taken by the payload bay cameras during a survey of the vehicle condition. A damaged tile was reported by the crew on the port-side OMS pod and a white piece of debris was noted on the starboard side of the vertical stabilizer. Neither of these conditions was considered anomalous and both were of no concern for entry.

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

Five videos of the Orbiter's approach and landing were reviewed. No anomalies were detected. Fifteen landing films were reviewed, and no anomalies were noted. Drag chute operations appeared to be nominal from the photographic data review.

TABLE I.- STS-64 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
APU Activation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	252:22:18:02.84 252:22:18:03.79 252:22:18:05.00
SRB HPU Activation[a]	LH HPU System A start command LH HPU System B start command RH HPU System A start command RH HPU System B start command	252:22:22:27.102 252:22:22:28.262 252:22:22:28.382 252:22:22:28.542
Main Propulsion System Start[a]	ME-3 start command accepted ME-2 start command accepted ME-1 start command accepted	252:22:22:48.413 252:22:22:48.535 252:22:22:48.657
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	252:22:22:54.982
Throttle up to 100 Percent Thrust[a]	ME-3 command accepted ME-2 command accepted ME-1 command accepted	252:22:22:58.694 252:22:22:58.695 252:22:22:58.698
Throttle down to 67 Percent Thrust[a]	ME-3 command accepted ME-2 command accepted ME-1 command accepted	252:22:23:21.094 252:22:23:21.095 252:22:23:21.098
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	252:22:23:46
Throttle up to 104 Percent Thrust[a]	ME-3 command accepted ME-2 command accepted ME-1 command accepted	252:22:23:56.615 252:22:23:56.616 252:22:23:56.619
Both SRM's Chamber Pressure at 50 psi[a]	LH SRM chamber pressure mid-range select RH SRM chamber pressure mid-range select	252:22:24:52.502 252:22:24:52.622
End SRM Action[a]	LH SRM chamber pressure mid-range select RH SRM chamber pressure mid-range select	252:22:24:54.862 252:22:24:54.992
SRB Physical Separation[a]	LH rate APU turbine speed - LOS RH rate APU turbine speed - LOS	252:22:24:57.462 252:22:24:57.462
SRB Separation Command[a]	SRB separation command flag	252:22:24:58
Throttle Down for 3g Acceleration[a]	ME-3 command accepted ME-2 command accepted ME-1 command accepted	252:22:30:26.082 252:22:30:26.102 252:22:30:26.108
3g Acceleration	Total load factor (g)	252:22:30:27.9
Throttle Down to 67 Percent Thrust for Cutoff[a]	ME-3 command accepted ME-2 command accepted ME-1 command accepted	252:22:31:23.363 252:22:31:23.383 252:22:31:23.390
SSME Shutdown[a]	ME-3 shutdown command accepted ME-2 shutdown command accepted ME-1 shutdown command accepted	252:22:31:29.643 252:22:31:29.664 252:22:31:29.670

TABLE I.- STS-64 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
MECO	MECO command flag MECO confirm flag	252:22:31:30 252:22:31:30
ET Separation	ET separation command flag	252:22:31:49
APU Deactivation	APU-3 GG chamber pressure APU-1 GG chamber pressure APU-2 GG chamber pressure	252:22:39:22.37 252:22:39:28.76 252:22:39:35.44
OMS 2 Ignition	Right engine bi-propellant valve position Left engine bi-propellant valve position	252:22:59:04.0 252:22:59:04.0
OMS 2 Cutoff	Right engine bi-propellant valve position Left engine bi-propellant valve position	252:23:01:09.7 252:23:01:09.9
PLBD Open	PLBD right open 1 PLBD left open 1	252:23:52:17 252:23:53:37
SPIFEX First Grapple	Payload captured	253:20:33:08
SPIFEX First Unberth	Payload select 1 latch 2B released	253:20:41:32
SPIFEX First Berth	Payload select 1 latch 2B latched	255:15:56:02
SPIFEX First Release	Payload captured	255:15:59:14
SPARTAN First Grapple	Payload captured	256:20:40:20
SPARTAN Unberth	Payload select 2 latch 1A released	256:20:48:24
SPARTAN First Release	Payload captured	256:21:29:57
SPARTAN Second Grapple	Payload captured	258:21:00:55
SPARTAN Berth	Payload select 1 latch 2A latched	258:22:28:04
SPARTAN Second Release	Payload captured	258:22:29:51
Cabin Depressurization	Cabin pressure	258:14:32:15
OMS 3 Ignition	Left engine bi-propellant valve position Right engine bi-propellant valve position	N/A 258:22:51:47.0
OMS 3 Cutoff	Left engine bi-propellant valve position Right engine bi-propellant valve position	N/A 258:22:52:04.8
OMS 4 Ignition	Left engine bi-propellant valve position Right engine bi-propellant valve position	258:23:36:47.1 N/A
OMS 4 Cutoff	Left engine bi-propellant valve position Right engine bi-propellant valve position	258:23:37:04.9 N/A

TABLE I.- STS-64 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
Airlock Depressurization	Airlock differential pressure 1	259:14:39:14
Airlock Repressurization	Airlock differential pressure 1	259:21:33:16
Cabin Repressurization	Cabin pressure	259:22:32:10
SPIFEX Second Grapple	Payload captured	260:13:45:17
SPIFEX Second Unberth	Payload select 1 latch 3A released	260:13:49:21
SPIFEX Second Berth	Payload select 1 latch 1B latched	260:21:07:04
SPIFEX Second Release	Payload captured	260:21:09:02
FCS Checkout APU Activation APU Deactivation	 APU-3 GG chamber pressure APU-3 GG chamber pressure	 261:13:29:07.48 261:13:35:43.09
First PLBD Close	PLBD left close 1 PLBD right close 1	262:14:47:17 262:14:49:33
Second PLBD Open	PLBD right open 1 BFS PLBD left open 1 BFS	262:18:35:52 262:18:37:11
Second PLBD Close	PLBD left close PLBD right close	262:14:38:16 263:14:49:35
APU Activation for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	263:20:12:01.79 263:20:28:09.21 263:20:28:10.92
Deorbit Burn Ignition	Right engine bi-propellant valve position Left engine bi-propellant valve position	263:20:17:00.1 263:20:17:00.4
Deorbit Burn Cutoff	Right engine bi-propellant valve position Left engine bi-propellant valve position	263:20:20:01.7 263:20:20:02.0
Entry Interface	Orbital altitude/reference ellipsoid	263:20:41:03
Blackout End	Data locked at high sample rate	No blackout
Terminal Area Energy Management (TAEM)	Major Mode Code (305)	263:21:06:26
Main Landing Gear Contact	MLG left-hand outboard tire pressure 1 MLG right-hand outboard tire pressure 2	263:21:12:52 263:21:12:52
Main Landing Gear Weight On Wheels	MLG right-hand no weight on wheels MLG left-hand no weight on wheels	263:21:12:52 263:21:12:53
Drag Chute Deployment	Drag chute deploy 1 cap volts	263:21:12:58.6
Nose Landing Gear Contact	Nose landing gear right-hand tire pressure 1	263:21:13:03
Nose Landing Gear Weight On Wheels	Nose landing gear no weight on wheels	263:21:13:04
Drag Chute Jettison	Drag chute jettison 1 cap volts	263:21:13:31.1

TABLE I.- STS-64 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
Wheels Stop	Velocity with respect to runway	263:21:13:54
APU Deactivation	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	263:21:29:16.53 263:21:29:17.88 263:21:29:19.03

TABLE II.- ORBITER PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-64-V-01	Aft MCA Status 4 Went to Zero No Ferry Flight Impact	254:11:55 G.m.t. 01:13:32 MET CAR 64F04 IPR 63V0002	At approximately 254:11:55:42 G.m.t. (01:13:32::48 MET), Aft Motor Control Assembly 1 Operational Status Bit 4 transitioned from a 1 to a 0. At approximately 254:15:03:37 G.m.t. (01:16:40:43 MET), the status bit returned to 1. No drive currents were detected on the supplying ac buss. No position changes of the controlled motors were noted. No change in the aft power controller 4 voltage or current measurements occurred during the transition times. This measurement is downlinked at one sample per second through MDM 0A1, Card 7, Channel 00. No other measurements on that channel changed states during the period in question. MDM O1A card 7 channel 00 was evaluated to determine if any other measurements had been affected. The AMCA 1 Operations status 4 is the only measurement affected. Of the motors controlled by AMCA 1 string 4, only the umbilical door centerline latch 1 motor 1 deploy B and latch 2 motor 1 STW B were not verified either during Entry of postlanding. All other motors on this string performed nominally. KSC: Troubleshooting on October 7 revealed nominal resistance of 5.1K on the MCA circuit. Cable was wiggled with no anomalies.
STS-64-V-02	FES Supply Water Accumulator Temperature Cycling Low Level III Closure No Ferry Flight Impact	253:06:23 G.m.t. 00:08:00 MET CAR 64RF01 PR ECL-3-20-1006	The FES supply water system A accumulator temperature cycled between 48 °F and 55 °F since approximately 253:02:00 G.m.t. The normal control range for the thermostat is 55 °F to 75 °F. The temperature cycles indicate that the heater is operating properly. The FES was reconfigured to the B heater system. The data from the B system is similar to the A system data, indicating that the temperature sensor is debonded. KSC: Troubleshoot and replace sensor, if found anomalous.

TABLE II.- ORBITER PROBLEM TRACKING LIST

STS-64-V-03	Primary RCS Thruster L1A Failed Off/Deselected on Low Chamber Pressure	261:14:56 G.m.t. 08:16:33 MET CAR 64RF02 PR LP01-23-0636	During RCS hot-fire at 261:14:56 G.m.t. (08:16:33 MET), primary thruster L1A was declared failed off by RCS RM when it was commanded to fire. A good command was observed out of the reaction jet driver (RJD), but no chamber pressure was observed. Thirty seconds after the fail off, RM annunciated fail leak on this thruster because the oxidizer injector temperature fell below the RM limit of 30 °F. The oxidizer temperature was cycling between 10 °F and 40 °F. The fuel injector temperature remained above 60 °F, indicating no fuel leakage. The manifold was drained and a pad was placed between the isolation valve and the thruster at DFRC before ferry. KSC: Remove and replace thruster. The thruster will be sent to White Sands Test Facility for water flush.
STS-64-V-04	APU 3 Exhaust Gas Temperature (EGT) 2 Failed Level III Closure No Ferry Flight Impact	263:20:50 G.m.t. 10:22:27 MET IPR 63V-0009 CAR 64RF03	APU 3, EGT 2 became increasingly erratic from about 263:20:50 G.m.t. (10:22:27 MET) until APU shutdown. The measurement read about 100 °F at APU shutdown and slowly rose to a value near that of APU 3 EGT 1. The EGT is one of the new design sensors. KSC: Troubleshooting could not isolate anomaly. Remove and replace sensor.
STS-64-V-05	Ku-band Radar Failed to Acquire at Low Range No Ferry Flight Impact	256:21:29 G.m.t. 03:23:06 MET	Following the deployment of the SPARTAN satellite, the Ku-band radar system failed to acquire the satellite. Ku-band radar acquired the SPARTAN about 1 hour later, when the target was located at -21.3 roll and 15.5 pitch and a range of 2700 ft. on scan 37. The radar continued to track the SPARTAN to a range of 9100 ft when the Ku-band system switched back to comm mode. For rendezvous phase, the Ku-band radar was turned on at 258:16:14 G.m.t. (05:17 51 MET) when SPARTAN was at an estimated range of 128,000 ft. Radar immediately acquired and tracked the payload all the way into about 81 ft. KSC: Performed contingency Ku-band radar OMRS. Troubleshooting was performed on October 31 and it did not confirm the failure of EA2.
STS-64-V-06	BFS DR 109628 Big X on BFS Display on Transition from Halt During Deorbit Preparation Block 4 Level III Closure	262:14:01 G.m.t. 09:15:38 MET	During deorbit preparation block 4, the crew reported that the BFS would not drive a CRT. A big X was displayed with a "Poll Fail." Also, the BFS variable parameter (VP) slot 2 (memory location 05281) displayed a steady 0000. These signatures indicate that the conditions described in BFS DR 109628 occurred. KSC: No action required.

TABLE II.- ORBITER PROBLEM TRACKING LIST

	No Ferry Flight Impact		
STS-64-V-07	PDI/LITE Decommutator 4 BITE Discrepancy	256:13:54 G.m.t. 03:15:31 MET IPR 63V-0010	At approximately 256:13:54:00 G.m.t. (03:15:31 MET), the crew selected the "quiescent" format whose decommutated format (17) was loaded into PDI decommutator 4. The BITE bits for Decommutator 4 went high and those for Decommutator 1 went low as expected. About 2 minutes later, the crew selected the "regular" format. The BITE bits for decommutator 1 went high again, but only the Bit Rate Accuracy bit for decommutator 4 Bite went low. The bit lock, word lock, and master frame lock bits for decommutator 4 went low approximately 22 minutes later at 256:14:20:00 G.m.t. (03:15:57 MET). No payload data were lost by this occurrence, nor was any data loss anticipated should the event recur. KSC: Perform troubleshooting.
STS-64-V-08	Right and Left Main Landing Gear Door Thermal Barrier Assemblies Fell Out During Door Opening	263:21:12:32 G.m.t. PR LWing-3-20-5466 PR Rwing-3-20-4896	Two thermal barrier assemblies separated from their respective base plates on the aft edge of each main gear well. The barrier assemblies were found 100 yards from the perimeter fence. One barrier was frayed. No carrier plate damage was evident. Each barrier assembly was clipped in place for ferry flight. KSC: Perform troubleshooting and repair the hardware.
STS-64-V-09	Slow Chamber Pressure Rise on Primary Thruster F4D	256:16:01 G.m.t. 03:17:38 MET CAR 64RF09	Primary thruster F4D exhibited slow chamber pressure ramp-up on 0.080 second pulses (16 of 122 total pulses). The longer pulse on F4D also appeared to indicate slow chamber pressure rise. Detailed review of data from the deorbit preparation of 10 of 13 flights since return-to-flight indicates a steadily increasing number of slow chamber pressure rise indications. The exact cause of the failure is unknown, and the signature is outside the experience base. KSC: Boroscope revealed chamber pressure sensing tube was unblocked. Thruster will be replaced.

TABLE III.- GOVERNMENT FURNISHED EQUIPMENT PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-64-F-01	Drink Bag Septum Installation Manufacturing Problem	255:18:09 G.m.t. 02:19:47 MET	The crew reported under-fill of the drink bags. The crew was briefed generically preflight at KSC concerning the potential for under-dispense problems with some beverage bags. The dispense problem was due to the partial collapse of the channel in the septum adapter assembly. The collapse of the channel occurred from improper manufacturing (over- heating of the septum and seal). Testing has determined that 50 percent of the suspect containers will have the collapsed channel.
STS-64-F-02	Side Hatch Locking Device Obstruction	257:14:07 G.m.t. 04:15:45 MET	Following post-insertion procedures, the crew reported that the side hatch locking device could not be installed because of an obstruction. This device is carried up by one of the crewmembers in a pocket of the LES, and installed as one of the first post-ascent activities. Potential causes that have been proposed are something loose on the handle that is preventing installation; or part or parts of the lock guard out of tolerance. The position of the latch handle is not suspect, since this is checked after the hatch is closed using an inspection mirror through a small port that is subsequently plugged for flight. FCE is working on a postflight plan - so far this consists of visual inspection and dimensional tolerance checks. The crew downlinked the video of the side hatch and locking device.
STS-64-F-03	SPARTAN Berthing Camera Failed to Operate	256:20:45 G.m.t. 03:22:22 MET	At 256:20:45 G.m.t. (03:22:22 MET), during SPARTAN unberthing, the crew saw no berthing camera image on the monitor. Subsequent investigation found that the berthing camera and VTR play switch labels on panel A7U were mislabeled. The camera worked fine during SPARTAN retrieval when the correct switches were used.
STS-64-F-04	TCS (DTO-700-5) RS-422-Y Cable Problem	256:21:00 G.m.t. 03:22:37 MET	At 256:21:00 G.m.t. (03:22:37 MET), during Trajectory Control System (TCS) activation, the TCS failed to track SPARTAN. During troubleshooting, TCS was recovered when the TCS

TABLE III.- GOVERNMENT FURNISHED EQUIPMENT PROBLEM TRACKING LIST

			PGSC was connected directly to the PDIP using a straight cable instead of a Y cable. Subsequent troubleshooting revealed that the Y-cable ends had been mislabeled. Switching Y-cable connections yielded successful TCS operation during SPARTAN retrieval.
STS-64-F-05	Articulating Portable Foot Restraint (APFR) Simulator Fit Interface	259:20:15 G.m.t. 06:21:52 MET	The APFR simulator thermal cover interfered with full insertion of the APFR simulator into the SPARTAN MPESS PFR socket during the APFR Limiter evaluation.
STS-64-F-06	Electronic Cuff Checklist Problems a) ECC 2 Touch Screen Operation Degraded	260:00:58 G.m.t. 07:02:35 MET	During the EVA, ECC 1 did not always respond when the upper middle sextant was depressed. Post-EVA, following return to the cabin, ECC 1 touch screen operation returned to normal.
	b) Write ROM Error During ECC 2 Checklist	260:14:45 G.m.t. 07:16:23 MET	During an attempt to update the contents of ECC 2, a "Write ROM Error" was displayed on the PGSC by the ECC update application. The crew was instructed to proceed with the update despite the error message.

TABLE IV.- MSFC PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-66-B-01	Right-hand Frustum MSA-2 Not Adhering to Painted Surface	Postflight inspection	The right-hand frustum had Marshall Sprayable Ablator (MSA) -2 that did not adhere to the painted surface adjacent to PR-1422 sealant over fastener unbonds. No material loss was associated with the unbonded areas. Potential contributors are: 1. Microballoons were lower in moisture content than previous lots (moisture content still within specification; and 2. Pump return flow rate on low side (normally spray parameters could be adjusted to compensate for dryness of microballoons.

DOCUMENT SOURCES

In an attempt to define the official as well as the unofficial sources of data for this mission report, the following list is provided.

1. Flight Requirements Document
2. Public Affairs Press Kit
3. Customer Support Room Daily Reports
4. MER Daily Reports
5. MER Mission Summary Report
6. MER Quick Look Report
7. MER Problem Tracking List
8. MER Event Times
9. Subsystem Manager Reports/Inputs
10. MOD Systems Anomaly List
11. MSFC Flash Report
12. MSFC Event Times
13. MSFC Interim Report
14. Crew Debriefing comments
15. Shuttle Operational Data Book

ACRONYMS AND ABBREVIATIONS

The following is a list of the acronyms and abbreviations and their definitions as these items are used in this document.

AFRSI	Advanced felt reusable surface insulation
ALC	automatic light control
AMOS	Air Force Maui Optical Site
APFR	articulating portable foot restraint
APU	auxiliary power unit
ARPCS	atmospheric revitalization pressure control system
ARS	atmospheric revitalization system
ATCS	active thermal control system
BFS	backup flight system
BITE	built-in test equipment
BRIC	Biological Research in Canisters
CRT	cathode ray tube
DDHU	digital data handling unit
DEU	display electronics unit
DOD	Department of Defense
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔV	differential velocity
deg/hr	degree per hour
EAFB	Edwards Air Force Base
ECC	electronic cuff checklist
EGT	exhaust gas temperature
EI	entry interface
EMU	extravehicular mobility unit
EPDC	electrical power distribution and control subsystem
ET	External Tank
EVA	extravehicular activity
FCE	flight crew equipment
FCS	flight control system
FES	flash evaporator system
ft/sec	feet per second
g	gravity
GAS	Getaway Special
GFE	Government furnished equipment
G.m.t.	Greenwich mean time
GN&C	guidance, navigation and control
GPC	general purpose computer
HAINS	high accuracy inertial navigation system
HDRR	high data rate recorder
HPFTP	high pressure fuel turbopump
HPOT	high pressure oxidizer turbine
HPOTP	high pressure oxidizer turbopump
IMU	inertial measurement unit

IPL	initial program load
JSC	Johnson Space Center
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt hour
LCC	Launch Commit Criteria
LCD	liquid crystal display
LED	light emitting diode
LES	launch/entry suit
LESC	Lockheed Engineering and Science Company
LH_2	liquid hydrogen
LIDAR	light distance and ranging
LITE	Lidar In-Space Technology Experiment
LO_2	liquid oxygen
LOS	loss of signal
LRSI	low temperature reusable surface insulation
MADS	modular auxiliary data system
MAST	Military Application of Ship Tracks Experiment
MCA	motor controller assembly
MCDS	multifunction CRT display system
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MET	mission elapsed time
MLGD	main landing gear door
MMU	manned maneuvering unit
MPESS	mission peculiar experiment support equipment
MPM	manipulator positioning mechanism
MPS	main propulsion system
MSFC	Marshall Space Flight Center
MUM	MCDS update module
NASA	National Aeronautics and Space Administration
NLGD	nose landing gear door
NPSP	net positive suction pressure
NSTS	National Space Transportation System (i.e., Space Shuttle Program)
OI	operational instrumentation
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
ONR	Office of Naval Research
OPS	operations
OTP	operational test procedure
PAL	protuberance air load
P_c	chamber pressure
PDI	payload data interleaver
PDU	power drive unit
PFR	portable foot restraint
PGSC	payload and ground support computer
PLBD	payload bay door
PMBT	propellant mean bulk temperature
POHS	position orientation hold select

PROX OPS	proximity operations
PRSD	power reactant storage and distribution
RCS	reaction control subsystem
RM	redundancy management
RME	Radiation Monitoring Equipment
RMS	remote manipulator system
ROMPS	Robot Operated Materials Processing System
RSRM	Redesigned Solid Rocket Motor
RTLS	return to launch site
SAFER	Simplified Aid for EVA Rescue
SAREX	Shuttle Amateur Radio Experiment
SLF	Shuttle Landing Facility
SMS	Shuttle Mission Simulator
SPARTAN	Shuttle Pointed Autonomous Research Tool for Astronomy
SPIFEX	Shuttle Plume Impingement Flight Experiment
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSCE	Solid Surface Combustion Experiment
SSME	Space Shuttle main engine
SWDLPA	supply water dump line purge assembly
TACAN	Tactical Air Navigation
TCS	Trajectory Control Sensor
TDRS	Tracking and Data Relay Satellite
TE	thermoelectric
TFL	telemetry format load
TPS	thermal protection subsystem
TRAD	Tools for Rendezvous and Docking
TU	transport unit
UV	ultraviolet
UVCS	Ultraviolet Coronal Spectrometer
WCS	Waste collection system
WLC	White Light Coronagraph
WSB	water spray boiler