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SPACE SHUTTLE
MISSION REPORT

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NOTE

The STS-63 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

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STS-63

SPACE SHUTTLE

MISSION REPORT

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STS-63 Table of Contents

Title **Page**

INTRODUCTION 1
MISSION SUMMARY 3
MIR RENDEZVOUS AND FLYAROUND 6
PAYLOADS 8
SPACEHAB-3 8
SHUTTLE POINTED AUTONOMOUS RESEARCH TOOL FOR ASTRONOMY-204 11
HITCHHIKER PAYLOADS 12
Cryogenic System Experiment GLO-2 Payload 12
Orbital Debris Radar Calibration Spheres-2 13
IMAX Cargo Bay Camera 13
SOLID SURFACE COMBUSTION EXPERIMENT 13
AIR FORCE MAUI OPTICAL SITE 13
VEHICLE PERFORMANCE 14
SOLID ROCKET BOOSTERS 14
REUSABLE SOLID ROCKET MOTORS 14
EXTERNAL TANK 15
SPACE SHUTTLE MAIN ENGINE 16
SHUTTLE RANGE SAFETY SYSTEM 16
ORBITER SUBSYSTEMS PERFORMANCE 17
Main Propulsion System 17
Reaction Control Subsystem 17
Orbital Maneuvering Subsystem 18
Power Reactant Strorage and Distribution Subsystem 19
Fuel Cell Powerplant Subsystem 19
Auxiliary Power Unit Subsystem 20
Hydraulics/Water Spray Boiler Subsystem 21
Electrical Power Distribution and Control Subsystem 21
Environmental Control and Life Support Subsystem 22
Airlock Support System 23
Smoke Detection and Fire Suppression Subsystem 24
Avionics and Software Systems 24
Displays and Controls Subsystems 25
Communications and Tracking Subsystems 25
Operational Instrumentation/Modular Auxiliary Data System 26
Structures and Mechanical Subsystems 26
Integrated Aerodynamics, Heating and Thermal Interfaces 27

STS-63 Table of Contents

Title **Page**

Thermal Control Subsystem 27
Aerothermodynamics. 27
Thermal Protection Subsystem and Windows. 27
Drag Chute Subsystem. 28
REMOTE MANIPULATOR SYSTEM. 29
EXTRAVEHICULAR ACTIVITY. 31
FLIGHT CREW EQUIPMENT/GOVERNMENT FURNISHED EQUIPMENT 32
CARGO INTEGRATION. 33
DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES. 34
DEVELOPMENT TEST OBJECTIVES 34
DETAILED SUPPLEMENTARY OBJECTIVES. 36
PHOTOGRAPHY AND TELEVISION ANALYSIS 37
LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS. 37
ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS 37
LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS 37

List of Tables

TABLE I - STS-63 SEQUENCE OF EVENTS. 38
TABLE II - STS-63 ORBITER PROBLEM TRACKING LIST. 41
TABLE III - STS-63 GFE PROBLEM TRACKING LIST 43
TABLE IV - MSFC PROBLEM TRACKING LIST 44

Appendixes

A - DOCUMENT SOURCES A-1
B - ACRONYMS AND ABBREVIATIONS B-1

INTRODUCTION

The STS-63 Space Shuttle Program Mission Report summarizes the Payload activities and provides detailed data on the Orbiter, External Tank (ET), Solid Rocket Booster (SRB), Reusable Solid Rocket Motor (RSRM), and the Space Shuttle main engine (SSME) systems performance during this sixty-seventh flight of the Space Shuttle Program, the forty-second since the return to flight, and twentieth flight of the Orbiter vehicle Discovery (OV-103) In addition to the OV-103 Orbiter vehicle, the flight vehicle consisted of an ET that was designated ET-68, three SSMEs that were designated 2035, 2109, and 2029 in positions 1, 2, and 3, respectively, and two SRBs that were designated BI-070 The RSRMs that were an integral part of the SRBs were designated 360Q042A for the left SRB and 360L042B for the right SRB

The STS-63 mission was planned as an 8-day duration mission with two contingency days available for weather avoidance or Orbiter contingency operations The primary objectives of the STS-63 mission were to perform the Mir rendezvous operations, accomplish the Spacehab-3 experiments, and deploy and retrieve the Shuttle Pointed Autonomous Research Tool for Astronomy-204 (SPARTAN-204) payload The secondary objectives were to perform the Cryogenic Systems Experiment (CSE)/Shuttle Glo-2 Experiment (GLO-2) Payload (CGP)/Orbital Debris Radar Calibration Spheres (ODERACS-2) (CGP/ODERACS-2) payload objectives, the Solid Surface Combustion Experiment (SSCE), and the Air Force Maui Optical Site Calibration Test (AMOS) The objectives of the Mir rendezvous/flyby were to verify flight techniques, communication and navigation-aid sensor interfaces, and engineering analyses associated with Shuttle/Mir proximity operations in preparation for the STS-71 docking mission

The STS-63 Space Shuttle Mission Report fulfills the Space Shuttle Program requirement as documented in NSTS 07700, Volume VIII, Appendix E The requirement states 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 STS-63 sequence of events is shown in Table I, the Orbiter Problem Tracking List is shown in Table II, the Government Furnished Equipment (GFE) Problem Tracking List is shown in Table III and the MSFC Problem Tracking List is shown in Table IV In addition, the Shuttle 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 the document All times, except for the launch delay times, are given in Greenwich mean time (G m t) and mission elapsed time (MET)

The six-person crew for STS-63 consisted of James D Wetherbee, CDR , U S Navy, Commander, Eileen M Collins, Lt Col , U S Air Force, Pilot, Bernard A Harris, Jr , M D , Payload Commander and Mission Specialist 1, C Michael Foale, Ph D , Mission Specialist 2, Janice Voss, Ph D , Mission Specialist 3, and Vladimir Georgievich Titov, Col Russian Air Force, Mission Specialist 4 STS-63 was the third space flight for the Commander and Mission Specialist 2, the second space flight for the Payload Commander (Mission Specialist 1) and Mission Specialist 3, the first space flight for the Pilot and the first Space Shuttle flight for Mission Specialist 4 Lt Col E M Collins was the first female Space Shuttle Pilot, and Col V G Titov (a veteran of three Russian space flights) was the second Russian cosmonaut to fly on the Space Shuttle

MISSION SUMMARY

The STS-63 launch was delayed from 12 47 44 a m e s t on February 2, 1995, until 12 22 04 a m e s t on February 3, 1995, because inertial measurement unit (IMU) 2 failed during the launch countdown The high accuracy inertial navigation system (HAINS) IMU was replaced, and the unit was retested satisfactorily

The STS-63 Shuttle vehicle was launched from Launch Complex 39, pad B at 034 05 22 03 994 G m t (12 22 04 a m e s t) on February 3, 1995 The ascent phase was nominal in all respects, and no orbital maneuvering subsystem (OMS) -1 maneuver was required A determination of vehicle performance was made using vehicle acceleration and preflight propulsion prediction data The average flight-derived engine specific impulse (Isp) for the time period between SRB separation and the start of 3-g throttling was 452 6 seconds, compared to an MPS tag value of 452 80 seconds

During the Orbiter separation maneuver from the ET, primary reaction control subsystem (RCS) thruster R1U failed off at 034 05 30 53 G m t (00 00 08 49 MET), and failed leak at 034 05 32 08 G m t (00 00 10 04 MET) Also, primary RCS thruster L2D failed off at 034 05 30 56 G m t (00 00 08 52 MET)

The OMS-2 maneuver was performed at 034 06 04 14 G m t (00 00 42 10 MET) The maneuver was 155 7 seconds in duration and the differential velocity (ΔV) was 252 1 ft/sec The orbit after completion of the maneuver was 168 8 by 183 9 nmi

Four unsuccessful attempts were made to stop the oxidizer leakage from the RCS R1U thruster by closing the manifold isolation valves, allowing oxidizer manifold pressure to decrease, followed by opening the isolation valves to allow rapid repressurization of the oxidizer manifold No significant change in the leak signature was observed as a result of these operations The manifold isolation valves were then closed to isolate the leak RCS right manifold 1 isolation valves were reopened again at approximately 037 07 29 14 G m t (03 02 07 10 MET) to manage fuel manifold pressure changes that were being caused by solar heating The oxidizer leak was still present at a lower rate, and the right RCS manifold 1 isolation valves were closed for the Mir rendezvous

At 034 21 50 G m t (00 16 28 MET), the cabin pressure transducer shifted low by 0 24 psi from 14 64 psi to 14 40 psi All other available instruments indicated a nominal cabin pressure

An input/output (I/O) error message against cathode ray tube (CRT) 4 was annunciated and two I/O errors were logged by general purpose computer (GPC) 4 about 35 minutes after powering on CRT 4 The crew found the CRT screen blank, and the display electronics unit (DEU) built-in-test-equipment (BITE) flag tripped CRT 4 was recovered by performing a power cycle The DEU/CRT 4 experienced three recurrences of the failure and the DEU/CRT was recovered each time with a power cycle The crew used the DEU at their discretion, and there was no mission impact

The SPARTAN-204 payload was grappled at 035 06.33 G m t (01 01 11 MET), unberthed and used to perform Shuttle Glow (GLO) observations while attached to the remote manipulator system (RMS)

The primary RCS thrusters L1L, L1U, R4U, F3L, and F3U fired simultaneous 80-ms-duration pulses in response to an unexpected +Y/+Z translation hand controller (THC) command following the power-up of the aft THC at 035 11 41 06 G m t (01 06 19 MET) The THC had not been deflected Data review indicated that the THC command probably resulted from a transient response of the THC contacts upon application of flight controller power

A hot-fire test of the RCS low-Z thrusters was performed in preparation for the Mir rendezvous After a nominal firing of F1F, the thruster's oxidizer injector temperature dropped to 16 5 °F, causing leak detection software to deselect the thruster The temperature drop is characteristic of an oxidizer valve leak The fuel injector temperature eventually dropped below 40 °F, prompting isolation of the forward RCS manifold 1 at 035 20 27 40 G m t (01 15 05 36 MET), after which the injector temperatures recovered Manifold 1 was re-opened at 036 04 21 G m t (01 22 59 MET) to allow the force of repressurizing the manifold to clear potential contaminants from the oxidizer valve seat No further leakage was noted The thruster was subsequently fired nominally three times and was returned to normal operation

The rendezvous with the Mir Space Station was performed in an outstanding manner The Orbiter approached to within 12 meters of the Mir The approach, stationkeeping, back-away and fly-around were performed flawlessly The videos were spectacular, originating simultaneously from the Mir and the Orbiter The Mir cosmonauts reported no vibrations or solar array movement as a result of the approach to the Mir

At 037 20 06 G m t (03 14 43 MET), the latch A indication in the port radiator latch gang 1-6 actuator began toggling off and on After toggling frequently for approximately one hour, the indication returned to normal operation except for occasional toggles The redundant indication (latch B) showed nominal position and no erratic behavior

The RMS was used to successfully deploy the SPARTAN-204 payload at 038 12 12 28 G m t (04 06 50 24 MET)

The flight control system (FCS) checkout was performed using auxiliary power unit (APU) 3 APU 3 ran for 7 minutes 22 seconds with APU start at 039 10 05 28 G m t (05 04 43 24 MET) Water spray boiler (WSB) cooling was required because of the extended run time of the APU with spray cooling lasting approximately 5 seconds

The rendezvous with the SPARTAN-204 payload was completed satisfactorily The Ku-Band radar acquired SPARTAN-204 at 135,000 ft and tracked to a distance of 85 ft Radar performance was satisfactory throughout the rendezvous operations The RMS successfully grappled the SPARTAN at 040 11 33 20 G m t (06 06 11 16 MET) and the satellite was berthed at 040 12 10 26 G m t (06 06 48 22 MET)

All preparations for the planned extravehicular activity (EVA) were completed and the two crew members began the EVA at 040 11 56 30 G m t (06 06 34 26 MET) The Development Test Objective (DTO) 833 extravehicular mobility unit (EMU) Thermal Evaluation and EVA worksite evaluation rest period were conducted satisfactorily The RMS was used to maneuver the extravehicular crewmembers during the EVA

The EVA mass handling procedures were performed during a night pass Ten minutes into the night pass, extravehicular crewmember 1 (EV1) reported uncomfortably cold hands, and EV2 reported cold hands and feet Crew thermal comfort was restored during the following day pass Mass handling activities were shortened and payload bay clean-up was initiated

The EVA was concluded at 040 16 34 43 G m t (06 11 12 39 MET) with an official EVA time of 4 hours and 39 minutes The EMU performance was nominal during the EVA During airlock repressurization, the EV2 crewmember reported a burning sensation in his eyes Brown flecks of material were found on the inner surface of the visor when the helmet was doffed

During the EVA, a small pressure drop was detected in the Spacehab module The pressure decreased from 14 80 psi to 14 16 psi over a 5-hour 18-minute period

The Spacehab hatch was closed at 041 15 45 G m t (07 10 23 MET) All entry stowage and deorbit preparations were completed The payload bay doors were successfully closed and latched at 042 08 06 28 G m t (08 02 44 24 MET) The deorbit maneuver for a Kennedy Space Center (KSC) landing was performed at 042 10 44 04 G m t (08 05 22 00 MET), and the maneuver was 254 3 seconds in duration with a ΔV of 450 4 ft/sec

Entry was completed satisfactorily, and main landing gear touchdown occurred at concrete runway 15 at 042 11 50 19 G m t (08 06 28 15 MET) on February 11, 1995 The Orbiter drag chute was deployed satisfactorily at 042 11 50 27 G m t , and nose landing gear touchdown occurred 6 seconds later The drag chute was jettisoned at 042 11 51 05 G m t , with wheels stop occurring at 042 11 51 40 G m.t The rollout was normal in all respects The flight duration was 8 days 6 hours 28 minutes and 15 seconds with landing occurring on orbit 129 The APUs were shut down 21 minutes 39 seconds after landing

MIR RENDEZVOUS AND FLY-AROUND

The primary objective of the STS-63 mission was accomplished with the successful completion of the Mir rendezvous and fly-around The rendezvous and fly-around were jeopardized by the oxidizer leaks from RCS thrusters R1U and F1F Flight rules for STS-63 stated that if low-Z redundancy were lost, the Shuttle would not approach the Mir within 1000 ft, and no venting would be allowed within 40 nmi of the Mir

Final negotiations with the Russians for a rendezvous with the Mir were intensified when the Orbiter RCS thrusters R1U and F1F started leaking After recovery of thruster F1F, and an analysis of the leaking R1U thruster indicated that the small oxidizer leak would not contaminate the Mir, the Russians agreed to the conduct of the flight day 4 rendezvous as planned To stop thruster R1U from leaking required the closure of the R1 manifold, and this in turn eliminated low-Z redundancy by isolating thruster R1A It was finally agreed that the R1 manifold would be closed and the Shuttle could approach the Mir If thruster R3A had failed, the R1 manifold would be reopened to re-enable R1A, and the Mir would tolerate the small leak from R1U while the Orbiter backed away No additional thruster failures occurred during the rendezvous and fly-around operations

In final preparation for the Mir rendezvous, a single OMS right-engine straight-feed height-adjust (HA) maneuver was initiated at 034 14 20 15 G m t (00 08 58 11 MET) The maneuver was approximately 39 7 seconds in duration and imparted a 32 1 ft/sec ΔV to the vehicle The Orbiter was in a 188 x 182 nmi orbit as a result of the maneuver The post-maneuver data review indicated nominal OMS performance

At 035 14 26 48 G m t (01 09 04 24 MET), a left OMS engine straight-feed nominal correction (NC) rendezvous maneuver was initiated The maneuver was approximately 24 5 seconds in duration and imparted a 20 1 ft/sec ΔV to the vehicle The maneuver placed the Orbiter in a 199 by 182 nmi orbit

At 036 18 37 39 G m t (02 13 15 35 MET), the OMS-5 maneuver, a left-engine straight-feed firing, was initiated The firing was approximately 49 6 seconds in duration, and imparted a 40 7 ft/sec ΔV to the vehicle A 208 X 197 nmi orbit was established as a result of the maneuver The OMS performance during the maneuver was again nominal

The OMS was used to perform two orbit-adjust maneuvers critical to the Mir rendezvous Both maneuvers were performed in the straight-feed configuration using only the left engine The OMS-6 nominal height (NH) maneuver was initiated at 037 14 24 03 G m t (03 09 01 59 MET) This maneuver was 10 4 seconds in duration and resulted in a ΔV of 8 5 ft/sec The OMS-7 terminal initiation (TI) maneuver was initiated at 037 16 36 43 G m t (03 11 14 39 MET) and was 18 6 seconds in duration

The firing imparted a ΔV of 15 4 ft/sec The orbit following OMS-7 was 213 7 x 205 nmi and the Orbiter vehicle was in-plane with the Mir.

The Shuttle vehicle approached the Mir on the V-bar to within 40 feet (approximately 12 meters), performed stationkeeping with the Mir for 15 minutes, then backed away and performed a fly-around at 400 ft The approach, stationkeeping, back-away and fly-around were performed flawlessly The crews exchanged greetings via the very high frequency (VHF) communication system and provided spectacular live video, which originated simultaneously from the Mir and the Shuttle The Mir cosmonauts reported no vibrations or solar array movement as a result of the approach

After the Shuttle backed away, the Mir was maneuvered back to its inertial attitude The Russians reported that the Mir attitude control system (ACS) performance was as expected Errors remained small, and no saturation firings were commanded Control was maintained via the gyrodins using five from the KVANT module and four from KVANT-2 Visual assessments of the docking targets in the video indicated that both vehicles were remaining quite stable

PAYLOADS

The primary payload for the STS-63 mission was the Spacehab-3 module and its experiments The Spacehab-3 module is a pressurized, commercially developed space research laboratory that was located in the forward end of the payload bay STS-63 was the third flight of the Spacehab module -- the first two highly successful missions were STS-57 in June 1993 and STS-60 in February 1994 The Spacehab module contained over 20 experiments, which represented a diverse cross-section of technological, biological, and scientific disciplines

In addition to the Spacehab, the SPARTAN-204 payload obtained data in the far ultraviolet region of the spectrum from diffuse light sources The SPARTAN-204 payload had two operational periods during the mission The payload was initially grappled and unberthed to measure Orbiter surface glow The surface glow measurements were made while the SPARTAN-204 was still attached to the RMS on flight day 2 Far ultraviolet spectrographic data were also obtained while pointing at a primary RCS thruster while it was firing The payload was then berthed On flight day 5, the SPARTAN-204 was unberthed and released for a 48-hour observation period, separated from the Orbiter

Three payloads were carried as a part of the Hitchhiker Program and were known as the CGP/ODERACS-II

SPACEHAB-3

This second flight of Spacehab flight unit -1 (FU-1) was completely successful except for the problems experienced with video system enhancements added to the Spacehab module for this mission Modifications to the module air circulation system made after STS-60 were successful Neither fan-inlet-debris screen blockage nor flexible duct deformation were noted and the fan differential pressure (ΔP) remained nominal throughout the mission

Problems with Hitchhiker data dropout on Ku-band channel 2 were noted when down-linking Spacehab video through the video switching unit (VSU) on Ku-band channel 3 A related problem was distortion of the Public Affairs Office (PAO) video and shared camcorder video routed through the VSU when the Orbiter S-band frequency modulation (FM) system was in operation Various cable-configuration changes were made to the VSU during the flight to troubleshoot the problem, and it is now suspected that the VSU design is the source of both problems

The VSU is a new piece of hardware developed to enhance the Spacehab data system It allows the connection of up to eight video sources in Spacehab to a single output to the Orbiter video system Video sources to the VSU can be switched by ground command or on-board using the payload and general support computer (PGSC)

When camcorders were connected to the Spacehab video output, which was connected to the Orbiter video system using Orbiter video interface units (VIUs) in the configuration used on previous flights, the performance was completely nominal in all Ku-band and FM system modes This is another strong indication that the problems were isolated to the VSU The VSU will be modified and retested before a reflight occurs

Experiment operations occurred on or close to the preplanned timeline throughout the mission and the communications and cooperation between the Spacehab Payload Operations Control Center (POCC), the Mission Control Center (MCC), and the Orbiter flight crew were excellent Additional effort was expended to make the first flight of the Charlotte robotic experiment a success, and these efforts were successful, as Charlotte attained or exceeded all of its preflight objectives

Overall, the Spacehab complement of experiments was very successful when evaluated from an operational standpoint Scientific success will be measured after the return of the experiments and data to the Principal Investigators (PI's) and data are evaluated

The status of the Spacehab experiments at the end of the flight was as follows

a Astroculture IV - The Astroculture (ASC) IV experiment operations were nominal All planned on-orbit operations were successfully completed

b Bioserve Pilot Laboratory - The Bioserve Pilot Laboratory (BPL) experiment operations were nominal All planned on-orbit operations were successfully accomplished

c Protein Crystallization Facility - The light scattering and temperature-controlled facility performed nominally All planned on-orbit operations were successfully completed

d Three-Dimensional Microgravity Accelerometer - The Three Dimensional Microgravity Accelerometer (3-DMA) unit is believed to have collected data during ascent The unit was turned off early in the on-orbit phase because the unit's hard drives were not cycling properly, causing the unit to over-heat The unit was switched to descent mode and repowered for entry Despite some concerns regarding on-orbit data recording, the PI believes that the 3-DMA functioned as expected in the ascent and entry modes

e Biological Research in Canisters - The Biological Research in Canisters (BRIC) experiment hardware performed nominally All planned on-orbit operations were successfully completed f Commercial Generic Bioprocessing Apparatus - The Commercial Generic Bioprocessing Apparatus (CGBA) experiment hardware performed nominally All planned on-orbit operations were successfully completed

g Charlotte - The Charlotte robotic hardware performed nominally with all on-orbit operations successfully completed The robot attained or exceeded all of its preflight objectives The PI was very pleased with the operation of the robot on orbit

h Chromosome and Plant Cell Division in Space - The Chromosome and Plant Cell Division in Space (CHROMEX) experiment hardware operated nominally All planned on-orbit operations were successfully completed

i Commercial Protein Crystal Growth-Vapor Diffusion Apparatus - The Commercial Protein Crystal Growth-Vapor Diffusion Apparatus (CPCG-VDA) experiment hardware operated nominally All planned on-orbit operations were successfully completed

j Charged Particle Directional Spectrometer - The Charged Particle Directional Spectrometer (CPDS) experiment hardware operated nominally All planned on-orbit operations were successfully completed

k Cosmic Radiation Effects and Activation Monitoring - The Cosmic Radiation Effects and Activation Monitoring (CREAM) experiment hardware operated nominally All planned on-orbit operations were successfully completed

l Equipment for Controlled Liquid Phase Sintering Experiment - The Equipment for Controlled Liquid Phase Sintering Experiment (ECLIPSE) experiment hardware performed nominally All planned on-orbit operations were successfully completed

m Gas Permeable Polymer Membrane - The Gas Permeable Polymer Membrane (GPPM) hardware performed nominally All planned on-orbit operations were successfully completed

n Fluids Generic Bioprocessing Apparatus - The Fluids Generic Bioprocessing Apparatus (F-GBA) hardware performed nominally All planned on-orbit operations were successfully completed

o Protein Crystal Growth-Small Thermal Enclosure System - Hand-Held Diffusion Test Cells/Protein Crystallization Apparatus for Microgravity - The Protein Crystal Growth-Small Thermal Enclosure System (PCG-STES) - Hand-Held Diffusion Test Cells (HH-DTC)/Protein Crystallization Apparatus for Microgravity (PCAM) experiment performed nominally All planned on-orbit operations were successfully completed p Immunology Experiment - The Immunology (IMMUNE) experiment hardware performed nominally All planned on-orbit operations were successfully completed

q National Institute of Health-Cells - The National Institute of Health-Cells (NIH-C) hardware performed nominally All planned on-orbit operations were successfully completed

r Radiation Monitoring Experiment-III - The Radiation Monitoring Experiment-III (RME-III) performed nominally All planned on-orbit operations were successfully completed

s Space Acceleration Measurement System - The Space Acceleration Measurement System (SAMS) hardware was deactivated on flight day 6 as the optical disk drives appeared to not be recording, and the SAMS was not repowered for the rest of the mission Prior to that time, the SAMS was operating properly

t Window Experiment - The Window Experiment (WINDEX) hardware performed nominally All planned on-orbit operations were successfully completed

SHUTTLE POINTED AUTONOMOUS RESEARCH TOOL FOR ASTRONOMY-204

The SPARTAN-204 portion of the mission was performed in two phases The first phase consisted of the crew grappling the payload with the RMS and unberthing it from the support structure The SPARTAN-204 payload was then pointed toward the Orbiter tail to observe and measure the surface glow, and these observations included measurements taken during a primary RCS thruster firing After completion of the first phase, the payload was reberthed in its support structure where it remained until the Mir rendezvous was completed Following the rendezvous and stationkeeping activities as well as separation maneuvers from the Mir, the RMS was again used to grapple, unberth, and deploy the SPARTAN-204 for almost 48 hours of free-flight observations

Initial indications from the data are that all SPARTAN-204 systems operated as expected throughout the mission On flight day 2, the SPARTAN-204 attached operations were successfully completed with two surface glow observations and day and night thruster-firing observations These tasks were followed by a Trajectory Control Sensor (TCS) performance test, after which the SPARTAN-204 spacecraft was reberthed in the payload bay Two days later, SPARTAN-204 was released at the beginning of its window at 038 12 27 G m t (04 07 05 MET) to begin making observations of celestial targets in the far-ultraviolet wavelength SPARTAN-204 was grappled at 040 11 33 G m t (06 06 11 MET) Final berthing of SPARTAN-204 was completed in record time using biased references in the berthing camera view that were determined during the SPARTAN-204 release Postflight analysis will determine the success of data collection during the SPARTAN-204 free-flight period

HITCHHIKER PAYLOADS

The Hitchhiker Program enables customers to fly quick-reaction and low-cost experiments on Shuttle Three experiments were flown as part of this payload, and the acronym that was used to describe the payload was CGP/ODERACS-II The titles and descriptions of the payloads that make up the acronym are as follows

1 Cryogenic System Experiment (CSE) validated and characterized the on-orbit performance of two thermal management technologies that comprise a hybrid cryogenic system

2 Shuttle Glow (GLO-2) experiment investigated the mysterious shroud of luminosity, called the "glow phenomenon", that was observed by crewmembers of previous missions

3 Orbital Debris Radar Calibration System-II (ODERACS-II) experiment placed small calibration targets in low Earth orbit that were used to calibrate ground-based radar and optical systems

In addition, the IMAX camera was also flown on this structure

Cyrogenic System Experiment GLO-2 Payload

The Cryogenic System Experiment (CSE) GLO-2 Payload (CGP) was activated at 034 10 10 G m t (00 04 48 MET) after which a successful functional checkout was performed All systems continued to operate nominally throughout the mission, and this resulted in over 100 percent of the mission objectives being accomplished using the Oxygen Heatpipe and the Improved Spacecraft Standard Cryocooler (ISSC)

The GLO-2 payload was able to complete 100 percent of its mission objective by collecting Jupiter spectra, aurora, airglow, dayglow, moon, earth limb, payload bay scan and stellar observations GLO-2 operated nominally, but in a reduced science data-take mode because the data recording unit (DRU) was not responding throughout the mission Data were collected on the 16-megabyte random access memory and dumped to the ground when possible, or provided directly to the ground when Ku-band coverage was available The high-voltage power supply (HVPS) failed intermittently through flight day 2 but operated nominally during the data takes An in-flight maintenance (IFM) procedure that reversed the cable polarity was successful in restoring the video signal capability

Orbital Debris Radar Calibration Spheres-2

The ODERACS successfully deployed three spheres (2, 4, and 6 inches in diameter) and three dipoles (1 6 inches in diameter by 5 2, 1 7, and 5.2 inches in length, respectively) over a span of 15 2 seconds into a 182 by 190 nmi orbit at 035 04 57 G m t (00 23 35 MET) The deployment was moved to flight day 2 to provide a better elevation to the ground site From video analyses, the exit velocities were determined to be within 8 to 14 percent of what was expected Targets were visible as they separated from the Orbiter The dipoles were visually calculated to be tumbling at a rate of once per second Haystack ground station detected most of the targets on the first over-flight and later reported tracking all targets After 40 days, the separation distance between the first and last sphere was approximately 3,000 kilometers

IMAX Cargo Bay Camera

The IMAX cargo bay camera (ICBC) performed flawlessly throughout the mission Over 8 minutes of film of the V-bar approach to the Mir, stationkeeping with the Mir, and separation from the Mir was exposed Approximately 51 seconds of film was exposed while EV-1 was on the RMS at 040 15 18 G m t (06 09 56 MET) The remaining film was exposed with an earth view of South America at 041 14 43 G m t (07.09 21 MET)

SOLID SURFACE COMBUSTION EXPERIMENT

The SSCE was flown for the eighth time on this flight in the continuing study of flame propagation in the microgravity environment The experiment tested the combustion of different materials under different atmospheric conditions All activities for this experiment were conducted between 036 07 52 G m t (02 02 30 MET) and 036 09 22 G m t (02 04 00 MET) Postflight analysis is required to determine the success of this experiment

AIR FORCE MAUI OPTICAL SITE

The flight path of STS-63 did not provide opportunities for the AMOS or the site at Areciebo, Puerto Rico, to observe thruster firings

VEHICLE PERFORMANCE

SOLID ROCKET BOOSTERS

All SRB systems performed as expected The SRB prelaunch countdown was normal, and no SRB Launch Commit Criteria (LCC) or Operational Maintenance Requirements Specification Document (OMRSD) violations occurred

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 Liftoff was normal and both SRBs performed satisfactorily during powered flight with no anomalies noted

Both SRBs were successfully separated from the ET at T+ 125 040 seconds, and both SRBs were located by radar near the retrieval ships Because of the high seas, the recovery of the SRBs was delayed approximately 24 hours. The postflight assessment of the SRBs revealed major damage to the forward assemblies, the ET attachment (ETA) rings, and the aft assemblies of both boosters (Flight Problem STS-63-B-1) Both forward skirts were buckled and cracked The thrust vector control (TVC) systems on both boosters sustained heavy damage Both of the ETA rings were damaged, and the left-hand aft skirt sustained structural damage Investigation has concluded that the damage occurred after separation The left-hand forward skirt and the left-hand main parachute index no 2 were not found The left-hand forward skirt and the left-hand TVC tilt actuator were lost during the tow back to port because of the high seas

As a result of the heavy damage, a prediction of the steady-state surface winds in the SRB retrieval area will be provided to the Mission Management Team prior to ET tanking on future missions Steady-state surface winds in excess of 26 knots increase the risk of SRB damage at water impact Also, a requirement change notice (RCN) to the OMRSD will be processed to make surface winds in the SRB retrieval area a consideration throughout the launch window

REUSABLE SOLID ROCKET MOTORS

The Reusable Solid Rocket Motors (RSRMs) performed nominally No LCC or OMRSD violations were noted during the countdown All prelaunch RSRM temperatures were maintained within acceptable limits

Power-up and operation of field-joint heaters was accomplished routinely The field-joint heaters were powered approximately 29 percent of the time during the LCC time frame to maintain temperatures in the normal operating range The igniter-joint heater operation was nominal with power being applied approximately 64 percent of the time to maintain temperatures in the normal operating range

Data indicate that the flight performance of both RSRMs was well within the allowable performance envelopes, and the performance was typical of that observed on previous flights The RSRM propellant mean bulk temperature was 60 °F at liftoff The propulsion performance of the RSRMs is shown in the following table

RSRM PROPULSION PERFORMANCE

Parameter	Left motor, 60 °F		Right motor, 60 °F	
	Predicted	Actual	Predicted	Actual
Impulse gates				
I-20, 10^6 lbf-sec	64 94	65 36	65 27	65 12
I-60, 10^6 lbf-sec	173 41	175 32	174 17	175 58
I-AT, 10^6 lbf-sec	296 73	297 84	296 97	297 01
Vacuum Isp, lbf-sec/lbm	268 4	269 4	268 4	268 5
Burn rate, in/sec @ 60 °F at 625 psia	0 3688	0 3703	0.3697	0 3707
Burn rate, in/sec @ 60 °F at 625 psia	0 3688	0 3703	0 3697	0 3707
Event times, seconds[a]				
Ignition interval	0 232	N/A	0 232	N/A
Web time[b]	110 8	110 1	110 3	109 8
50 psia cue time	120 6	120 0	120 1	119 8
Action time[b]	122 7	122 4	122 2	122 0
Separation command	125 5	124 9	125 5	124 9
PMBT, °F	60	60	60	60
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	Predicted		Actual	
differential, Klbf-sec	N/A		159 9	

Impulse Imbalance = left motor minus right motor

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

[b] Referenced to liftoff time (ignition interval)

EXTERNAL TANK

All objectives and requirements associated with the ET propellant loading and flight operations were satisfactorily met All ET electrical equipment and instrumentation operated satisfactorily The ET purge and heater operations were monitored and all performed properly No ET LCC or OMRSD violations were identified

Typical ice/frost formations were observed on the ET during the countdown Frost was observed on the liquid hydrogen (LH_2) tank acreage during the T-3 hour hold, but the frost subsided as the relative humidity increased Normal quantities of ice or frost were present on the liquid oxygen (LO_2) and 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 were acceptable per NSTS-08303 The ice/frost personnel reported that no anomalous thermal protection system (TPS) conditions were noted

The ET pressurization system functioned properly throughout engine start and flight The minimum LO_2 ullage pressure experienced during the ullage pressure slump was 14 0 psid

ET separation was confirmed The postflight prediction of the ET impact point was approximately 63 nmi uprange of the preflight prediction

SPACE SHUTTLE MAIN ENGINE

All Space Shuttle main engine (SSME) parameters were normal throughout the 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 All Interface Control Document (ICD) start and shutdown transient requirements were met Engine performance during start, mainstage, throttling and shutdown was nominal and as predicted, with cutoff times for SSME 1, 2, and 3 being 517 49, 517 60, and 517 70 seconds, respectively (referenced to engine start command) Controller and software performance was excellent

Flight data indicate that the SSME performance during propellant dumping operations was normal High pressure oxidizer turbopump (HPOTP) and high pressure fuel turbopump (HPFTP) temperatures appeared to be well within specification throughout engine operation Main engine cutoff (MECO) occurred at T+511 1 seconds

There were no SSME in-flight anomalies, however, spikes were noted in several pressure measurements that were attributed to ground radar As a result, an integration anomaly (Flight Problem STS-63-I-01) was assigned to evaluate this condition In conjunction with this anomaly, the SSME 1 main combustion chamber (MCC) coolant discharge pressure spiked at engine start (ES) + 77 5 seconds, HPOTP secondary seal cavity pressure channel A spiked at ES + 82 2 seconds, channel B spiked at ES + 84 seconds, and the fuel system purge pressure spiked at ES + 92 2 seconds

SHUTTLE RANGE SAFETY SYSTEM

The Shuttle Range Safety System (SRSS) closed-loop testing was completed as scheduled during the countdown All SRSS safe and arm (S&A) devices were armed and system inhibits turned off at the appropriate times All SRSS measurements indicated that the system operated as expected throughout the countdown and flight

An 18-inch length of SRSS ground checkout coaxial cable flew attached to the connector at the ET umbilical, normally this cable separates at the connector Since this cable installation is outside the NSTS 08303 stated debris zone, no flight debris concern existed Furthermore, this cable location is in a benign aerodynamic heating region, and no thermal concerns existed

As planned, the SRB S&A devices were safed and the SRB system power was turned off prior to SRB separation The ET system remained active until ET separation from the Orbiter

ORBITER SUBSYSTEM PERFORMANCE

Main Propulsion System

The overall performance of the main propulsion system (MPS) was as expected LO_2 and LH_2 loading were performed as planned with no stop-flows or reverts 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 start of fast-fill) was approximately 100 ppm, which compares favorably with previous data from this vehicle

A comparison of the calculated propellant loads at the end of replenish versus the inventory results in a loading accuracy of +0 01 percent for LH_2 and +0 03 percent for LO_2

MPS performance throughout ascent was nominal All fill and drain valves closed normally, and the gaseous hydrogen (GH_2) flow control valves performed nominally The ET pressurization system functioned properly throughout the flight All net positive suction pressure (NPSP) requirements were met throughout the flight

This was the first flight of the new dump patch to the OI-23 software, and the patch performed as predicted with the maximum pressure after the vacuum inert being 14 psia

Manifold repressurization for entry was normal with 61 3 lbm of helium used

Reaction Control Subsystem

The RCS performed adequately in fulfilling all requirements placed on the subsystem during the mission The RCS consumed 4575 4 lbm of propellant from the RCS tanks, and 3241 4 lbm of the OMS propellants during interconnect operations Three anomalies were identified and these are discussed in the following paragraphs

During the Orbiter separation maneuver from the ET, primary RCS thruster R1U was failed off by the redundancy management (RM) at 034 05 30 53 G m t (00 00 08 49 MET), and was failed leak at 034 05 32 08 G m t (00 00 10 04 MET) (Flight Problem STS-63-V-01) Also, primary RCS thruster L2D was failed off by RM at 034 05 30 56 G m t (00 00 08 52 MET) (Flight Problem STS-63-V-02) Thruster L2D remained deselected for the remainder of the flight

Four unsuccessful attempts were made to stop the oxidizer leak from the RCS R1U thruster by closing the manifold 1 isolation valves, allowing oxidizer manifold pressure to decrease, and opening the isolation valves allowing rapid repressurization of the oxidizer manifold beginning at 036 12 41 G m t (02 07 19 MET) The manifold 1 oxidizer pressure was allowed to decrease to 100 psi on the first two attempts and to 50 psi on the third attempt The manifold isolation valves were then closed for more than 4 hours and subsequently reopened No significant change in the leak signature was observed as a result of these operations The manifold isolation valves were then closed to isolate the leak RCS right manifold 1 isolation valves were reopened again at approximately 037 07 29 14 G m t (03 02 07 10 MET) to manage the fuel manifold pressure changes that were being caused by solar heating Although the leak had decreased, thruster R1U continued to leak at 150 to 200 cc/hr Therefore, the right RCS manifold 1 isolation valves were closed for the Mir rendezvous The RCS performance during the rendezvous maneuvers was nominal

The RCS low-Z hot-fire was performed in two phases Phase 1 was initiated at 035 19 16 52 G m t (01 13 54 48 MET) and involved one pulse of the F1F, F2F, L3A, and R3A thrusters Phase 2 was initiated at 035 19 20 04 G m t (01 13 58 00 MET) and involved one pulse of the L1A, R1A, and F3F thrusters Following phase 1 of the hot-fire, the thruster F1F oxidizer injector temperature dropped to 16 5 °F (Flight Problem STS-63-V-03), and as a result, leak detection software deselected the thruster The temperature drop is characteristic of an oxidizer valve leak The fuel injector temperature eventually dropped below 40 °F, prompting isolation of the forward RCS manifold 1 at 035 20 27 40 G m t (01 15 05 36 MET), after which the injector temperatures recovered Manifold 1 was re-opened at 036 04 21 G m t (01 22 59 MET) to allow the force of repressurizing the manifold to clear potential contaminants from the oxidizer valve During three subsequent firings of thruster F1F, good thruster performance was observed with normal chamber pressure (Pc) and injector temperature profiles No further leakage was noted, and thruster F1F was returned to normal operation but was not fired again during the mission

Orbital Maneuvering Subsystem

The OMS performed satisfactorily during the seven firings (two dual engine and five single engine) performed during the mission A total of 21,820 6 lbm of propellants was used during the seven firings and the RCS interconnect operation, which used 8 29 percent from the left pod and 16 74 percent from the right pod The following table shows the data for the seven OMS firings

OMS FIRINGS

OMS firing	Engine	Ignition time, G m t /MET	Firing duration, seconds	ΔV, ft/sec
OMS-2	Both	034 06 04 14 7 G m t 00 00 42 10 7 MET	155 7	252 1
OMS-3	Right	034 14 20 16 2 G m t 00 08 58 12 2 MET	39 7	32 1
OMS-4	Left	035 14 26 49 G m t 01 09 04 45 MET	24 5	20 1
OMS-5	Left	036 18 37 39 5 G m t 02 13 15 35 5 MET	49 6	40 7
OMS-6	Left	037 14 24 04 3 G m t 03 09 02 00 3 MET	10 4	8 5
OMS-7	Left	037 16 36 43 3 G m t 03 11 14 39 3 MET	18 6	15 4
Deorbit	Both	042 10 44 04 3 G m t 08 05 22 00 3 MET	254.3	450 4

Power Reactant Storage Distribution Subsystem

The power reactant storage and distribution (PRSD) subsystem performance was satisfactory with no anomalies noted A total of 2237 lbm of oxygen and 272 lbm of hydrogen was consumed during the mission Of the oxygen total, 76 lbm was provided to the crew cabin for crew breathing The four manifold isolation valves were cycled during the mission The mission extension capability was 54 hours at an average power level of 15 8 kW, and 78 hours at an extension-day average power level of 11 1 kW

Fuel Cell Powerplant Subsystem

The fuel cell powerplant subsystem performed satisfactorily, producing 3142 kWh of electricity at an average power level of 15 8 kW and average load of 517 amperes during the 198 5 hours of operation The fuel cells consumed 272 lbm of hydrogen and 2161 lbm of oxygen and produced, as a by-product, 2433 lbm of water Fuel cell 3 ended the mission with 2194 total accumulated hours on the stack, the most total hours for any Space Shuttle fuel cell in use

Approximately 15 minutes after the start-up of fuel cell 3, the hydrogen flow on two occasions indicated increases from 0 80 to almost 1 10 lb/hr The flow reading soon returned to the nominal value and read nominally throughout the mission

Approximately 3 hours prior to landing at 042 09 04 22 G m t (08 03 42 18 MET), the fuel cell 2 hydrogen-pump-motor voltage sensor indication increased instantaneously from 0 62 Vdc to 0 82 Vdc, indicating that the hydrogen pump was drawing more current The voltage gradually decreased to the 0 62-Vdc level after 45 seconds No change in fuel cell performance was noted during this transient Review of the AC bus 2 phase currents during the same time period indicated that the phase A and B currents rose 160 mA, and phase C decreased 160 mA If the pump was drawing more current due to a higher load, all three phase currents would be expected to change more gradually as well as increase in all three phases. A similar occurrence but of lesser magnitude was observed during prelaunch operations for STS-42 (same vehicle) in the same fuel cell position but not the same fuel cell Extensive troubleshooting after STS-42 did not isolate the cause of the problem The conclusion reached was that since this anomaly occurred on the same vehicle and same position, the fuel cell was probably not the cause

Auxiliary Power Unit Subsystem

The APU subsystem performed nominally throughout the mission with no in-flight anomalies noted The APUs were shut down after ascent in the APU 2, APU 1, and APU 3 order to fulfill the requirements of DTO 414, sequence B The results of this DTO are discussed in the Development Test Objective section of this report The APU fuel consumption and run-time by APU position and serial number are shown in the table on the following page

The exhaust gas temperature (EGT) 1 measurement on APU 1 operated erratically during entry, however, this condition did not impact APU operation APU 1 also had two gearbox repressurizations during entry The first occurred one minute after start, and the second occurred about 30 minutes after start Neither of these repressurizations affected entry operations

APU RUN TIMES AND FUEL CONSUMPTION

Flight phase	APU 1 (S/N 407)		APU 2 (S/N 204)		APU 3 (S/N 306)	
	Time, min sec	Fuel consumption, lb	Time, min sec	Fuel consumption, lb	Time, min sec	Fuel consumption, lb
Ascent	19 50	50	19 38	58	19 54	49
FCS checkout					7 22	16
Entry[a]	65 30	129	92 45	207	65 32	145
Total	85 20	179	112 25	265	92 48	210

[a] The APUs ran for about 21 minutes 33 seconds after landing

Hydraulics/Water Spray Boiler Subsystem

The hydraulics/water spray boiler (WSB) subsystem performed nominally throughout the mission The main hydraulic pump outlet pressure of hydraulic system 1 showed unusual oscillations at APU 1 start prior to entry The oscillations were about 250-psi peak-to-peak with the maximum value under 975 psi The specification for this condition states that the oscillation peaks are to be no greater than 1000 psi These oscillations did not affect WSB performance during entry

Ascent was performed on WSB system 2 controller B and entry was performed on controller A in an attempt to isolate out-of-specification over-cooling conditions that have been experienced on six of the seven previous missions of this vehicle Typically, controller A is used for ascent and controller B is used for entry However, using the A controller resulted in no over-cooling conditions of WSB system 2 during this mission Initial indications are that the B controller may be contributing to the over-cooling conditions that have been experienced The next flight of this vehicle will use the same controller configuration for additional verification that the B controller may be at fault

Electrical Power Distribution and Control Subsystem

The electrical power distribution and control (EPDC) subsystem performed nominally throughout the mission All data analyzed showed nominal voltage and current signatures, and no specified limits were violated

One in-flight anomaly, the loss of CRT 4 during the flight was evaluated to determine if the cause of the anomaly could possibly be a remote power controller (RPC) problem

Environmental Control and Life Support System

The active thermal control system (ATCS) performed satisfactorily The ATCS successfully supported payload cooling requirements after the flow proportioning valve in Freon cooling loop (FCL) 2 was placed in the payload position at 034 07 25 G m t (00 02 03 MET) The loop was returned to the interchanger position at 041 16 12 G m t (07 10 50 MET)

The radiator cold-soak provided cooling during entry through touchdown plus 10 minutes when ammonia system A, using the primary/GPC controller, was activated This was the first flight of the system A controller since it was adjusted to compensate for under-temperature operation on this particular heat exchanger System A controlled to 36 °F, well above freezing temperatures System A operated for 36 minutes and was deactivated 46 minutes after landing when the ground cooling cart was connected to the vehicle The flow proportioning module in FCL 2 was returned to the payload position 41 minutes after landing to support Spacehab postlanding cooling requirements

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 overboard dump system and the flash evaporator system (FES) Three supply water dumps were performed simultaneously with the waste water dumps The supply water dumps were performed at an average dump rate of 1 51 percent/minute (2 50 lb/min) The supply water dump line temperature was maintained between 66 °F and 96 °F throughout the mission with the operation of the line heater

Waste water was gathered at approximately the predicted rate Three waste water dumps were performed at an average rate of 1 87 percent/minute (3 1 lb/min) The waste water dump line temperature was maintained between 57 °F and 85 °F throughout the mission, while the vacuum vent line temperature was between 60 °F and 84 °F, and the vacuum vent nozzle was between 146 °F and 174 °F

The waste water and supply water dump test was performed from 036 06 14 G m t (02 00 52 MET) to 036 07 37 G m t (02 02 15 MET) Live video of the dump was provided, however, the dump streams were not visible because of lighting conditions There was no visible buildup of ice on the payload bay door (PLBD) The total supply water dumped overboard was 34 lb The total waste water dumped overboard was 71 8 lb

A second simultaneous supply/waste water dump was satisfactorily completed at 038 19 42 G m t (04 14 20 MET) Two cycles were required to dump a total of 96 5 lb of waste water A single cycle was required to dump 35 3 lb of supply water The RMS wrist camera and spotlight were used to view the spray patterns from the nozzles during a night pass in an attempt to evaluate possible water spray impingement on the PLBD Neither the spray pattern nor any possible impingement were visible in the desired wide-angle view of the dump No ice deposits were found on the PLBD.

The third simultaneous supply and waste water dump was initiated at 041 16 08 34 G m t (07 10 46 31 MET) and was completed at 041 16 58.26 G m t (07 11 36 22 MET) A total of 46 3 lb of supply water and 104 1 lb of waste water was dumped Spray patterns were visible when the RMS wrist camera was zoomed in and pointed toward the nozzles, but the patterns were not visible when the camera was panned outboard No ice deposits were noted on the PLBD

This was the second flight of the supply water dump line purge assembly (SWDLPA) on OV-103 The SWDLPA provides 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 before the use of the SWDLPA, the burping has been known to repeat up to 10 times An air purge was used to stop the burping condition on those flights A modified procedure was used this mission since during the last flight of OV-103 (STS-64), two singular burps did occur On STS-63, no burps were noted in the data from the three dumps

The waste collection system (WCS) performed normally throughout the mission

The atmospheric revitalization system performed nominally

At 034 21 50 G m t (00 16 28 MET), the cabin pressure transducer shifted low by 0 24 psi from 14 64 psi to 14 40 psi (Flight Problem STS-63-V-06) All other cues indicated nominal cabin pressure Since no 10 2-psi activity was planned for this mission, this anomaly had no impact on the flight At the time of the occurrence, the Spacehab pressure was 14 8 psi

Airlock Support System

All airlock support system parameters indicated normal performance The airlock/tunnel adapter was used to support a four-hour 39-minute EVA on flight day 7

During the EVA, a small pressure drop, equivalent to a 17 to 20 lb/day leak, was detected in the Spacehab module (Flight Problem STS-63-V-08) The pressure decreased from 14 80 psi to 14 16 psi over a 5-hour 18-minute period Three possible sources of the leak were identified

a Tunnel adapter hatch D sealing,

b Hatch D equalization valves, or

c Payload air isolation valve and cap assembly

Postflight troubleshooting will be performed to isolate the cause of the leak

Smoke Detection and Fire Suppression Systems

All smoke detection parameters indicated normal performance throughout the mission No indication of smoke generation was evident Use of the fire suppression system was not required

Avionics and Software Systems

The performance of the guidance, navigation and control (GN&C) during ascent and entry was nominal The STS-63 launch was delayed approximately 24 hours from 12 47 44 a m e s t on February 2, 1995, until 12 22 04 a m e s t on February 3, 1995, because inertial measurement unit (IMU) 2 failed During the moding of IMU 2 from standby to operate on the day of the first launch attempt, the unit annunciated a platform-fail built in test equipment (BITE) and also indicated that the platform had tumbled A second attempt at moding from standby to operate was also unsuccessful The HAINS IMU was removed, replaced and the newly installed unit retested satisfactorily

The downlisted data from STS-63 indicates that outboard elevon load relief was experienced twice, once 54 seconds after liftoff at Mach 1 15 and again at about 60 seconds at Mach 1 35 The load relief was active for approximately 3 seconds in each instance

An input/output (I/O) error message against cathode ray tube (CRT) 4 was annunciated and two I/O errors were logged by general purpose computer (GPC) 4 about 35 minutes after powering on CRT 4 The crew confirmed that CRT 4 was operating nominally when it was powered up The crew found the CRT screen blank, and the display electronics unit (DEU) built-in-test-equipment (BITE) flag tripped (Flight Problem STS-63-V-04) CRT 4 was recovered by performing a power cycle At 035 08 41 G m t (01 03 19 MET), the crew reported that CRT 4 was again blank, although its power switch was still on Also, the DEU BITE was tripped and an I/O error message for CRT 4 was noted on the other operating CRTs The signature was the same as on the first failure - the CRT simply dropped off without a current spike or a circuit breaker tripping The crew performed a dump of the DEU BITE register, then recovered the CRT with a power cycle when performing the malfunction procedure The DEU/CRT 4 experienced two additional failures prior to the rendezvous on flight day 4 The DEU/CRT was recovered each time with a power cycle The flight crew utilized the DEU at their discretion and there was no mission impact A similar failure signature occurred at the CRT 4 position during ground checkout operations on DEU 4, and the unit was replaced and successfully retested prior to flight

The primary RCS thrusters L1L, L1U, R4U, F3L, and F3U fired 80-ms-duration pulses in response to an unexpected +Y/+Z THC command following the power-up of the aft THC at 035 11 41.06 G m t (01:06 19 02 MET) (Flight Problem STS-63-V-07) No physical deflection of the THC had occurred coincident with the thruster firings Initial data review appeared to indicate that the THC command resulted from a transient response of the THC contacts upon application of flight control system (FCS) power The digital autopilot (DAP) response was nominal for a valid +Y/+Z command The translation mode was in NORM, requiring the DAP to fire thrusters only while the THC was deflected. Since the power transient duration was under 80 ms, only one minimum-duration firing of 80 ms was commanded

A similar event occurred during STS-66 in which a -Y/-Z command was generated coincident with power-up of the forward station FCS switch Tests in the Shuttle Avionics Integration Laboratory (SAIL) following the STS-66 event demonstrated that a THC command can be generated from the flight control power-on operation because of the staggered fall of the THC contact discrete outputs

The crew reported that thrusters did not fire in response to a short-duration +Y THC input at 041 14 43 14 G m.t (07 08 21 15 MET) Previous to, as well as after this occurrence, +Y commands from the same THC resulted in nominal thruster firings The THC was probably not deflected long enough to fire the thrusters

The landing was soft and resulted in the RM deselecting the right main gear proximity switch because the indication toggled However, the redundancy in the system resulted in the correct outputs being generated

Displays and Controls Subsystems

The displays and controls subsystems performed nominally

Communcations and Tracking Subsystems

All communications and tracking systems performed nominally The communications systems were also used to support two Development Test Objectives (DTOs) and one Detailed Supplementary Objective (DSO) The results of these DTOs and the DSO are reported in the Development Test Objective/Detailed Supplementary Objective section of this report

Ku-band channel 2 data became degraded when the camcorder video that was routed through the Spacehab video switching unit (SVSU) was downlinked. Also, degradation of the Spacehab downlink video was noted when the Orbiter S-band FM system was operating An interface incompatibility between the Orbiter VSU and the SVSU is believed to be the most likely cause of the problem

Operational Instrumentation/Modular Auxiliary Data System

The operational instrumentation (OI)/Modular Auxiliary Data System (MADS) performed very satisfactorily No problems or anomalies were identified

Structural and Mechanical Subsystems

The structural and mechanical subsystems performed nominally with one anomaly identified 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	1349	212.2	~ 3.0	N/A
Nose gear touchdown	5437	150 1	N/A	~4 2
Brake initiation speed			58 4 knots (keas)	
Brake-on time			32 8 seconds	
Rollout distance			11,002 feet	
Rollout time			80 4 seconds	
Runway			15 (Concrete) EAFB	
Orbiter weight at landing			224,130 2 lb	

Brake sensor location	Peak pressure, psia	Brake assembly	Energy, million ft-lb
Left-hand inboard 1	634	Left-hand outboard	5 66
Left-hand inboard 3	687	Left-hand inboard	7 90
Left-hand outboard 2	581	Right-hand inboard	6 86
Left-hand outboard 4	647	Right-hand outboard	4 07
Right-hand inboard 1	581		
Right-hand inboard 3	726		
Right-hand outboard 2	462		
Right-hand outboard 4	568		

At 037:20:06 G.m t (03.14 43 MET), the latch A indication in the port radiator latch gang 1-6 actuator began toggling off and on for approximately 1 and 1/2 hours (Flight Problem STS-63-V-05), after which the indication returned to normal operation except for occasional periods of erratic behavior The redundant indication (latch B) showed no erratic behavior

Integrated Aerodynamics, Heating and Thermal Interfaces

The ascent and descent aerodynamics were nominal Active elevon load relief was initiated at two points in the high dynamic pressure portion of the trajectory during ascent These new occurrences of load relief were at approximately 54 to 56 seconds and 60 to 62 seconds and are the result of using a modified elevon schedule during STS-63

The ascent aerodynamic and plume heating were nominal with no instances of problems Likewise, the aerodynamic entry heating of the SSME nozzles was nominal

The thermal interface temperatures were nominal as was the whole area of thermal interface heating

Thermal Control Subsystem

The performance of the thermal control subsystem (TCS) was nominal during all phases of the mission, and all Orbiter subsystem temperatures were maintained within acceptable limits No problems or anomalies were identified in the TCS area

Aerothermodynamics

The acreage heating was nominal during entry, and there was no unusual local heating Boundary layer transition was nominal based on the structural temperature rise data Boundary layer transition from laminar to turbulent flow occurred at 1200 seconds after entry interface (EI) on the forward centerline and aft left-hand side of the vehicle Transition occurred at 1175 seconds at the aft right-hand side of the vehicle, indicating slightly asymmetric boundary layer transition

Thermal Protection Subsystem and Windows

The thermal protection subsystem (TPS) performed satisfactorily during the mission Based on structural temperature response data (temperature rise), the entry heating was slightly above average for this vehicle, but well within the flight experience

The TPS sustained a total of 125 hits of which 14 had a major dimension of 1 inch or larger The lower surface had a total of 84 hits of which 7 had a major dimension of 1 inch or greater and that is much lower than the average of 14 The largest tile damage site measured 5 5 inches by 1.5 inches by 0 75 inch deep, and the damage was located outboard of the ET/Orbiter LH_2 umbilical and directly aft of the left main landing gear and showed no signs of entry heating or erosion. Room temperature vulcanizing (RTV) material from the main landing gear may have come off during gear deployment and caused the damage prior to touchdown, however, no RTV material was found on the runway No other tile damage was attributed to material from the wheels, tires or brakes The tires were in good condition after the landing on the KSC runway

No ice adhered to the payload bay door. The waste and supply water dump nozzles appeared to be in normal condition No unusual tile damage was visible on the leading edges of the OMS pods and vertical stabilizer
The number of hits aft of the ET/Orbiter LH_2 and LO_2 umbilicals, believed to be impacts from ice, were less than usual Also, no tile damage from micrometeorites or on-orbit debris was identified

The ET/Orbiter separation devices functioned properly and the debris plungers were seated All ET/Orbiter umbilical separation ordnance retention shutters were closed No significant amounts of foam or red purge seal adhered to the ET/Orbiter LH_2 umbilical near the 4-inch flapper valve No debris was found on the runway beneath the ET/Orbiter umbilical cavities,

Orbiter window 4 exhibited moderate-to-heavy hazing Windows 3 and 5 exhibited light-to-moderate hazing Only a very light haze was present on the other windows Surface wipes were taken from all windows for laboratory analysis Tile damage on the window perimeter tiles was typical A tile-damage site, 5 inches long by 0 4 inch wide, was located on the upper canopy forward of window 7 The tile surface coating was damaged, but all the tile surface coating remained adhered to the tile

Drag Chute Subsystem

The drag chute performance was nominal with deployment at 182 2 knots estimated air speed (keas), and the chute was jettisoned at 60 7 keas. All drag chute hardware was recovered after landing and no damage was noted Also, no damage was noted to the vertical stabilizer stinger or around the drag chute door from drag chute deployment

REMOTE MANIPULATOR SYSTEM

The RMS performed satisfactorily throughout this fortieth flight of the RMS The main RMS activities were the SPARTAN-204 deployment and retrieval, mass handling exercises by the EVA astronauts, several Orbiter surveys and attached SPARTAN operations for Surface Glow Observations, Tracking Control System (TCS) tests, and support of DTO 671 operations during the EVA

About 2 hours 40 minutes after launch, the RMS was powered, the shoulder brace was released and the manipulator positioning mechanisms (MPMs) were rolled out The shoulder brace release time was 6 seconds

The RMS checkout procedure was initiated about 6 hours after launch The checkout was completed successfully with the RMS performance nominal At the end of the RMS checkout, the arm was used to perform a payload survey using the end effector (EE) camera With no visual payload anomalies observed, the payload survey was completed and the arm was moved to the extended-park position

On flight day 2, the RMS was used for SPARTAN-204 attached operations The arm was used to grapple, unberth and then position SPARTAN to the Surface-Glow observation position When the surface glow observations were complete, the RMS was used to maneuver SPARTAN between near- and far-field positions for day and night observations of primary RCS thruster firings

TCS tests were conducted upon completion of the primary RCS thruster-firing observations To support the TCS tests, six laser retro-reflectors that were mounted on the SPARTAN-204 were used TCS tracking data were recorded as the arm maneuvered the SPARTAN to eight different test points using the operator-commanded auto sequence (OCAS) Once the TCS tests were complete, the SPARTAN was berthed in the cargo bay The RMS was then briefly positioned in the pre-cradle position in preparation for an OMS firing, after which it was moved to the extended-park configuration

Using the EE camera, the RMS was used for several Orbiter surveys on flight day 3 The arm was first used to survey hot firings of primary forward RCS thruster F1F to help troubleshoot an oxidizer leak which had been detected earlier The survey helped verify that this RCS thruster anomaly had been corrected The arm was then moved to the modified supply/waste water dump survey position for the first of three such surveys As an icicle had formed on the payload bay doors during this dump procedure on STS-66, there was an effort made on this flight to characterize the dump nozzle spray profiles with this survey Due to poor lighting conditions, the spray patterns were not visible

The arm was also used to survey the RCS thruster R1U leak Once this survey was complete, the arm was moved to the pre-cradle configuration in preparation for an OMS firing At the end of the OMS firing, the arm was positioned in the extended-park configuration

On flight day 4 when preparing for the Shuttle/MIR rendezvous, the RMS was cradled, latched and placed in temperature-monitor mode where it remained until rendezvous operations with the Mir Space Station were completed

Beginning at 038 11 00 13 G m t (04 05 38 09 MET) on flight day 5, the arm was reselected, uncradled and SPARTAN-204 was grappled in preparation for unberthing and deploying the satellite After reaching the release position, SPARTAN used a rigidize sensing grapple fixture (RSGF) to execute the pre-programmed post-release sequence This was done using a quick derigidize/rigidize sequence just prior to the actual release The first thing that SPARTAN was programmed to do was perform a pirouette maneuver, which demonstrated that it was operating properly This was seen with the RMS wrist camera, and the Orbiter then began a series of separation maneuvers, moving away from SPARTAN

Near the end of flight day 5, the second modified supply/waste water dump survey was performed and monitored by the RMS-mounted camera Again, poor lighting prevented the spray patterns from being visible with the camera After this survey, the arm was moved to the extended-park position

On flight day 7, after rendezvous with the SPARTAN satellite, the RMS grappled the free-flyer and berthed it in the cargo bay

The RMS was used by the spacewalking crew members, EV1 and EV2, during a thermal evaluation of the EMUs and for EVA mass handling exercises with SPARTAN During the EMU thermal evaluations, one crewmember stood in the portable foot restraint (PFR) on the end of the arm and held on to the second EVA crewmember while the arm moved them approximately 20 ft above the flight deck Upon completion of this evaluation, the arm was used to move EV2 over to SPARTAN to begin mass handling exercises While standing in the PFR on the end of the arm, EV2 held on to SPARTAN while it was unlatched and then unberthed using the arm During the mass handling exercises, which began during a night pass, both EVA crewmembers reported cold extremities Mass handling exercises were shortened and SPARTAN was berthed and latched back in the payload bay

On flight day 8, the third and final modified supply/waste water dump survey was monitored using the RMS-mounted camera This time, with the dump scheduled to ensure proper lighting conditions, the spray patterns of the nozzle were visible with the EE camera Once this last survey was complete, the arm was cradled, latched and the MPMs were stowed in preparation for return to earth

EXTRAVEHICULAR ACTIVITY

The checkout of the two EMUs was performed on flight day 6 All life support systems were verified to be operating within design limits Communications functions were also verified as well as the battery-charging capability

On flight day 7, the two EVA crewmembers donned their EMUs and performed the normal 4-hour prebreathe before depressurizing the airlock and tunnel adapter to vacuum At vacuum, the crewmembers egressed the tunnel adapter hatch and began EVA operations

The mass handling procedures using the SPARTAN-204 were performed during a night pass Ten minutes into the night pass, the EV1 crewmember began reporting uncomfortably cold hands Overall body thermal comfort was good The EV2 crewmember also experienced cold hands and feet Later mass handling activities were shortened and payload-bay clean-up was initiated.

The thermal over-gloves, which provide thermal protection for the hand, were not used during the mass handling activities but were put on by EV2 at the completion of this activity EV2 stated that his hands felt a little warmer with the over-gloves on, but the cold could still be sensed through the gloves Crew thermal comfort was restored during the following day pass

The 4-hour 39-minute EVA was performed nominally and the EMUs performed nominally During airlock repressurization to 5 psia, the EV2 crewmember experienced a burning sensation in his eyes The airlock repressurization was completed, and the crewmember removed the EMU and flushed his eyes with cold water Investigations conducted during the postflight activities revealed no evidence of contaminants present in the EMU

FLIGHT CREW EQUIPMENT/GOVERNMENT FURNISHED EQUIPMENT

All flight crew equipment/government furnished equipment (FCE/GSE) performed very satisfactorily Two in-flight anomalies were identified in the area of FCE/GSE

During the airlock repressurization following the EVA, the EV2 crewmember reported eye discomfort as well as an odor in the suit (Flight Problem STS-63-F-01) The postflight inspection of the suit revealed small brown flecks on the inner surface of the visor Lithium hydroxide, internal suit contamination, suit contamination from an external source, and oxygen supply contamination were all investigated as possible causes of the condition, but were found to be improbable causes of the eye irritation Toxicological tests of the brown flecks showed them to be organic The eye irritation is believed to have been caused by the anti-fog (modified soap) solution that is placed on the internal surface of the helmet visor prior to each EVA Four EVA crewmembers from previous missions reported varying levels of discomfort after perceived contact with this solution

Neither of the electronic cuff checklists (ECCs), worn by the EVA crewmembers, operated correctly during the EVA (Flight Problem STS-63-F-02) The EV1 ECC responded in only one (bottom middle) of the six touch areas, however, the unit resumed full functionality prior to repressurization The EV2 ECC did not respond in the right two areas and remained unresponsive throughout the EVA Both units lost their display capability later in the EVA, but the displays returned prior to repressurization

CARGO INTEGRATION

The integration hardware performance was nominal throughout the mission with no in-flight anomalies identified

DEVELOPMENT TEST OBJECTIVES/DETAILED SUPPLEMENTARY OBJECTIVES

A total of 21 DTOs and 14 DSOs were assigned to the STS-63 mission The following subsections provide preliminary data as available on many of the objectives

DEVELOPMENT TEST OBJECTIVES

DTO 312 - ET TPS Performance - This DTO was not accomplished because of the loss of a thruster during the maneuver to the photographic attitude

DTO 414 - APU Shutdown Test (Sequence B) - The APUs were shut down in the order required by the DTO The data showed no anomalous pressure hang-ups or power drive unit (PDU) motor back-driving as a result of this shutdown sequence

DTO 671 - EVA Hardware for Future Scheduled EVA Missions (14 7 Prebreathe Protocol), Test 9 - The mass handling tool performed as expected Information on the additional tools evaluated during the EVA may be obtained from the DTO sponsor

DTO 672 - EMU Electronic Cuff Checklist - STS-63 was the second flight test of the electronic cuff checklist Based on the results of these two flights, a need has been identified for further refinement related to tolerance to cold temperatures

DTO 700-5 - Payload Bay Mounted Rendezvous Radar - The TCS was powered during all proximity operations During the Mir approach, the TCS acquired the target at 614 feet and tracked until the backaway at 322 feet, when a failure prevented the laser from focusing accurately This failure did not recur during the SPARTAN-204 deployment Upon commanding, the TCS started tracking SPARTAN-204 at 178 feet and continued to track until 463 7 feet when the relative position of SPARTAN-204 was first outside the bearing rate capability and then outside the operational angles of the TCS During the SPARTAN-204 retrieval, the TCS exhibited instrumentation problems upon activation that resulted in the crew being asked to inhibit the temperature and voltage fault messages that kept occurring Following this corrective action, the crew activities did not provide time for initiating the tracking mode The ground data indicated that the TCS would have acquired and tracked SPARTAN-204 at approximately 2000 ft While data were acquired during the Mir rendezvous and the SPARTAN-204 deployment, the SPARTAN-204 retrieval was to provide the best source of data for TCS evaluation because the targets were in view at longer distances

DTO 805 - Crosswind Landing Performance - This DTO was not performed because of the lack of adequate wind conditions at landing

DTO 833 - EMU Thermal Comfort Evaluations (14 7 prebreathe protocol) (Tests 1 and 2) - The EMU thermal comfort was successfully evaluated in the cold environment Crew feedback and recorded ambient and glove temperatures are being analyzed for comparison to thermal models and to determine the next generation of thermal comfort improvements

DTO 835 - Mir Approach Demonstration (Objectives 2, 4, and 5) - All three objectives were successfully accomplished during the Mir approach and backaway. This information will be evaluated for verification and for its impact on future Phase-1 Mir flights

DTO 836 - Tools for Rendezvous and Docking (Tests 1, 3, and 4) - The Tools for Rendezvous and Docking (TRAD) DTO provided the complement and configuration of tools for this flight They included DTO 700-2 (Laser Range and Range Rate Device) [Hand-Held Lidar (HHL)], DTO 700-5 TCS and DTO 700-7 Orbiter Data for Real-Time Navigation Evaluation These tools were tied together through the Rendezvous Proximity Operations Program (RPOP) software in the payload general support computers (PGSCs) The TCS being inactive during the SPARTAN-204 retrieval limited the evaluation of the tools, but the Mir approach and the SPARTAN-204 deployment did provide data for postflight evaluation of all the TRAD systems

DTO 838 - Near Field Targeting and Reflecting Alignment System - This DTO was performed with the Spacehab experiment Charlotte The crew reported that the activities were nominal Postflight evaluation of the data is required, and the sponsor for this DTO may be contacted for the results

DTO 1118 - Photographic and Video Survey of Mir Space Station - Video of the Mir Space Station was viewed in real-time Photography of the Mir was reviewed postflight and the results of the DTO may be obtained from the sponsor

DTO 1210 - EVA Operations Procedures/Training - Mass handling was successfully completed, however, the RMS-based portion of this DTO was not accomplished The results of this DTO may be obtained from the sponsor

The following DTOs were accomplished, but details are lacking on the operations and the results

a DTO 301D - Ascent Structural Capability Evaluation,
b DTO 305D - Ascent Compartment Venting Evaluation,
c DTO 306D - Descent Compartment Venting Evaluation,
d DTO 307D - Entry Structural Capability,
e DTO 319D - Shuttle Payload Low Frequency Environment,
f DTO 524 - Landing Gear Loads and Brake Stability Evaluation,
g DTO 623 - Cabin Air Monitoring,
h DTO 677 - Portable In-Flight Landing Operations Trainer (PILOT), and
i DTO 832 - Target of Opportunity Navigation Sensors (TONS)

DETAILED SUPPLEMENTARY OBJECTIVES

DSO 327 - Shuttle-Mir VHF Voice Link Verification - Excellent communications with the cosmonauts on the Mir were completed An additional check was made to determine if the Orbiter crew could communicate with Houston using the Shuttle Amateur Radio Experiment -II (SAREX-II), but interference from the Mir VHF frequency was experienced Future plans will include transmitting on different frequencies

The following DSOs were reported to have been accomplished nominally at various times throughout the flight These were

a DSO 201B - Sensor- Motor Investigation,
b DSO 483 - Back Pain Pattern in Microgravity,
c DSO 486 - Physical Examination in Space,
d DSO 492B - In-Flight Evaluation of a Portable Clinical Blood Analyzer, and
e DSO 608 - Effects of Space Flight on Aerobic and Anaerobic Metabolism During Exercise

In addition, the following DSOs were assumed to be accomplished, however, no report from the crew was received These were

a DSO 200B - Radiobiological Effects,
b DSO 204 - Visual Observation From Space,
c DSO 489 - EVA Dosimetry Evaluation,
d DSO 901 - Documentary Television,
e DSO 902 - Documentary Motion Picture Photography, and
f DSO 903 - Documentary Still Photography

Two DSOs were programmed to be completed only during the preflight and postflight periods, and they were completed These were

a DSO 487 - Immunological Assessment of Crewmembers, and
b DSO 491 - Characterization of Microbial Transfer Among Crewmembers During Space Flight

PHOTOGRAPHY AND TELEVISION ANALYSIS

LAUNCH PHOTOGRAPHY AND VIDEO DATA ANALYSIS

On launch day, all 24 of the launch day videos were reviewed for anomalies, In addition during the days following launch, 52 films were reviewed No anomalous conditions were found in any of the video or photographic data.

ON-ORBIT PHOTOGRAPHY AND VIDEO DATA ANALYSIS

Analysis of the video taken of the Orbital Debris Radar Calibration Spheres (ODERACS) experiment was performed in support of the Principal Investigator The velocity of the dipoles and spheres ejected from the Get-Away Special (GAS) canister in the payload bay was calculated from the video data These data were provided to the Principal Investigator within 30 minutes of the deployment

An analysis of the nitrogen tetroxide particles (snowballs) leaking from the RCS R1U thruster was performed, The data provided to the Mission Evaluation Manager included size, number and velocity of the "snowballs". These data were provided in support of the decision on the point of closest approach of the Orbiter to the Mir during the rendezvous and stationkeeping activities

LANDING PHOTOGRAPHY AND VIDEO DATA ANALYSIS

Analysis was performed on the 11 landing videos including NASA Select, which is a composite of all available landing views No anomalous conditions were identified in this analysis In addition, 10 landing films were reviewed, and no anomalous conditions were found in the films

TABLE I.- STS-63 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	034 05 17 13 47 034 05 17 14 58 034 05 17 15 60
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	034 05.21 36 124 034.05:21 36 284 034 05 21 36 444 034.05 21 36 604
Main Propulsion System Start[a]	ME-3 start command accepted ME-2 start command accepted ME-1 start command accepted	034 05 21 57 446 034 05 21 57 553 034 05 21 57 675
SRB Ignition Command (Liftoff)	Calculated SRB ignition command	034 05 22 03 994
Throttle up to 104 Percent Thrust[a]	ME-2 command accepted ME-1 command accepted ME-3 command accepted	034 05 22 07 993 034 05 22 07 995 034 05.22 08 006
Throttle down to 94 Percent Thrust[a]	ME-2 command accepted ME-1 command accepted ME-3 command accepted	034 05 22.22 074 034 05 22 22 076 034 05 22.22 087
Throttle down to 69 Percent Thrust[a]	ME-2 command accepted ME-1 command accepted ME-3 command accepted	034.05 22 34 874 034 05 22 34 876 034·05 22 34 887
Maximum Dynamic Pressure (q)	Derived ascent dynamic pressure	034 05.22 55
Throttle up to 104 Percent Thrust[a]	ME-2 command accepted ME-1 command accepted ME-3 command accepted	034 05 22.57 274 034 05 22 57 276 034 05.22 57 287
Both SRM's Chamber Pressure at 50 psi[a]	RH SRM chamber pressure mid-range select LH SRM chamber pressure mid-range select	034 05·24 03 674 034 05 24 03 874
End SRM Action[a]	LH SRM chamber pressure mid-range select RH SRM chamber pressure mid-range select	034 05.24 07 414 034 05 24 07 644
SRB Physical Separation[a]	LH rate APU turbine speed - LOS RH rate APU turbine speed - LOS	034 05:24 08 994 034 05 24 08 994
SRB Separation Command[a]	SRB separation command flag	034 05 24 10
Throttle Down for 3g Acceleration[a]	ME-2 command accepted ME-1 command accepted ME-3 command accepted	034 05 29 31 841 034:05 29 31 844 034 05.29 31 855
3g Acceleration	Total load factor (g)	034 05 29 45 2
Throttle Down to 69 Percent Thrust for Cutoff[a]	ME-2 command accepted ME-1 command accepted ME-3 command accepted	034·05 30 29 121 034 05 30 29 125 034 05 30 29 136

[a]Data supplied by Marshall Space Flight Center

TABLE I.- STS-63 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
SSME Shutdown[a]	ME-2 shutdown command accepted	034:05 30 35 162
	ME-1 shutdown command accepted	034:05·30 35 165
	ME-3 shutdown command accepted	034·05 30.35 176
MECO	MECO command flag	034.05 30 36
	MECO confirm flag	034 05 30 36
ET Separation	ET separation command flag	034:05 30 55
APU Deactivation	APU-2 GG chamber pressure	034:05 36 52 57
	APU-1 GG chamber pressure	034:05 37 03 29
	APU-3 GG chamber pressure	034 05 37 09 95
OMS 2 Ignition	Right engine bi-propellant valve position	034 06·04 14.7
	Left engine bi-propellant valve position	034.06 04:14 7
OMS 2 Cutoff	Right engine bi-propellant valve position	034 06 06 50 4
	Left engine bi-propellant valve position	034.06.06 50 4
PLBD Open	PLBD right open 1	034 07 11 48
	PLBD left open 1	034:07 13 07
OMS 3 Ignition	Left engine bi-propellant valve position	N/A
	Right engine bi-propellant valve position	034 14.20 16 2
OMS 3 Cutoff	Left engine bi-propellant valve position	N/A
	Right engine bi-propellant valve position	034.14 20 55 9
ODERACS Deploy	Video call	035:04·57:06
SPARTAN First Unberth	Payload select 2 latch 1A release	035.06 48·31 3
SPARTAN First Berth	Payload select 2 latch 1A latch	035.13 18.25 3
OMS 4 Ignition	Left engine bi-propellant valve position	035 14.26 49 0
	Right engine bi-propellant valve position	N/A
OMS 4 Cutoff	Left engine bi-propellant valve position	035·14 27·13 5
	Right engine bi-propellant valve position	N/A
OMS 5 Ignition	Left engine bi-propellant valve position	036.18 37 39 5
	Right engine bi-propellant valve position	N/A
OMS 5 Cutoff	Left engine bi-propellant valve position	036 18 38 29 1
	Right engine bi-propellant valve position	N/A
OMS 6 Ignition	Left engine bi-propellant valve position	037·14 24:04 3
	Right engine bi-propellant valve position	N/A
OMS 6 Cutoff	Left engine bi-propellant valve position	037 14 24 14 7
	Right engine bi-propellant valve position	N/A
OMS 7 Ignition	Left engine bi-propellant valve position	037·16:36.43 3
	Right engine bi-propellant valve position	N/A
OMS 7 Cutoff	Left engine bi-propellant valve position	037·16:37 01 9
	Right engine bi-propellant valve position	N/A
SPARTAN Second Unberth	Payload select 2 latch 1A release	038 11·56·32 5
SPARTAN Deploy	Payload captured	038 12 27 36 5
FCS Checkout		
APU Activation	APU-3 GG chamber pressure	039.10 05 28 09
APU Deactivation	APU-3 GG chamber pressure	039 10 12 50 27

[a]Data supplied by Marshall Space Flight Center

TABLE I.- STS-63 SEQUENCE OF EVENTS

Event	Description	Actual time, G.m.t.
SPARTAN Grapple	Payload captured	040:11·33:20.1
SPARTAN Second Berth	Payload select 2 latch 1A latch	040 12 10 27 3
Payload Bay Door Close	PLBD left close 1 PLBD nght close 1	042 08 03 04 042 08 05.29
APU Actıvatıon for Entry	APU-2 GG chamber pressure APU-1 GG chamber pressure APU-3 GG chamber pressure	042 10 39 07 62 042 11 06.22 52 042 11 06.23.39
Deorbıt Burn Ignıtıon	Rıght engıne bı-propellant valve posıtıon Left engıne bı-propellant valve posıtıon	042 10 44.04 3 042 10 44.04 3
Deorbıt Burn Cutoff	Rıght engine bi-propellant valve posıtıon Left engıne bı-propellant valve posıtıon	042·10·48 18 6 042 10 44 18 6
Entry Interface	Orbıtal altıtude/reference ellıpsoıd	042 11 19.10
Blackout End	Data locked at high sample rate	No blackout
Termınal Area Energy Management (TAEM)	Major Mode Code (305)	042 11 43 56
Maın Landıng Gear Contact	MLG left-hand outboard tıre pressure 1 MLG nght-hand outboard tıre pressure 2	042 11 50 19 042 11 50.19
Maın Landıng Gear Weıght On Wheels	MLG nght-hand no weıght on wheels MLG left-hand no weıght on wheels	042·11 50.19 042 11 50.25
Drag Chute Deployment	Drag chute deploy 1 cap volts	042 11·50.26 6
Nose Landıng Gear Contact	Nose landıng gear right-hand tıre pressure 1	042·11·50·33
Nose Landıng Gear Weıght On Wheels	Nose landıng gear no weıght on wheels	042 11 50,34
Drag Chute Jettıson	Drag chute jettıson 1 cap volts	042·11·51 05 0
Wheels Stop	Velocity wıth respect to runway	042 11 51 41
APU Deactıvatıon	APU-1 GG chamber pressure APU-2 GG chamber pressure APU-3 GG chamber pressure	042 12 11.52.80 042 12 11 53 49 042·12 11 54 59

[a]Data supplıed by Marshall Space Flıght Center

TABLE II - ORBITER PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-63-V-01	Primary Thruster R1U Fail Off/Fail Leak Level III Closure	034 05 30 G m t 00 00 08 MET CAR 63RF01 PR RP03-0678	RCS Thruster R1U was deselected after a 320 msec firing Peak chamber pressure (Pc) reached 2 4 psia The oxidizer valve began to leak The oxidizer temperature dropped below 30 °F, and the fuel temperature dropped to the 50 to 60 °F range Manifold 1 was isolated and repressurized several times without successfully stopping the leak Manifold 1 was repressurized for entry and re-isolated just prior to touchdown Leak stopped during entry KSC Manifold 1 propellant sampled and thruster replaced
STS-63-V-02	Primary Thruster L2D Fail Off Level III Closure	034 05 30 G m t 00 00 08 MET CAR 63RF02 PR LP01-24-0672	RCS thruster L2D was deselected after a 320 msec firing Peak Pc reached was 13 psia Both oxidizer and fuel flow occurred Low heat soak-back confirmed low performance KSC Thruster replaced
STS-63-V-03	Primary RCS Thruster F1F Failed Leak Level III Closure	035 19 16 G m t 001 13 54 MET CAR 63RF03 PR FRC3-21-0466	RCS thruster F1F failed leak due to an oxidizer leak after a nominal firing of the thruster Forward manifold 1 was closed after the fuel injector temperature dropped below the 40 °F lower limit The manifold was repressurized and the leak stopped Three successful firings were performed, and the thruster was reselected Ground testing confirmed that the leak had stopped Thruster will be reflown
STS-63-V-04	Recurring Loss of CRT 4 Display	034 06 40 G m t 000 01 18 MET IPR 70V-0004 CAR 63RF04	A nominal CRT 4 power-up was noted after orbital insertion At 034 07 04 G m t (00 01 42 MET), the crew reported that CRT 4 was blank and that the DEU BITE flag was tripped The failure recurred with the same signature three additional times (035 08 04 06 G m t , 037 15 52 53 G m t , and 037 16 06 08 G m t CRT 4 was recovered each time with a power cycle A DEU dump was performed after the second occurrence and it showed only nominal power cycles A similar failure signature was observed prelaunch, and it resulted in the replacement of DEU 4 KSC Troubleshooting found forward power control assembly (FPCA) 3 remote power controller (RPC) output intermittent FPCA 3 replaced
STS-63-V-05	Port Radiator Latch 1-6 Actuator Latch A Indication Toggling Level III Closure	037 20 06 G m t 003 14 43 MET IPR 70V-0003 CAR 63RF05	At 037 20 06 G m t (03 14 43 MET), the port radiator latch 1-6 A latched indication (V37X3528E) began cycling off then on with the radiator panel stowed and latched After approximately one hour of constant toggling, the indication settled and only occasionally repeated the erratic behavior Redundant B indication (V37X3533E) showed the latch properly closed KSC Radiator latches re-rigged and PDU replaced
STS-63-V-06	Cabin Pressure Sensor Shifted Low	034 21 50 G m t 000 16 28 MET IPR 70V-0005 CAR 63RF06	At 034 21 50 G m t (00 16 28 MET), the cabin pressure transducer shifted low by 0 23 psi from 14 64 to 14 41 psi All other cues indicated nominal cabin pressure Spacehab pressure was at 14 8 psi KSC Transducer replaced

TABLE II - ORBITER PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-63-V-07	Inadvertent Firing of L1L, L1U, R4U, F3L, and F3U	035 11 41 G m t 01 06 19 MET	The L1L, L1U, R4U, F3L, and F3U primary RCS thrusters fired for 80 msec in response to an inadvertent valid +Y/+Z command that occurred when the aft flight control power was applied at 035 11 41 06 G m t (01 06 19 02 MET) No physical deflection of the THC occurred coincident with the thruster firings A similar event occurred on STS-66 when a -Y/-Z command was apparently generated when the forward station flight control power was applied Procedural work-arounds will be implemented to prevent a recurrence until permanent changes are implemented KSC No action required
STS-63-V-08	Spacehab Pressure Decay During EVA	040 11 34 G m t 06 06 12 MET IPR 70V-0006	The Spacehab pressure decayed from 14 80 psia to 14 16 psia during the 5-hour 18-minute period that the Airlock was depressurized No change in Spacehab temperature was noted During postflight testing, the D hatch seal and equalization valve leak checks were nominal Tunnel adapter duct isolation valve and cap assembly leak check was double the allowable amount, but < 1 percent of on-orbit leak rate Removal of lint from seat restored isolation valve to specification level Removal of paint chips and replacement of bent pin in Marman clamp restored cap assembly to the specification level Excessive lint build-up found in duct Cause of build-up and potential corrective actions are under investigation

TABLE III - GOVERNMENT FURNISHED EQUIPMENT PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-63-F-01	EV2 Eye Discomfort During Repressurization after EVA	040 17 07 G m t 06 11 45 MET	The EV2 crewmember reported eye discomfort and odor during airlock repressurization following the EVA Small brown flecks were found on the inner surface of the helmet visor
STS-63-F-02	Electronic Cuffs Unresponsive	040 17 07 G m t 06 11 45 MET	The electronic cuffs (ECCs) worn by the EV1 crewmember responded in only one of six touch areas (bottom middle) The ECC worn by the EV2 crewmember did not respond on the right two areas Both lost the display later during the EVA, and then the display reappeared prior to repressurization The unit worn by the EV1 crewmember resumed normal functioning just prior to repressurization The unit worn by EV2 remained unresponsive

TABLE IV - MSFC PROBLEM TRACKING LIST

No.	Title	Time	Comments
STS-63-B-01	Left-Hand and Right-hand SRB Damage to Both Forward Skirts and Both Aft Assemblies	Postflight inspection	The left-hand and right-hand SRBs sustained significant damage primarily to both forward skirts and both aft assemblies Both forward skirts were cracked and buckled The left-hand forward skirt and left-hand tilt actuator were lost during the SRB tow back to port Ascent film review has not revealed any anomalies No identified ascent loads could cause this conditions Similar but less severe damage was sustained to the left-hand SRB on STS-37 and STS-44 That damage was primarily manifested in the forward skirt The previous conclusion was that damage occurred during descent This occurrence is not a safety of flight concern as the investigtion has eliminated ascent and SRB separation phases as possible times of occurrence It is concluded that the SRB damage is attributed to splashdown and the the SRBs are at an increased risk of sustaining damage when surface winds in the retrieval area are high
STS-63-I-01	Main Engine 1 Experienced Single Point Spikes on Three Pressure Measurements	034 06 39 53 G m t 000 01 17 50 MET	Main engine 1 experienced single-point spikes on three pressure measurements The main combustion chamber (MCC) coolant discharge pressure spiked at engine start + 77 5 seconds, the high-pressure oxidizer turbopump (HPOTP) secondary seal cavity pressure channel A spiked at + 81 9 seconds, and the HPOTP secondary seal cavity pressure channel B spiked at 83 5 seconds The remainder of the flight showed no additional spikes The time and amplitude of the spikes match those believed to be caused by ground radar noise These two sensors have passed screening by the micro-focus X-ray/PIND technique with excellent scores, which would say the the sensors are clean with respect to contamination which could cause spikes

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

ACS	attitude control system (Mir Space Station)
AMOS	Air Force Maui Optical Site
APU	auxiliary power unit
ASC	Astroculture-IV Experiment
ATCS	active thermal control system
BITE	built-in test equipment
BPL	Bioserve Pilot Laboratory
BRIC	Biological Research in Canisters
cc/hr	cubic centimeters per hour
CGBA	Commercial Generic Bioprocessing Apparatus
CGP	Cryogenic Systems Experiment/Shuttle Glow-2 Experiment Payload
CHROMEX	Chromosome and Plant Cell Division in Space
CPCG	Commercial Protein Crystal Growth
CPDS	Charged Particle Directional Spectrometer
CREAM	Cosmic Radiation Effects and Activation Monitoring
CRT	cathode ray tube
CSE	Cryogenic Systems Experiment
DEU	display electronics unit
DSO	Detailed Supplementary Objective
DTO	Developmental Test Objective
ΔP	differential pressure
ΔV	differential velocity
ECC	electronic cuff checklist
ECLIPSE	Equipment for Controlled Liquid Phase Sintering Experiment
EE	end effector
EGT	exhaust gas temperature
EI	entry interface
EMU	extravehicular mobility unit
EPDC	electrical power distribution and control subsystem
ET	External Tank
EV1	extravehicular crewmember 1
EV2	extravehicular crewmember 2
EVA	extravehicular activity
FCE	flight crew equipment
FCL	Freon coolant loop
FCS	flight control system
FES	flash evaporator system
F-GBA	Fluids - Generic Bioprocessing Apparatus
FM	frequency modulation
ft/sec	feet per second
FU-1	Flight Unit-1
GAS	Getaway Special
GFE	Government furnished equipment

GH_2	gaseous hydrogen
GLO-2	Shuttle Glow Experiment Payload
G m t	Greenwich mean time
GN&C	guidance, navigation and control
GPC	general purpose computer
GPPM	Gas Permeable Polymer Membrane
HA	height adjust maneuver
HAINS	high accuracy inertial navigation system
HH-DTC	Hand-held Diffusion Test Cells
HHL	hand-held LIDAR
HPFTP	high pressure fuel turbopump
HPOTP	high pressure oxidizer turbopump
HVPS	high-voltage power supply
Hz	Hertz
ICBC	IMAX cargo bay camera
ICD	Interface Control Document
IFM	in-flight maintenance
IMMUNE	Immunology Experiment
IMU	inertial measurement unit
I/O	input/output
Isp	specific impulse
ISSC	Improved Spacecraft Standard Cryocooler
keas	knots estimated air speed
KSC	Kennedy Space Center
kW	kilowatt
kWh	kilowatt hour
lb	pound
lbm	pound-mass
LCC	Launch Commit Criteria
LESC	Lockheed Engineering and Science Company
LH_2	liquid hydrogen
LIDAR	light distance and ranging
LO_2	liquid oxygen
mA	milliampere
Mach	measurement of speed of sound
MADS	modular auxiliary data system
MC1	midcourse correction 1 (maneuver)
MCC	Mission Control Center
MDM	multiplexer/demultiplexer
MECO	main engine cutoff
MET	mission elapsed time
Mir	Russian Space Station
MMT	Mission Management Team
MPM	manipulator positioning mechanism
MPS	main propulsion system
MSFC	Marshall Space Flight Center
MVAC	Module Vertical Access Kit
NASA	National Aeronautics and Space Administration
Nc	nominal correction (maneuver)

NCC	nominal corrective combination (maneuver)
Nh	nominal height (maneuver)
NIH-C	National Institute of Health-Cells
nmi	nautical miles
NPSP	net positive suction pressure
NSTS	National Space Transportation System (i e , Space Shuttle Program)
ODERACS	Orbital Debris Radar Calibration Spheres-2
OMRSD	Operations and Maintenance Requirements and Specifications Document
OMS	orbital maneuvering subsystem
PAL	protuberance air load
P_c	chamber pressure
PCAM	Protein Crystallization Apparatus for Microgravity
PCG-STES	Protein Crystal Growth - Small Thermal Enclosure System
PDU	power drive unit
PFR	portable foot restraint
PGSC	payload and ground support computer
PI	Principal Investigator
PILOT	Portable In-Flight Landing Operations Trainer
PLBD	payload bay door
PMBT	propellant mean bulk temperature
POCC	Payload Operations Control Center
PRSD	power reactant storage and distribution
psi	pound per square inch
psid	pound per square inch differential
RCN	Requirements Change Notice
RCS	reaction control subsystem
RM	redundancy management
RME-III	Radiation Monitoring Equipment-III
RMS	remote manipulator system
RSGF	rigidize sensing grapple fixture
RSRM	Redesigned Solid Rocket Motor
RTV	room temperature vulcanizing (material)
S&A	safe and arm
SAIL	Shuttle Avionics Integration Laboratory
SAMS	Space Acceleration Measurement System
SAREX	Shuttle Amateur Radio Experiment
SPARTAN-204	Shuttle Pointed Autonomous Research Tool for Astronomy-204
SRB	Solid Rocket Booster
SRSS	Shuttle range safety system
SSCE	Solid Surface Combustion Experiment
SSME	Space Shuttle main engine
SVSU	Spacehab video switching unit
SWDLPA	supply water dump line purge assembly
TCS	Trajectory Control Sensor/thermal control system
3-DMA	Three-Dimensional Microgravity Accelerometer
THC	translational hand controller
TI	terminal initiation
TONS	Target of Opportunity Navigation Sensors

TPS	thermal protection subsystem
TRAD	Tools for Rendezvous and Docking
TVC	thrust vector control
VDA	Vapor Diffusion Apparatus
Vdc	Volts direct current
VHF	very high frequency
VIU	video interface unit
VSU	video switching unit
WCS	Waste collection system
WINDEX	Window Experiment
WSB	water spray boiler

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