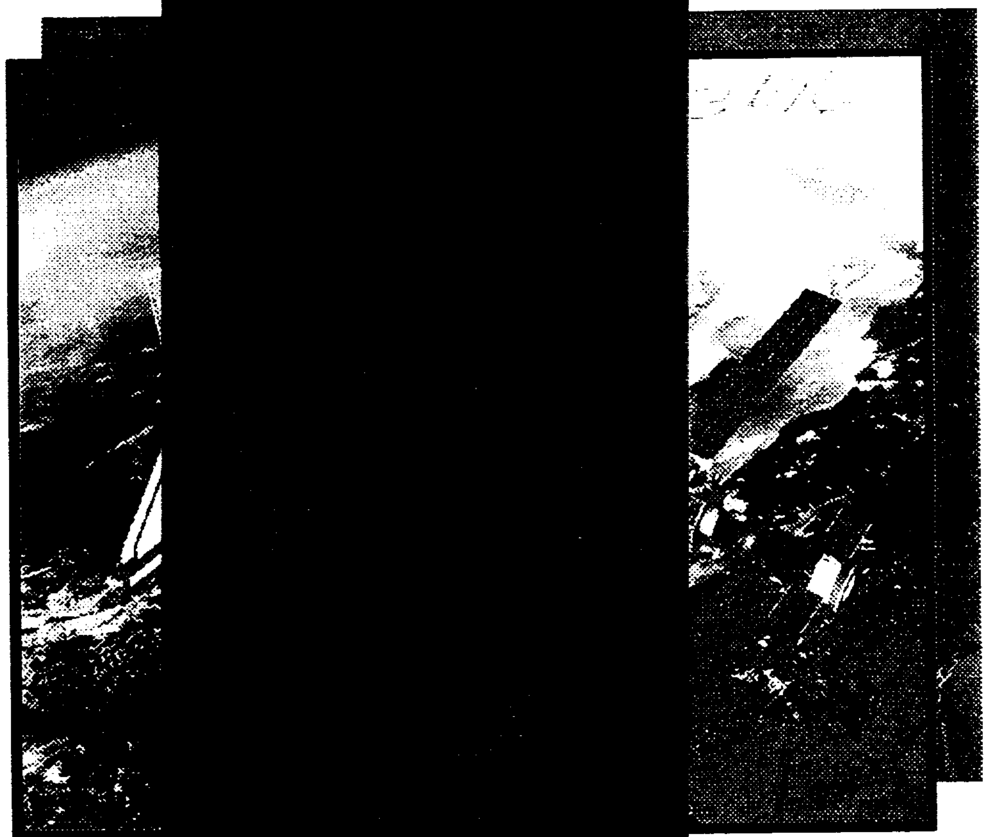
IN-12-TM

NASA-TM-112694



REPORT OF THE TASK FORCE ON THE

Shu[redacted] Re[redacted] & [redacted]

THOMAS P. STAFFORD
1006 Cameron Street
Alexandria, VA 22314

29 July 1994

Dr. Bradford Parkinson
Chairman, National Aeronautics and
Space Administration Advisory Council
National Aeronautics and Space Administration
Washington, DC 20546-0001

Dear Dr. Parkinson:

On 12 and 13 July 1994, I convened the second meeting of the NASA Advisory Council Task Force on the Shuttle-Mir Rendezvous and Docking Missions at the Johnson Space Center (JSC). The attached report contains the results of that meeting. It focuses on the issues which the Task Force working groups reviewed over the past six weeks and provides specific recommendations.

During our review, it was apparent that a great deal of work has gone into the preparations for the first two rendezvous and docking missions, STS-71 and STS-74. Planning for these Shuttle-Mir missions has been extensive and a high level of dedication and commitment exists throughout the organizations involved. STS-63, the Shuttle-Mir rendezvous mission, presents NASA with a unique opportunity to assess numerous operational techniques, systems, and hardware to be used on STS-71 and subsequent Phase 1 missions. Every effort should be made to capitalize on STS-63 in preparing for STS-71.

The Task Force received tremendous cooperation from the Johnson Space Center, the International Space Station Alpha Program, and the Space Shuttle Program. This is particularly appreciated given the busy schedules of the many individuals who provided briefings and information to the Task Force members.

Given that STS-71, the first Shuttle-Mir mission, is quickly approaching, time is a critical element in the implementation of these recommendations. Of particular importance are any management initiatives which NASA might choose to make as a result of the Task Force's report. If they are to be effective it is imperative that they be acted upon quickly.

It is the opinion of the Task Force that the Androgenous Peripheral Docking Assembly (APDA) mechanism is one of the most critical hardware components in ensuring mission success. While we have identified a number of concerns in the attached report with regard to the APDA mechanism, we feel that this is an area which merits further attention. As such, the Task Force strongly recommends that NASA continue to closely monitor this element. Likewise, we will do the same.

Finally, the total number of missions required to accomplish the Phase 1 objectives and the modification of a second Orbiter for Mir docking are two issues which the Task Force identified but which it does not address in this report. We did not feel that we had enough data at this time to analyze these issues; however, we intend to thoroughly review them at our next meeting.

I will convene the next meeting of the Task Force in early October. At that time, we will review the status of the Task Force's recommendations, examine additional APDA concerns and issues, and address the number of missions required for Phase 1 as well as the need to modify a second Orbiter for Mir docking.

Sincerely,

Thomas P. Stafford

Thomas P. Stafford

cc:
NASA/Code A/Mr. Goldin
NASA/Code M/Gen. Pearson
NASA/Code M/Mr. Vantine
NASA/Code I/Ms. Accola

REPORT OF THE NASA ADVISORY COUNCIL TASK FORCE ON THE SHUTTLE-MIR RENDEZVOUS AND DOCKING MISSIONS

JULY 29, 1994

TABLE OF CONTENTS

1.0 INTRODUCTION

Shuttle-Mir Missions - Phase 1 of the International Space Station Alpha Program

In October 1992, Russia and the U.S. formally agreed to conduct a fundamentally new program of human cooperation in space. This original "Shuttle-Mir" project encompassed combined astronaut-cosmonaut activities on the Shuttle, Soyuz, and Mir spacecraft. At that time, the project was limited to:

- the STS-60 Shuttle mission, which was completed in February 1994 and carried the first Russian cosmonaut,
- the planned March 1995 Soyuz 18 launch which will carry a U.S. astronaut to the Mir space station for a three month mission, and
- the STS-71 Shuttle mission which is scheduled to rendezvous and dock with the Mir space station in June 1995.

In November 1993 the scope of the planned cooperation was expanded considerably and became Phase 1 of the International Space Station Alpha program. This expanded program combines the original Shuttle-Mir program with additional Shuttle flights to Mir and U.S. crews aboard Mir.

Planned missions include up to 10 Shuttle flights to Mir between 1995 and 1997. The U.S. Shuttle will assist with crew exchange, resupply, and payload activities for Mir. Mir capabilities will be enhanced by contributions from both the U.S. and Russia. The Shuttle will bring new solar arrays to replace existing arrays on Mir. Russia will add Spektr and Priroda modules to Mir. These modules will be equipped with U.S. and Russian scientific hardware to support science and research requirements.

One of the primary advantages of Phase 1 is that it will provide valuable experience and test data that will greatly reduce technical risks associated with the construction and operation of the international space station. The international space station will also be enhanced by combined space operations and joint space technology demonstrations. Phase 1 will also provide early opportunities for extended scientific and research activities.[1]

Task Force on the Shuttle-Mir Rendezvous and Docking Missions

In May 1994, the Task Force on the Shuttle-Mir Rendezvous and Docking Missions was established by the NASA Advisory Council. Its purpose is to review Shuttle-Mir planning, training, operations, rendezvous and docking, and

[1] Source: Addendum to Program Implementation Plan, 1 November 1993

management and to provide interim reports containing specific recommendations to the Advisory Council.

At the initial Task Force briefings on May 24 and 25, 1994 and in subsequent Task Force discussions, a number of issues surfaced. In an effort to address these issues, four working groups were established. Each of these working groups is composed of Task Force members and technical advisors (see Appendix C). The four working groups and their purpose are as follows:

Management Working Group

The complexity of the International Space Station Alpha development effort demands close cooperation among the ISSA Program, the Shuttle Program, and the Johnson Space Center as well as a host of other NASA organizations and facilities if it is to be successful. The purpose of the Management Working Group is to examine the current management structure of the overall effort, review proposals for strengthening that structure, and provide specific recommendations on the best approach for improving it. In that process, careful consideration will be given to the following:

- Chain of command
- Accountability
  - Milestones
  - Mission success
  - Funding
- Russian interface

Phase 1 Working Group

The Phase 1 program offers a unique opportunity to achieve objectives in several critical areas, particularly ISSA risk mitigation, technology development, and long duration science. Evaluating and prioritizing opportunities in these areas across the ten missions of the Shuttle-Mir program is a complex task which requires a clear vision of the ultimate objectives and a thorough understanding of the constraints.

The Phase 1 Objectives Working Group will examine the planning which has been done in this area and the existing approach to establishing and accomplishing the Phase 1 objectives. The working group will provide recommendations on structuring, prioritizing, and accomplishing the Phase 1 objectives. Particular attention will be given to improvements to the current organizational structure in this area.

Crew Systems, Training, and Operations Working Group

The Shuttle-Mir missions will involve an unprecedented level of cooperation between the U.S. and Russian space programs. They will also require a carefully orchestrated mission sequence and up to ten rendezvous and docking operations. The purpose of this working group is to examine planning for the Shuttle-Mir missions in the areas of crew systems, training, and operations; provide recommendations; and offer an independent assessment of related technical issues.

Vehicle Systems Working Group

When *Atlantis* first docks with the Mir-1 space station on the STS-71 mission, it will represent the success of a joint engineering and safety certification process involving a wide array of civil servants and contractors from both the U.S. and Russia. This cooperation will continue through the subsequent nine Shuttle-Mir flights and into Phases 2 and 3 of the ISSA program. The Vehicle Systems Working Group will examine the efforts to date in this area; provide recommendations on ways to improve the planning and implementation process; and offer an independent assessment of related technical issues.

Each of the working groups subsequently researched the issues in its particular area, compiled its findings, and reported back to the full Task Force. Open discussion of the working group recommendations was held at the Johnson Space Center (JSC), Building 1, Room 966 on July 13, 1994.

2.0 SHUTTLE-MIR (PHASE 1) PROJECT MANAGEMENT

2.1 Issue: Phase 1 Project management structure.

2.2 Observations

It is the opinion of the Task Force that at the current time there is no one person or organization clearly in charge of the Shuttle-Mir (Phase 1) Project. While there is a Memorandum of Agreement (MOA) between the International Space Station Alpha (ISSA) Program Manager and the Space Shuttle Program (SSP) Program Manager which addresses the working relationships between these two programs for Phase 1, there are at least four different organizations that claim some management responsibility for Phase 1: the Johnson Space Center (JSC) Russian Projects Office, the ISSA Phase 1 Manager, the Joint Management Working Group, and the Phase 1 Mission Director.

In addition, a "we/they" mentality seems to have developed among the organizations involved in Phase 1. This stems from the fact that the Program offices and a number of their functions are badged and report to Headquarters while others are badged and report to the Center.

It is also apparent to the Task Force that there is no overarching project plan, beyond the most cursory level, which addresses and attempts to integrate the operations development and utilization requirements. The three sources of mission requirements for Phase 1 are neither well coordinated nor focused. There is confusion and uncertainty about priorities with regard to ISSA risk mitigation, joint operations, and utilization as well as organizational responsibility for collecting and integrating these requirements.

On the other hand, the standard Shuttle mission preparations at the working level appear to be proceeding quite well. Flight operations planning and hardware integration is taking place and the organizations at JSC which perform these functions appear to be working together in an effective manner. It is not clear, however, that all of these efforts are being orchestrated in harmony with a clearly defined project plan.

The Task Force is encouraged by the recent efforts of the ISSA Program Manager to work with the Shuttle Program in capitalizing on the close working relationships established over the past year and a half between the Shuttle Program and the Russian operations and engineering organizations as well as facilitating further the coordination and integration between the Shuttle and Station programs. We are also encouraged by the management initiative at JCS involving the reorganization of space flight support activities into a Projects Office in order to consolidate and synergize the operational, engineering, and liaison support to multiple programs while minimizing cost and duplication. Within the Projects Office is a Russian Projects Office which is responsible for coordinating JSC-wide support to the Phase 1 Project. There is uncertainty, however, as to the relationships between the JSC Russian Projects Office, the SSP, and the ISSA as well as Phase 1 roles and responsibilities.

2.3 Recommendations

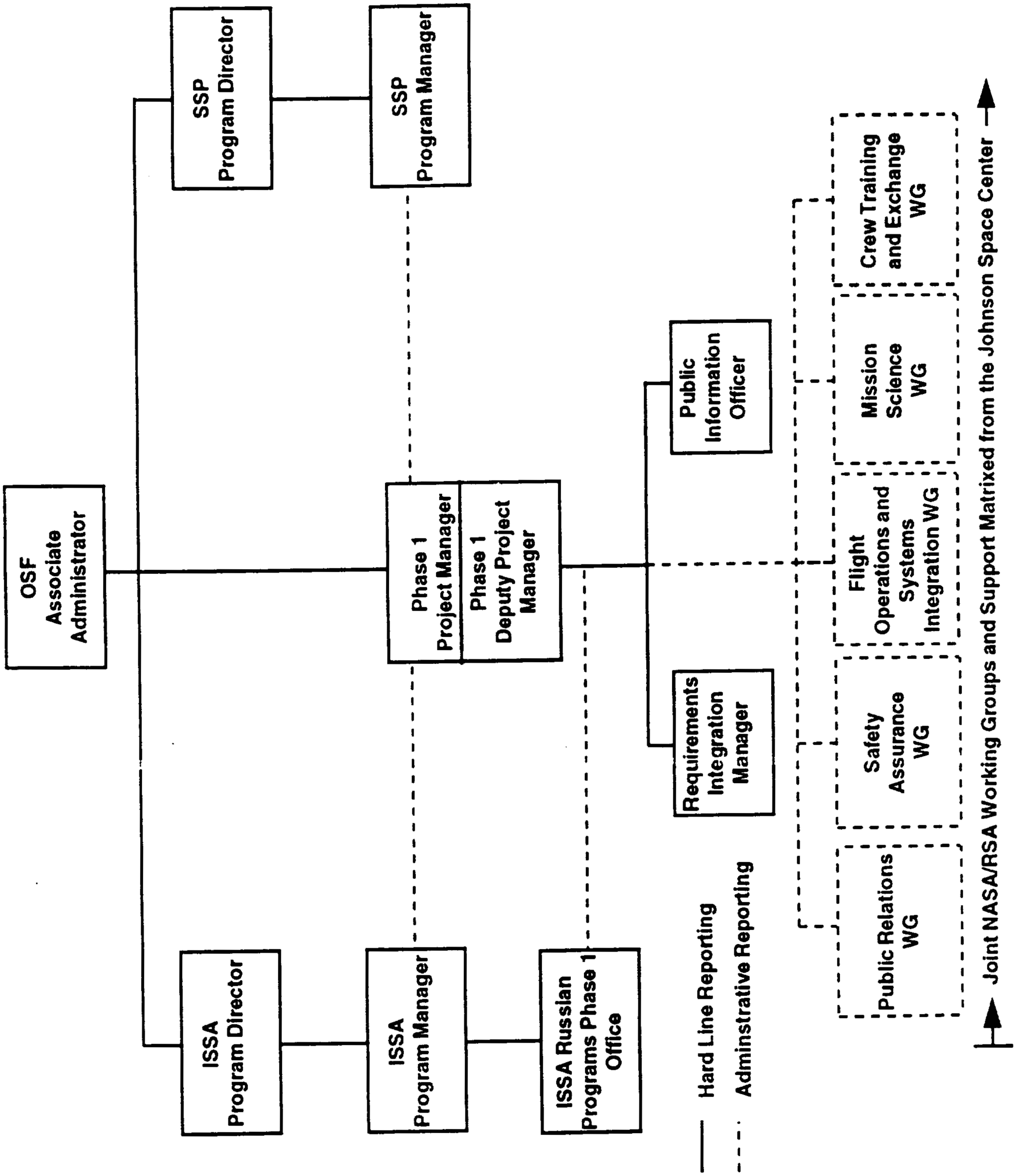
It is the Task Force's opinion that the ISSA and SSP program managers have tremendous challenges facing them without adding the challenges of managing the day-to-day integration activities of Phase 1, a multi-national, highly complex operation. While the Phase 1 Project is an ideal risk mitigation test bed for flight techniques and station-like operations, it is of sufficient complexity and magnitude to warrant separate management. The Task Force's specific recommendations that follow seek to:

1. minimize duplicate program structures and capitalize on existing experience;
2. impact the existing interfaces with the Russian Space Agency as little as possible;
3. provide a single focused team for overall Phase 1 planning, coordination, and implementation; and
4. facilitate further the coordination between the Space Shuttle Program, the ISSA, the payload community and the Russian Space Agency.

Given these considerations, it is the Task Force's recommendation that NASA should:

2.3.1 Establish a Phase 1 Project Manager (see organization chart on Page 6) with a small staff located at the Johnson Space Center. This job should be the sole responsibility of the individual assigned to it and he/she should not have dual responsibilities in any other organization. The Phase 1 Project Manager will have the following roles and responsibilities:

- **Accountable for implementation of Phase 1.**
- **Represents and reports directly to the Associate Administrator for Space Flight.**



PHASE 1 ORGANIZATIONAL STRUCTURE

- Responsible for the proper coordination among the various NASA offices, NASA centers, ISSA managers, SSP managers, and persons, groups, and organizations external to NASA who have a responsibility for the safe and successful execution of the mission.
- Ensures that management of full-time Mir operations as well as Shuttle-Mir operations and cargo integration is adequately addressed.
- Oversees mission training and concurs in the determination of flight readiness of the flight crew, the integrated operations team, and the mission management team for each mission.
- Establishes the goals, objectives, priorities, and policies for each mission with concurrence of the ISSA and SSP Program Managers.
- Approves the cargo mix, including secondary payloads, Development Test Objectives (DTOs), and Development Science Objectives (DSOs).
- Is a signatory on the Certificates of Flight Readiness that pertain to each mission.
- Serves on the Mission Management Team with specific duties during each phase of the mission, particularly the Orbiter untended portion, to be determined.
- Concurs in the approval or disapproval of flight specific waivers.
- Establishes special committees and assessment teams, as required, to assess the readiness of the STS and cargo to support mission requirements.
- Develops a Project Plan in response to the requirements provided by the ISSA Program Manager, SSP Program Manager, and the Payload Steering Committee who will each identify their specific Phase 1 requirements and their relative priority. Overall Phase 1 requirement priorities will be based on the following objectives listed in order of importance:
    1. Reduce technical risks associated with the construction and operation of the international space station.
    2. Conduct combined international space operations and joint space technology demonstrations.
    3. Provide early opportunities for extended scientific and research activities.

In addition to identifying Phase 1 requirements, the Project Plan should include the following:

- Project and mission baselines.
- Definition of key specific mission activities and metrics necessary to achieve overall project goals and objectives.
- Project schedules and major controlled milestones.

- Serves as the change authority for the Project Plan with concurrence from ISSA and SSP Program Managers.
- Monitors Phase 1 RSA contract performance.
- Works with the ISSA Program Manager to ensure that the Phase 1 Project has adequate representation in Russia for technical acceptance of hardware produced under the RSA Phase 1 contract.
- Works with the ISSA and SSP Program Managers in the development of standardized documentation and procedures for NASA and RSA.
- Works with the ISSA Program Manager to document that provisions are in place to transition into Phase 2 and 3.

2.3.2 The JSC Russian Projects Office should be matrixed to support the Phase 1 Project Manager with the Director of the JSC Russian Projects Office serving as the Phase 1 Deputy Project Manager. The Director of the JSC Russian Projects Office should continue to coordinate the administrative activities of the Joint Working Groups which are matrixed operationally to the Phase 1 Project Manager (see 2.3.3 below).

2.3.3 The joint NASA/RSA working groups, with the exception of the Management Working Group (WG-0) and the Safety Assurance Working Group (WG-2), should be matrixed intact and with the necessary administrative support from the JSC to support the Phase 1 Project Manager. The Task Force believes that a number of strong working relationships with the RSA and related organizations have been established and continue to develop in a positive vein. Given this, we feel that it would be a mistake to significantly change or expand on a structure which is already functioning well. Any restructuring of project management should leave those working groups intact.

2.3.4 The Phase I Project Manager should be responsible for the management direction and oversight of the integration and flight preparation process and accomplishment of the objectives for each Phase 1 mission. As such, the SSP should provide matrixed support to the Phase 1 Project Manager for all Shuttle Program activities associated with Phase 1. This relationship should be documented in a Memorandum of Agreement.

2.3.5 The ISSA Russian Programs Phase 1 Office currently reporting to the ISSA Program Manager should be matrixed intact to the Phase 1 Project Manager. The ISSA Russian Programs Phase 1 Office should be operationally accountable to the Phase 1 Project Manager but draw necessary administrative support from the ISSA Program. The Russian Programs Phase 1 Office Manager should continue to coordinate the RSA contract activities. This relationship should be documented in a Memorandum of Agreement.

2.3.6 A Requirements Integration Manager should be designated and report directly to the Phase 1 Project Manager. The Requirements Integration Manager should be responsible for assembling all Phase 1 requirements and assisting the Phase 1 Project Manager in developing the Phase 1 Project Plan. The Phase 1 Requirements Integration Manager, working together with the Associate Administrator for Life and Microgravity Sciences and Applications, should coordinate the development of a policy for Spacelab/Spacehab volume utilization for Phase 1 which satisfies cost, schedule, and performance requirements of the Phase 1 Project Plan.

2.3.7 A Public Information Officer (PIO) should be designated as a staff assistant to the Phase 1 Project Manager in order to achieve the maximum media benefit from the Phase 1 missions.

2.3.8 The Public Relations Working Group (WG-1) should be matrixed to the Phase 1 PIO intact.

2.3.9 The ISSA Program Manager should be designated as the sole source for ISSA risk mitigation requirements.

2.3.10 The Associate Administrator for Life and Microgravity Sciences and Applications should be designated as the focal point for the international research community's requirements and priorities.

2.3.11 The OSF Chief Medical Officer will chair the Medical Policy Board for the development of medical support for ISSA risk mitigation and all NASA/RSA joint development of medical

support for ISSA risk mitigation. The OSF Chief Medical Officer will coordinate those requirements with RSA through the joint NASA/RSA Medical Policy Board and the Phase 1 Project Manager.

3.0 STS-63, STS-71, and STS-74 MISSION SUCCESS

3.1 Introduction

The first Shuttle-Mir rendezvous and docking mission, STS-71, is scheduled to launch on 31 May 1995. The second mission, STS-74, will occur five months later and include installation of the Docking Module to be used on all subsequent Shuttle-Mir missions. These two missions will be historic and of great importance to the United States, Russia, and the other ISSA International Partners. From the day that the Shuttle launches on these Mir missions to the day it lands, the attention of millions of people around the world will be focused on it.

The Task Force, in addition to reviewing the entire Phase 1 Project, focused on the planning for the first two missions as well as the precursor mission, STS-63. STS-63 is a critical component in the success of Phase 1 as it will be the only opportunity to conduct Mir rendezvous and proximity operations (prox ops) prior to STS-71. For that reason, it is imperative that the STS-63 Mir rendezvous and prox ops objectives be given the highest priority on that mission.

This section contains the issues regarding these critical missions which the Task Force addressed and the observations and recommendations which resulted from that review.

3.2 Rendezvous and Docking Training

3.2.1 Action: Evaluate the Shuttle-Mir rendezvous and docking training tools including the Shuttle Engineering Simulator (SES), docking tunnel mock-up, and the Payload and General Support Computer (PGSC) laptop displays.

3.2.2 Observations

Shuttle Engineering Simulator

The SES simulator provides a full aft flight deck mockup with all relevant controls, displays, and switches. With its high fidelity graphics, the SES is an excellent simulator and training tool. The Orbiter/Mir plume model which it employs is dependent on estimates rather than actual data. It is important that this model be updated with such data as soon as it becomes available.

Docking Tunnel Mock-up

The docking tunnel mockup, located in Building 9N at JSC, is adequate for initial concept evaluations. Additional hardware fidelity will be required for complete training.

Payload and General Support Computer (PGSC)

See discussion of Tools for Rendezvous and Docking in Section 3.3 below.

3.2.3 Recommendations

3.2.3.1 The verified Shuttle Plume Impingement Flight Experiment (SPIFEX) data from STS-64 must be made available on or before 15 February 1995, the current schedule, and the SES updated with that data in adequate time to support STS-71.

3.3 Tools for Rendezvous and Docking (TRAD)

3.3.1 Issue: Evaluate the Tools for Rendezvous and Docking (TRAD) system and the plan for transitioning the TRAD system from Development Test Objective (DTO) status to operational status.

3.3.2 Observations

The TRAD system is comprised of several components. These are:

- Trajectory Control Sensor (TCS): Mounted in the Shuttle Payload Bay (PLB), the TCS utilizes a laser to provide accurate range and range rate data. Eventually, it will also provide data on attitude. The command and control software for the TCS is hosted on a PGSC.
- Hand Held Lidar (HHL): This unit is used from the flight deck to provide range and range rate data. As a hand held unit, its accuracy depends upon the ability of the astronaut user to track the target vehicle.
- Pulse Code Master Modulation Unit (PCMMU): Provides attitude and state vector data from the Orbiter IMUs and navigation system.
- Rendezvous and Proximity Operations Program (RPOP): This software is hosted on the PGSC and integrates data from the

TCS, HHL, and the Orbiter to provide current and predicted rendezvous and prox ops status.

A transition plan is in place for the TRAD system. Under this plan, the system will be incrementally assembled and tested through a series of DTO missions (STS-64, STS-66, and STS-63). This process will culminate with TRAD achieving operational status prior to the STS-71 mission. As STS-63 is the only mission which will perform a Mir rendezvous prior to STS-71, the Task Force emphasizes the importance of testing the TRAD system utilizing the Mir complex as the target.

3.3.3 Recommendations

3.3.3.1 During STS-63, perform HHL tests against the Mir complex and determine range-rate accuracy and stability.

3.3.3.2 During STS-63, perform a range and range rate checkout of the TCS against the Mir complex.

3.4 Mir Approach Development Test Objective (DTO 835)

3.4.1 Issue: Does the Mir Approach DTO provide adequate support for the Shuttle-Mir missions?

3.4.2 Observations

The Mir Approach DTO involves a series of missions using several different target vehicles - the Mir complex, SPARTAN, SPAS, and OAST-Flyer, the DTO encompasses the following five objectives:

1. Positive Radius Vector (+R-bar) approach demonstration: Modify the manual phase of the rendezvous to approach the target along the +R-bar rather than along the Positive Velocity Vector (+V-bar). This approach shall specifically demonstrate:
   a. Braking Gates required to satisfy a Mir approach.
   b. A 1000' Norm-Z to Low-Z transition range is desired. This range is prescribed by NPO-Energia to minimize contamination on Mir surface. Since the Low-Z mode is more propellant expensive, a fallback propellant budget for these demonstrations will define an alternate Norm-Z to Low-Z transition range which satisfies primary mission objectives and also satisfies this objective.

c. Low-Z to Norm-Z transition at an equivalent docking interface-to-interface range of 30' is desired. This range is prescribed to balance the minimization of Mir plume impingement with piloting control authority at close range.

2. Corridor approach demonstration: During the approach to the rendezvous target maintain the target within an 8 degree piloting corridor using the approach television camera image. This test will demonstrate the motion of the rendezvous target in the camera field of view due to Orbiter deadbanding. The corridor should be maintained from a range of approximately 250 feet until remote manipulator system (RMS) capture operations begin or a range of about 30 feet, whichever comes first. The corridor may be centered on any convenient location of the rendezvous target, as applicable. This approach shall be assessed by performance of the Digital Autopilot (DAP) while in the corridor and assessment of the Orbiter's position within the corridor. A subjective assessment will also include interaction of the DAP while piloting and maintaining the corridor. Specific assessment will be made of the number, timing, and type of jet firings required to maintain the corridor. This objective may be met for either a +V-bar or +R-bar approach.
3. Stationkeeping at 250 feet from the rendezvous target when performing an +R-bar approach: This objective shall demonstrate flyability, jet firing history, and propellant usage for stationkeeping ranges expected to be flown on Mir rendezvous missions.
4. Prox ops approach timing coordination: This objective demonstrates the arrival from a stationkeeping point to a prescribed near range at a predetermined time. The timing demonstration is desired for assessment of docking while in contact with a Russian ground station for the Mir rendezvous missions. This objective may be met for either a +V-bar or +R-bar approach.
5. Angular misalignment flyout demonstration: This objective can only be accomplished with a rendezvous target which has a visual alignment aid and can be viewed at a range where accurate measurements can be made. This demonstrates the angular misalignment flyout procedures and assesses the usefulness of the centerline target as a docking aid to quantify misalignments. Additionally, the effect of lighting conditions on visibility of the centerline target will be assessed.

The following table summarizes the candidate DTO missions, the objectives for each, and the applicability of those objectives to the first two Shuttle-Mir missions:

	DTO Candidate Flight			Operational Flights	
	STS-66	STS-63	STS-69(1)	STS-71	STS-74
Objective 1 Fly a +R-bar approach	*		*		*
Objective 2 Fly an approach corridor	*	*	*	*	*
Objective 3 Stationkeeping at 250' for a +R-bar approach	*		*		*
Objective 4 Coordinate prox ops approach timing	(2)	*	(2)	*	*
Objective 5 Angular misalignment flyout		(3)		*	*

(1) Applicable to OAST-Flyer only.
(2) Perform if no impact to rendezvous lighting conditions or timeline.
(3) Perform if approach is close enough to accurately read alignment target.

Although the details for the DTO missions are still being defined and refined, the overall plan appears comprehensive and should provide considerable preparation for the STS-71 and STS-74 missions.

3.4.3 Recommendations

3.4.3.1 Ensure that the Mir Approach DTO is fully implemented.

3.5 V-Bar or R-Bar Approach for STS-63 and STS-71

3.5.1 Issue: Evaluate the advisability of switching from a V-bar to an R-bar approach for STS-63 and STS-71.

3.5.2 Observations

A significant percentage of the operations and training community prefer the R-bar approach for both STS-63 and STS-71. Because orbital mechanics is continuously decreasing the approach velocity during the R-bar approach, little, if any, RCS braking is required. Since the approach will be flown from 1000 feet to 30 feet in low-Z, this becomes even more significant. The delta-V imparted by low-Z attitude maneuvers appears to be nullified by the orbital mechanics and results in less RCS fuel consumption and Mir solar array contamination concerns. At 30 feet the RCS plume loads on the Mir solar arrays are considered to be one half the magnitude at docking, and are therefore of less concern. Since the baseline for both V-bar and R-bar approaches call for transition to norm-Z at 30 feet, the primary plume loads and contamination concern center on DAP configuration rather than on the V-bar/R-bar approach issue.

DTO 835 (Mir Approach Demonstration) includes demonstration of R-bar approaches on flights STS-66 using a Shuttle Pallet Satellite (SPAS) and STS-69 using the Office of Aeronautics and Space Technology - Flyer (OAST-Flyer). These include capture on the R-bar radial, flying the approach corridor, station keeping of the R-bar, and Mir approach timing.

Total RCS propellant usage and standardization of crew training and techniques favors implementing the R-bar approach for STS-63 and STS-71. Neither of these reasons, however, appear to be the primary drivers in the decision.

The concern for adequate solar power during the docking phase has been raised by the RSA in various operations working group meetings. Since most if not all Mir solar panels will be feathered during the docking phase, the required Mir attitude to avoid a negative power condition may well determine the R-bar/V-bar decision. Additionally, there has been an indication in the working group telecons that the Mir configuration could be different from that planned for one of the early missions. Mir configuration, power, and communications remain open issues for both the V-bar and R-bar attitudes.

The Loads and Dynamics Section (ES42) supports an R-bar approach because of the reduced plume loads, but will require a database to confirm the absence of excessive plume loads during the backout maneuver. The concern is possible differences resulting from the orbital mechanics of the R-bar approach. A 250 run database will be required. This effort has already begun and will be completed by September 1, 1994. ES42 feels that RSA, once they have received the R-bar data, cannot perform a thorough Mir loads analysis in less than three months. To implement the R-bar approach for STS-71 would require moving the RSA on-orbit flight readiness statement from September to a later date. Resources to support this effort were estimated to be approximately one month and $150k.

The effects of an R-bar attitude on Mir air-ground communications because of Mir antenna locations and Shuttle blockage has not been fully addressed.

Observations of the Soyuz/Kristal prox ops and docking video indicate that the CTVC docking target TV monitor image may be very sensitive to sun shadow and relative sun orientation.

3.5.3 Recommendations

3.5.3.1 To avoid impacting the RSA assessment teams considering loads, power, and communications, NASA should not propose changing from the planned V-bar approach on STS-63 to an R-bar approach. However, in all subsequent, relevant discussions with RSA, the reduced RCS braking requirements of the R-bar approach and the associated plume load and contamination reductions should be emphasized. In addition, NASA should advise that they stand ready and willing to perform either a V-bar or R-bar approach based on the results of the Mir analysis. A date for the decision on the approach should be established to provide adequate time for crew training.

3.6 STS-63 Shuttle-Mir Objectives

3.6.1 Issue: Do the Shuttle-Mir related objectives of the STS-63 mission take full advantage of the Mir rendezvous and prox ops to be conducted during the mission? Also, does the current minimum approach distance of 100 feet allow these objectives to be met?

3.6.2 Observations

The STS-63 Flight Requirements Document (NSTS 17462-63, Revision H, May 1994) paragraph 3.4 b.2 specifies the rendezvous and proximity operations objectives for STS-63. Paraphrasing the requirements in Section 3.4 (Integrated Activity/Functional Requirements), STS-63 is currently required to perform the following activities on a propellant-available basis:

1. Rendezvous and stationkeep with Mir (to a distance of 30 meters)
2. Perform a flyaround of Mir

The listed elements of these objectives include:

a. developing and exercising the communications between NASA and RSA/NPO Energia;
b. developing and gaining experience with Mir rendezvous techniques (specifically develop the necessary planning, training, and analysis products);
c. testing the Orbiter/Mir voice communication techniques and concepts;
d. obtain documentary photography of the condition of Mir areas of interest; and
e. fly a cosmonaut as a member of the Shuttle crew.

The details of the activities to be performed in the vicinity of Mir are still under development. The Shuttle-Mir Flight Techniques panel is continuing to refine the content of these objectives to best support the follow-on missions and to make the best use of the STS-63 opportunity.

As part of that process a proposal for a "Near Mir Fly-By" within 30 feet of Mir was made at the July 5, 1994 Shuttle-Mir Flight Techniques panel meeting. The proposal included the following objectives:

- Shuttle angular alignment maneuver demonstration
- Docking target visibility demonstration
- Mir attitude control system response demonstration
- Mir solar panel natural frequency observations

The Task Force believes that accomplishment of those objectives will be an important contribution to mission success on STS-71 and STS-74; therefore, it strongly supports the proposal and the approach to within 30 feet.

Currently there is no plan to manifest the primary Shuttle-Mir docking tool, the Color Television Camera (CTVC) camera, on STS-63. This mission, however, provides an excellent opportunity to test visibility and assess angular flyout using the camera. The camera can be mounted below the optical quality window in Spacehab in a position almost identical to its location in the Orbiter Docking System (ODS). Power for the camera is available in Spacehab as is a video link to the Orbiter. Although no docking tunnel lights will be present on STS-63, PLB and Spacehab lights are available to provide target illumination. The Task Force sees this as an opportunity which should be exercised. In conjunction with the stationkeep and fly around objectives, and in particular with the proposed approach to 30 feet, particular attention should be focused on the impact of sun position and the resulting shadows. The attempt should be made to approximate the planned relative Orbiter, docking target, and sun positions for ISSA docking operations. A review of the video taken during the Soyuz/Kristall docking and undocking operations indicates that visibility will be sensitive to sun angle (i.e., shadows) and basic up sun/down sun orientation.

3.6.3 Recommendations

3.6.3.1 Because STS-63 represents the only opportunity to test the hardware, techniques, and operational procedures to be used in Mir rendezvous and prox ops, the Mir-related objectives must be given the top priority on the mission.

3.6.3.2 An approach of within 30 feet of Mir should be made on STS-63 to accomplish the "Near Mir Fly-By Objectives".

3.6.3.3 The CTVC camera should be manifested on STS-63 and mounted in the Spacehab module in order to:

- **perform a CTVC visibility checkout to include recording of camera output for post-mission evaluation;**
- **evaluate lighting and shadow effects on the target image; and**
- **conduct attitude fly-out tests in Low-Z.**

3.7 STS-71 Shuttle-Mir Objectives

3.7.1 Issue: As the first Shuttle-Mir docking mission, STS-71 will be a critical test of hardware, techniques, and operational procedures. It is also a precursor to STS-74 which will involve the installation of the Docking Module to be used for all subsequent Shuttle-Mir missions. Does it provide ample preparation for STS-74?

3.7.2 Observations

A summary of the objectives and DTOs on STS-71 which prepare for STS-74 is:

Rendezvous and Dock with Mir

Demonstrates crew techniques; ground controller involvement in both Mission Control Center - Houston (MCC-H) and Mission Control Center - Moscow (MCC-M); use of docking targets, boresight and other cameras; corridor constraints for protection of Mir solar arrays; Shuttle autopilot modifications for thrusting to achieve docking, undocking, and separation and fly around techniques; procedures for achieving docking over a Russian ground station; and air to air Very High Frequency (VHF) communications using the payload bay antenna.

Dock to Mir for a Period of 5 Days

Demonstrates both Shuttle and Mir attitude control capability in the docked configuration, including maneuvers for maintenance of Inertial Measurement Unit (IMU) alignment accuracy and to meet Shuttle thermal constraints while maintaining enough solar flux on Mir to provide power. Specific tests to determine structural response to Primary Reaction Control System (PRCS) thruster firings are planned. Additionally, test to determine Shuttle autopilot performance are planned with update to Shuttle Digital Auto Pilot (DAP) parameters as required. Joint mission control center capability to plan, and replan if necessary, and execute joint flight plans is demonstrated.

Logistical Resupply of Mir

In addition to the transporting and handling of gyrodynes and batteries, provides and installs docking target to Mir hatch specifically designed to accommodate STS-74 "clocking" (rotation of docking position to accommodate Mir solar arrays).

Unique Operations Directly Applicable to STS-74

Continued demonstration of the use of interpreters for real-time operations; exercise of new MCC positions in both MCC-H and MCC-M; exchange of systems operations consultants to respective MCCs; exercise of unique flight rules, procedures, and plans in the joint Houston/Moscow environment.

In a previous section, the Task Force recommended manifesting a CTVC camera in the STS-63 Spacehab module to evaluate the system for the docking target visibility and resolution, sun angle effects, angular flyout if required, etc. on STS-71. The camera could be located in the STS-63 Spacehab at the same approximate x, y, and z location as it would be in the Docking Module on STS-71. For STS-74, the extended docking module results in a CTVC location approximately 14 feet higher than on all other Phase I flights. The higher location will present a different target image response for an attitude flyout. The opportunity exists to install the CTVC camera at the RMS elbow camera station and position that camera at approximately the STS-74 docking camera location. The elbow camera position would be x=-664.6, y=0.1, z=-706.7. This would allow a flight verification check of the STS-74 camera configuration assumptions.

3.7.3 Recommendations

3.7.3.1 Investigate the value of performing attitude fly-out tests in low-Z using the CTVT mounted on the Remote Manipulator System elbow camera location.

3.8 Range Safety

3.8.1 Issue: Are options for attenuating range safety constraints on launch being actively pursued?

3.8.2 Observations

There are a series of activities already underway in this area. They include the following:

- Range Operations Control Center (ROCC) systems redundancy limitations
  - Range safety display systems: NASA funding request in work to provide third string display system.
  - Command Message Encoder Verifier (CMEV): NASA assessing feasibility and cost of third string CMEV configuration.
- Cloud ceiling limits
  - Shuttle landing limit: Being worked in Ascent/Entry Flight Techniques with study results expected in early Fall 1994.
  - Range safety limits: Being worked in the Range Safety Panel where several options are being assessed.
- External Tank (ET) disposal options: Exploring relief of the 200 nautical mile crosstrack ET disposal clearance required for South Pacific islands. This would allow a lower Direct Insertion altitude and, therefore, more phasing. The issue is being worked jointly by JSC and NASA Headquarters.
- Ship and aircraft clearance of Solid Rocket Booster (SRB) and emergency ET disposal region: Requirement exists to protect the general public. The option of beginning surveillance of the disposal region earlier in order to reduce potential impacts is being considered.
- Expanded crosswind limits: Issue being worked through Ascent/Entry Flight Techniques.
- Return to Launch Site (RTLS) rain shower acceptance flight rule: Flight Techniques is working with the Shuttle community to define safe precipitation and cloud types.

There is one additional option which merits further study - the use of additional RTLS sites to reduce the impact of weather conditions at the Kennedy Space Center (KSC). Although this option has apparently been considered previously, there is benefit in visiting it again in light of the 51.6 degree launch inclination required for the Shuttle-Mir and the ISSA missions. Before making any specific recommendation in this regard, the Task Force's Crew Systems, Training, and Operations Working Group intends to obtain and review any existing studies and discuss the concept with the appropriate technical staff.

3.9 Launch Window

3.9.1 Issue: Advisability of establishing a launch on-time policy.

3.9.2 Observations

Because of the performance constraints resulting from a 51.6 degree launch inclination, the 5-minute launch window is still under consideration. In order to obtain additional performance, it may be necessary to reduce the window to less than five minutes. During the Task Force's first meeting, the point was made that a launch on-time policy should be considered to ensure maximum performance.

In reviewing the issue, the Task Force relied primarily on the data collected during the recent extensive 5-minute launch window study. The data indicate that:

- Of 113 Shuttle launch attempts, 62 resulted in launch and 51 were scrubbed.
- 24 of the launches went on time.
- 38 of the 62 launches were delayed; of those 38 delays:
  - 3 went within 1 minute
  - 4 went within 2 minutes
  - 6 went within 3 minutes
  - 10 went within 4 minutes
  - 11 went within 5 minutes
- Of the 38 delayed launches, it is estimated that an additional 8 could have launched within a 5-minute window if it had been a requirement rather than the longer window applicable to each mission.

3.9.3 Recommendation

3.9.3.1 A launch on-time policy should not be instituted as it could result in missions being scrubbed which might otherwise be launched within a 5-minute or even shorter window.

3.10 Pressure Suits for Entry/Landing

3.10.1 Issue: Examine the continued use of pressure suits for entry and landing as opposed to a "shirt sleeve" approach.

3.10.2 Observations

During the first meeting of the Task Force, the suggestion was made to discontinue use of pressure suits for entry and landing in order to enhance the reach and visibility envelope during entry and to allow more mobility in the event of an emergency egress.

The NASA/JSC/Astronaut Office has expressed strong support for the continued use of the suits for reasons which include the following:

- Protection against cabin pressure leaks
- Escape systems utilize the harness integrated into the suits
- Protection against hazardous propellant

3.10.3 Recommendation

3.10.3.1 Continue to use pressure suits for entry and landing.

3.11 Payload Bay (PLB) Very High Frequency (VHF) Antenna Redundancy

3.11.1 Issue: No PLB VHF antenna is being flown on STS-63 and there is no redundant PLB VHF antenna on the Shuttle-Mir missions.

3.11.2 Observations

In order to support direct communications between the Orbiter and Mir, a VHF communications capability is necessary. No PLB VHF antenna will be flown on STS-63, only an in-cabin, window-mounted, SAREX-type antenna tuned to the correct VHF frequency range). This is adequate for the STS-63 mission and will provide valuable data on performance of the window-mounted system.

As to the need for PLB antenna redundancy on the Shuttle-Mir missions, the PLB antenna is a completely passive device with no active electrical or moving mechanical elements; electrical or structural failure is considered noncredible. The wiring to the antenna is coax cable which is not prone to breakage or internal shorts and has proved to be very reliable and rugged on Shuttle flights. An in-cabin antenna will be carried on all Shuttle-Mir missions as backup to the PLB antenna, although this will likely provide degraded performance (i.e., shorter range) compared with the PLB antenna.

3.11.3 Recommendations

3.11.3.1 No redundant PLB VHF antenna is required for Shuttle-Mir missions.

3.11.3.2 Ensure that the test plan for STS-63 window-mounted antenna includes performance assessment with respect to Mir antenna patterns.

3.12 Shuttle-Mir Demate Redundancy

3.12.1 Issue: Baseline provides only one backup system, pyrotechnic bolts, to separate the Shuttle and Mir if the mechanical system fails.

3.12.2 Observations

In order to dock the Shuttle to Mir, Rockwell Aerospace is in the process of developing an Orbiter Docking System (ODS) which incorporates an Androgenous Peripheral Docking Assembly (APDA) manufactured by NPO-Energia of Russia. The Shuttle APDA will dock with a similar APDA on the Kristall module of Mir.

Once the ODS APDA has successfully "captured" the Mir APDA, the ODS will be secured (i.e., "mated") to Mir by a series of twelve active docking hooks located in the ODS APDA. Both the ODS and Mir APDAs contain twelve active and twelve passive hooks. In order to mate the two vehicles, the active hooks in one APDA engage the passive hooks in the opposite APDA. The active hooks are divided into two sets of six hooks each. Each set of hooks is opened and closed via a cable system operated by an electrical motor with a second motor for redundancy.

The mechanical system for opening the ODS APDA active hooks has a backup in the form of pyrotechnic bolts installed in each hook. Rockwell has received data on the composition of the explosive used in the bolts and NPO-Energia has completed the first of a series of eight tests required to certify the "reliability for firing" of the bolts. In this process, Rockwell is working with NPO-Energia as they would with any subcontractor. All eight tests should be completed by the first quarter of CY 1995. Rockwell has stated that they will not be requesting waivers for any of the required tests.

In addition to Rockwell's work, serious consideration is also being given to utilizing the capabilities of Tsniimash, the Russian counterpart to NASA's Office of Safety and Mission Assurance (OSMA), to conduct an independent assessment of the risk associated with the improper functioning of the APDA mechanism. Tsniimash has an intimate knowledge of Russian aerospace industry practices - safety assurance philosophies and procedures, hardware reliability design techniques and methodologies, and quality assurance certification procedures.

These efforts, however, will not change the basic situation for STS-71. The pyrotechnic bolts will provide the only backup system for ODS demate. NSTS 07700 Vol. X (para 3.3.1.2.1.3.10.1), however, requires that mating systems shall be dual fault tolerant at a minimum to accomplish demating through the provision of at least two independent methods. A change to this requirement for STS-71 stating that the requirement does not apply for the noncredible failure modes resulting from a APDA mechanical jam was presented and disapproved (CR S086943) at the Program Review Control Board on June 16, 1994. Although Rockwell has been studying various options (external mechanical latches, expanding tube assembly, and frangible nuts) for providing further redundancy, none of these can be in place for STS-71 and may not be available for several of the subsequent Shuttle-Mir flights.

This leaves only two approaches for providing dual fault tolerance for STS-71 -- use of the Mir active hooks for mating or an EVA to remove the 96 bolts which fasten the ODS docking base to the ODS external airlock. In the case of the Mir active hooks, pyrotechnic bolts on the Orbiter passive hooks to which the Mir active hooks are latched could be fired in the event of a mechanical failure. If the ODS passive pyrotechnic bolts failed to produce a demate, the pyrotechnic bolts on the Mir active hooks could be fired. Information received to date indicates, however, that the pyrotechnic bolts on the Mir active hooks are not functional. Effort should be invested in determining if the Mir active hook pyrotechnic bolts are operational. If they are, this option could be reconsidered. Until such time, however, the EVA approach as the only option available for providing dual fault tolerance.

If EVA is required for Shuttle-Mir demating, it will entail substantial risk as it will occur after both the mechanical system and the pyrotechnic bolts have failed to demate the ODS. As the hooks are not equipped with individual sensors there will be no way to determine which hooks remain closed and what impact the resulting configuration of closed and open hooks may have on the dynamics of the mated Shuttle and Mir stack. The risk assessment and safety evaluation will need to occur in order for the EVA approach to be sanctioned.

Several members of the Task Force were briefed on the ODS at Rockwell's facilities in Downey and Seal Beach, California. This briefing included inspection of the engineering, or brassboard, version of the ODS. This initial inspection indicates that the 96 bolts appear to be accessible by EVA. Given the number of bolts, power tools will be required for their removal. The bolt torques are low enough (80-105 in-lbs) for Orbiter EVA tools to be used. Several modifications will need to be made to the ODS to accommodate the EVA such as nut plates and double height bolts. Rockwell has already begun the process of determining the required modifications and options for accomplishing them.

In addition to the ODS modifications, a clamping-type device will have to be developed which will allow the ODS docking base and external airlock to be clamped at several points while the bolts are removed. In addition, the wiring bundles connecting the docking base and external airlock will need to be severed. Once all wire bundles are severed and the bolts removed, the clamps would need to be unfastened in a manner which would ensure positive, simultaneous, and symmetrical release.

The EVA approach will require considerable planning and training. This process must begin as soon as possible in order to support STS-71.

Beyond ensuring that the EVA option is available for STS-71 and any subsequent missions requiring it for demate dual fault tolerance, additional consideration should also be given the overall reliability of the APDA mechanism. Of particular concern is the fact that the EVA backup approach discussed above, if required, will leave the Krystall APDA port blocked. Subsequent Shuttle-Mir dockings will not be possible. The review in this areas should include methods for improving overall APDA reliability as well as alternative methods, such as the magnetic docking system, which might prove more robust through the life of the ISSA.

3.12.3 Recommendations

3.12.3.1 **Ensure that the ODS active hooks will be cycled as part of the ODS testing to be conducted at KSC prior to STS-71.**

3.12.3.2 **The EVA approach to remove the 96 bolts which fasten the ODS docking base to the ODS external airlock should be developed and baselined as a contingency approach for APDA mechanical system and pyrotechnic failures.**

3.12.3.3 **Determine the tools, support equipment (e.g., handholds, PFR locations, etc.), training schedule, and equipment fidelity (e.g., WETF, mock-ups, etc) needed to support the EVA demate contingency for STS-71 and, if necessary, subsequent missions.**

3.12.3.4 **Establish EVA procedures including a method to ensure positive, simultaneous, and symmetrical release.**

3.13 Spare APDA for STS-71

3.13.1 Issue: No spare APDA will be available at KSC which puts the STS-71 launch at risk if a nongeneric problem develops with the flight APDA.

3.13.2 Observations

Spare parts and subsystems for various elements of the APDS are being provided with the flight unit. However, there are other elements which, if they fail, will require the unit to be refurbished at NPO-Energia and thus delay the STS-71 mission if the failures encountered prior to the launch.

NPO-Energia has a second flight unit already completed which can serve as a backup for the flight unit if it is received prior to STS-71. Under the current schedule specified in the NASA contract with the Russian Space Agency (RSA) under which all post-STS-71 hardware is being built, the second unit is not slated for delivery until June 1995. This is too late to support STS-71.

3.13.3 Recommendation

3.13.3.1 Investigate the feasibility of accelerating the schedule for the second APDA in time to serve as a backup for STS-71 and the impacts involved in doing so.

3.14 Orbiter Docking System/Docking Module Fit Checks

3.14.1 Issue: No fit check is planned between the Orbiter Docking System (ODS) and the Docking Module (DM)

3.14.2 Observations

The Docking Module (DM) is a 14 foot extension which will be installed on the Mir Kristall module's APDA-equipped port. The installation will be accomplished on the second Shuttle-Mir mission, STS-74, which is currently scheduled for October 1995. Mir will be in different configuration than during the STS-71 mission for STS-74 and all subsequent Shuttle-Mir missions. The DM is required in this revised configuration in order for the docked Orbiter to clear the Mir solar arrays. Once installed during STS-74, the DM will be left in place.

The DM is equipped with APDAs at both ends. One APDA will be mated to the ODS APDA prior to the Mir rendezvous and docking operation. The Orbiter cannot be launched with the DM mated to the ODS due to the height of the DM. The mating will occur on orbit.

NPO-Energia, which is building the DM under the NASA contract with RSA, will perform fit checks on the three STS-74 APDAs (two for the DM and one for the ODS) using the master tooling jig at their facility in Russia. No functional tests will be performed. Both the mechanical and electrical interfaces between the STS-74 ODS APDA and its corresponding DM APDA will be verified at NPO-Energia also.

During processing at KSC, there will be an electrical functional check between the ODS APDA and DM APDA via jumper cables. There is a reluctance to perform a mechanical fit check due to the extensive ground support and handling equipment which would need to be brought from Russia in order to do this.

3.14.3 Recommendations

3.14.3.1 Verify that the shipping environment did not adversely impact the three APDAs following their shipment from NPO-Energia where the final fit check will be performed.

3.14.3.2 Revisit the risk decision and assess the risk involved in handling the Docking Module as well as the ground support equipment needed to perform an ODS/DM fit check.

3.15 Docking Module Safety Reviews

3.15.1 Issue: The combined Phase I/II and the Phase III Docking Module (DM) Payload Safety Review Boards (PSRBs) have not been scheduled.

3.15.2 Observations

In support of the Phase I/II review, it is expected that NPO-Energia will supply the necessary data package in the November 1994 time frame. The data requirements, however, are still in negotiation in the Joint Safety Assurance Working Group (JSAWG) which includes U.S. and Russian representatives.

Delivery of the DM to KSC is currently scheduled for June 1995. The Phase III review may not precede delivery. If the review results in additional data requirements, they could result in "make-work" modifications at KSC or require acceptance of safety waivers.

3.15.3 Recommendations

3.15.3.1 Evaluate DM safety review schedule acceleration vs. risk acceptance.

3.16 Loads Analysis Development Test Objective (DTO) Plan

3.16.1 Issue: The value of the STS-71 loads analysis DTO depends upon the validity of the Russian dynamics model. In addition, no corresponding DTO for STS-74 is currently planned.

3.16.2 Observations

The proposed Loads Analysis DTO on the STS-71 mission provides for the firing of Shuttle thrusters to excite and allow subsequent observation of three or four critical mated vehicle structural modes. These identified modes would be used to update digital autopilot (DAP) attitude control software and verify the sequence of Primary Reaction Control System (PRCS) pulse timing interval selection.

The DTO details were briefed to NPO Energia at the loads lead engineer level during the week of June 13, 1994. The following agreements were reached:

- DTO, Part 1 - this consists of five PRCS pulses of 80 milliseconds duration to excite the mated structure, determine critical modes, and verify stability margins.
- DTO, Part 2 - five sets of 80 millisecond PRCS pulse followed after a 11 second delay by a second pulse. This would verify that the 11 second delay will not excite the stack resonant modes and overstress the structure.

Understanding the mated Shuttle-Mir stack dynamic response requires the use of the Russian Mir model and hence an understanding of its robustness.

The DTO offers significant benefits for STS-71. The low frequency Shuttle-Mir stack structural modes will be identified, enabling notch filters to be properly centered to prevent instabilities. With this understanding, overstressing of the core stack elements will be precluded. Higher modes, associated with other "light" weight appendages will not be identified by the DTO.

While some data from the STS-71 DTO may be of use in determining the stack lateral modes, it will not be sufficient. The DTO offers little support for STS-74 as it will excite and measure modes of the Shuttle-Mir stack while the Shuttle is mated to the Mir longitudinal axis.

3.16.3 Recommendations

3.16.3.1 The robustness of the Russian Mir model must be fully analyzed and understood in order to assess stack dynamic response.

3.16.3.2 A Loads Analysis DTO corresponding to the STS-71 DTO should be conducted on STS-74. The data this DTO will produce is critical to the safety of the Phase 1 program.

3.17 Shuttle-Mir Stack Rotation

3.17.1 Issue: The requirements for Shuttle-Mir stack rotation requires a detailed understanding of stack dynamics and will rely on the robustness of the Russian Mir model.

3.17.2 Observations

Three Shuttle-Mir operational modes have been defined which will require rotation of the Shuttle-Mir stack:

- The docking attitudes selected to put the docking port along the V-bar or R-bar axis are not gravity stable for the combined stack after docking.
- The Shuttle IMU alignment requires updating every 24 hours. The planned stack attitude is inadequate to site the Star Tracker.
- Thermal limitations at high beta angles limit Shuttle attitude to 16 hours.

Stack rotations will use existing digital autopilot (DAP) software codes. JSC Engineering is analyzing maneuver structural loads that result from DAP rotation commands and is also assessing control margins.

3.17.3 Recommendations

3.17.3.1 The Russian Mir structural dynamics model must be fully analyzed and the resulting DAP controllability and structural integrity determined.

4.0 APPENDIX A: ACRONYM LIST

APDA	Androgenous Peripheral Docking Assembly
CMEV	Command Message Encoder Verifier
CR	Change Request
CTVC	Color TeleVision Camera
DAP	Digital Autopilot
DM	Docking Module
DTO	Development Test Objective
ET	External Tank
EVA	Extra-Vehicular Activity
HHL	Hand Held Lidar
IMU	Inertial Measurement Unit
ISSA	International Space Station Alpha
Lidar	(L)ight (D)etection (a)nd (R)anging
JSC	Lyndon B. Johnson Space Center
KSC	John F. Kennedy Space Center
MOA	Memorandum of Agreement
NASA	National Aeronautics and Space Administration
NSTS	National Space Transportation System
OAST-Flyer	Office of Aeronautics and Space Technology - Flyer
ODS	Orbiter Docking System
OLMSA	Office of Life and Microgravity Sciences and Applications
OSMA	Office of Safety and Mission Assurance
PCMMU	Pulse Code Master Modulation Unit
PFR	Portable Foot Restraint
PGSC	Payload and General Support Computer
PIO	Public Information Officer
PLB	Payload Bay
PRCB	Program Review Control Board
PRCS	Primary Reaction Control System
Prox Ops	Proximity Operations
R-bar	Radius Vector
RCS	Reaction Control System
ROCC	Range Operations Control Center
RPOP	Rendezvous and Proximity Operations Program
RSA	Russian Space Agency
RTLS	Return to Launch Site
SAREX	Shuttle Amateur Radio Experiment
SES	Shuttle Engineering Simulator
SPARTAN	Shuttle Pointed Autonomous Research Tool for Astronomy
SPAS	Shuttle Pallet Satellite
SPIFEX	Shuttle Plume Impingement Flight Experiment

ACRONYMS (Continued)

SRB	Solid Rocket Booster
SSP	Space Shuttle Program
TCS	Trajectory Control Sensor
TRAD	Tools for Rendezvous and Docking
V-bar	Velocity Vector
VHF	Very High Frequency
WETF	Weightless Environment Training Facility
WG-0	Joint Management Working Group
WG-1	Joint Public Relations Working Group
WG-2	Joint Safety Assurance Working Group
WG-3	Joint Flight Operations and Systems Integration Working Group
WG-4	Joint Mission Science Working Group
WG-5	Joint Crew Training and Exchange Working Group

5.0 APPENDIX B: TASK FORCE MEMBERSHIP LIST

Chairman
Lt. Gen. Thomas P. Stafford, USAF (Ret.)
Stafford, Burke and Hecker, Inc.
1006 Cameron Street
Alexandria, VA 22314

Task Force Members
Col. James C. Adamson, USA (Ret.)
President
Monarch Precision
464 Carmine Drive
Cocoa Beach, Florida 32931

Dr. John Fabian
President and CEO
ANSER
1215 Jefferson Davis Highway
Suite 800
Arlington, VA 22202

Dr. Michael A. Greenfield
Deputy Associate Administrator
Office of Safety and Mission Assurance, Code Q
National Aeronautics and Space Administration
Washington, DC 20546-0001

Mr. James M. Heflin, Jr.
Flight Director Office, Code DA8
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, TX 77058

Maj. Gen. Ralph Jacobson, USAF (Ret.)
President and CEO
The Charles Stark Draper Laboratories
555 Technology Square
Cambridge, MA 02139

Mr. David Mobley
Assistant to the Center Director
for the Space Station, Code DA01
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, AL 35812

Dr. Arnauld E. Nicogossian
Deputy Associate Administrator
Office of Life and Microgravity Sciences
and Applications, Code U
National Aeronautics and Space Administration
Washington, DC 20546-0001

Mr. Chester A. Vaughan
Deputy Director, Engineering Directorate, Code E
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, TX 77058

Capt. John Young, USN (Ret.)
Special Assistant for Engineering, Operations, and Safety
Office of the Director
Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, TX 77058

Executive Secretary
Mr. William L. Vantine
Office of Space Flight, Code M
National Aeronautics and Space Administration
Washington, DC 20546-0001

Technical Advisors
Maj. Gen. Joe H. Engle, USAF (Ret.)
President
Engle Technologies, Inc.
1906 Back Bay Court
Houston, TX 77058

Mr. Glynn Lunney
President
Rockwell Space Operations Company
Code R01A
600 Gemini Avenue
Houston, TX 77058-2777

6.0 APPENDIX C: TASK FORCE WORKING GROUPS

Management Working Group

Col. James C. Adamson - Lead
Maj. Gen. Ralph Jacobson
Mr. Glynn Lunney

Phase 1 Working Group

Dr. Arnauld E. Nicogossian - Lead
Dr. John Fabian
Mr. James M. Heflin
Mr. Chester A. Vaughan

Crew Systems, Training, and Operations

Capt. John Young - Lead
Mr. David Mobley
Mr. James M. Heflin
Maj. Gen. Joe H. Engle

Vehicle Systems

Dr. Michael A. Greenfield - Lead
Mr. David Mobley
Maj. Gen. Ralph Jacobson
Mr. Michael Weeks - Technical Support