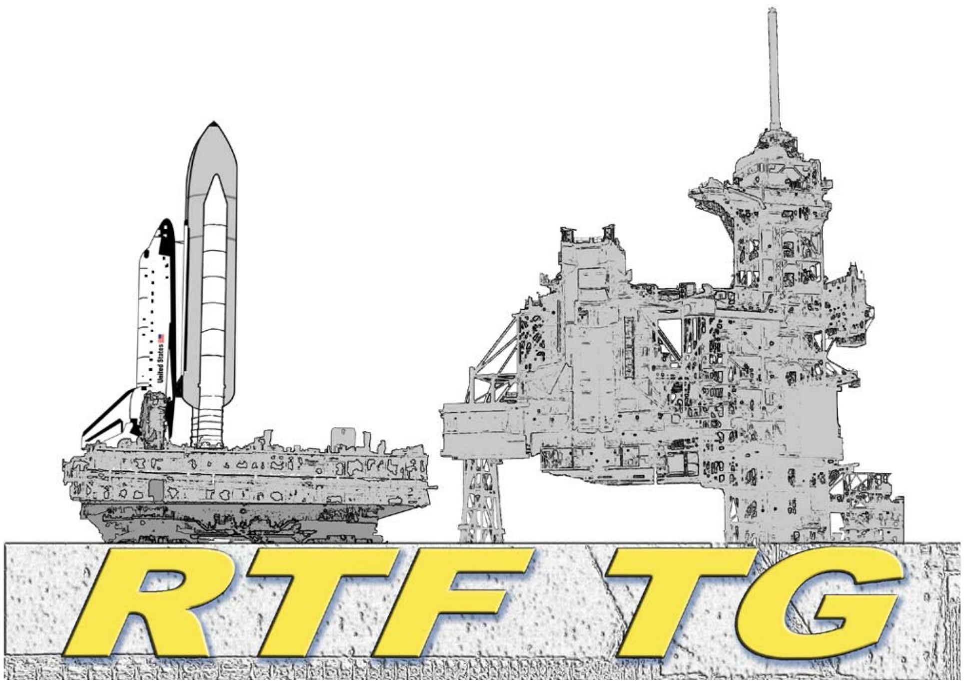
# Third Interim Report

## Return to Flight Task Group




**January 28, 2005**

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**Return to Flight Task Group**
**Third Interim Report**

**Approved by**

RO Covey

**Richard O. Covey**
**Task Group Co-Chairman**

January 28, 2005
**Date**

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## SUMMARY

Overview

As NASA approaches the first launch of the Space Shuttle since the Columbia accident (presently scheduled for the May-June 2005, launch window), it has become clear to the Return to Flight Task Group (RTF TG) that the recommendations of the Columbia Accident Investigation Board (CAIB) need to be considered not just individually, but also as a collection of activity that will result in reduced risk to the continued flights of the Shuttles and their crews. An ancillary benefit of all the activity thus far is the increased understanding of the remaining risk of return to flight and beyond. (See the risk evaluation framework included on pages 11-14.)

Various members of the CAIB have suggested their recommendations could be summarized as: 1) make the maximum effort possible to improve the Shuttle's safety related-performance; 2) establish and promote open communications within the Agency; and 3) go fly again. Neither the CAIB nor the RTF TG expects that risk can be eliminated. We have often heard the safest Shuttle is one that never leaves the ground.

NASA has not interpreted the CAIB recommendations to be a checklist, but rather has in many cases undertaken activities that far exceeded the intent of CAIB. In other instances, technological and other barriers have thus far prevented the kind of progress CAIB had hoped for, and NASA has striven for. Taken together, the RTF TG believes it is entirely possible NASA will be able to make sufficient progress on the CAIB recommendations before their current launch date.

Several activities will nonetheless be incomplete, and several issues raised by the CAIB, such as scheduling and resources, are timeless. Other oversight bodies, such as the Aerospace Safety Advisory Panel (ASAP) will be called upon to pick up the agenda after return to flight. Obviously, Congress will continue its usual oversight of NASA as well.

It is important to reiterate: NASA, and not the RTF TG, will have to ultimately determine if the remaining risk is sufficiently low to justify the return to flight. The RTF TG's charter is limited to the evaluation of NASA's implementation of the 15 CAIB recommendations for return to flight. We will not make a determination of the safety or reliability of the next flight. Despite press reports to the contrary, only NASA can make that determination.

Summary of Plenary

Over the course of the three days (December 14-16, 2004), it was determined NASA has made substantial progress on meeting the CAIB recommendations for return to flight. The panels recommended, and the RTF TG approved, the complete closure of six recommendations and the conditional closure of one additional recommendation.

However, considerable work remains. Eight items remain open including some of the toughest technological challenges the recommendations present: shedding of debris, strengthening the Reinforced Carbon-Carbon (RCC), hardening of the Orbiter, and repair of thermal protection tile and RCC. Most of the operational issues have been addressed, with the largest remaining concern involving the ability to detect and repair damage to the Shuttle while in orbit. Some planning remains to create the potential use of the Space Station as a viable "safe haven" for the crew of a damaged Shuttle while a rescue mission can be mounted. NASA has also made substantial progress on the various management issues the CAIB cited as "half" the cause of the demise of Columbia, but sufficient detail of plans, exercise of new capabilities and responsibilities, and adequate documentation remain open issues.

Several of the CAIB return to flight recommendations involve enhanced imagery of the Shuttle during launch and while on orbit. NASA has made sufficient progress on imagery to allow the RTF TG to fully or conditionally close three of the recommendations (3.4-1, 3.4-2, 6.3-2) and note substantial progress on a fourth (3.4-3, which will be formally considered as part of 6.4-1, On-Orbit Inspection and Repair).

Taken together, the changes in the capability to observe and examine the Shuttle on launch will allow a more complete evaluation of the adequacy of the design and process changes made to the External Tank (ET) in the reduction of critical debris. The enhanced imagery will also contribute to the ability to focus on-orbit inspections. There will undoubtedly be foam shed from the ET during the next and subsequent launches. The questions will be: how large are the pieces, where on the tank did the shedding occur, and where did the debris impact? The ascent imagery will help answer these questions.

Some months ago, it became clear to the RTF TG the immense amount of new data, much in the form of imagery, would require a new approach to integration. The RTF TG therefore constituted a sub-panel for Integrated Vehicle Assessment. In response, NASA formed a development team that has produced a Thermal Protection System (TPS) Operations Integration Plan (OIP) intended to allow the Mission Management Team (MMT) to make a timely entry readiness, repair, or safe haven determination. The latest version of the OIP, while benefiting from further simulation and testing, is very robust and a potential model for other integration activities within the Shuttle Program as well as the Agency.

Two recommendations affecting closeout procedures were also dispositioned at the plenary (4.2-3 and 10.3-1). "Closeout" refers to the process of finalizing work on the Shuttle, often in an area that is then sealed from further view or inspection. The requirement for "two-person" closeouts is simply intended to add an additional pair of eyes to the evaluation of the completed work before being sealed. The requirement for "digitized closeout photos" is intended to yield an adequate ability to both examine work after closeouts and the ability to easily recall the images, particularly while the Shuttle is on orbit.

During the course of their investigation, the CAIB uncovered a technical deficiency in the bolt catcher, a device that prevents the explosive bolts used to mate the Solid Rocket Boosters (SRB) to the ET from becoming debris that might impact the Orbiter (4.2-1). NASA has successfully redesigned, tested, and requalified the bolt catcher.

Although most of the management-related recommendations remain open, NASA has made substantial progress since the last plenary. Most notably, the response to Recommendation 7.5-1 to create an Independent Technical Authority (ITA) has been formulated and implementation has begun. The first “warrants,” the official delegation of ITA to specific individuals, have been issued.

The role of the MMT, which received much attention post-Columbia, has been clarified and expanded. The new MMT has conducted ten simulations of various aspects of the next mission and plans an end-to-end, full mission simulation beginning in late February and lasting several days.

The systems engineering and integration function, which the CAIB noted had atrophied over the course of time, has been reinvigorated and has an expansive role in return to flight. However, the RTF TG remains concerned that without adequate documentation the renewed vigor will dissipate after return to flight.

The Use of Analytical Models in Return to Flight

One way to view the loss of Columbia and her crew is in the analytical framework in which NASA must often work. That is, NASA must make assumptions from which can be derived “solutions” or “answers,” the quality of which are highly dependent on those assumptions. It is simply the nature of highly technical, cutting edge endeavors.

It was, simplistically stated, two faulty assumptions that were direct causes of the Columbia tragedy: 1) foam insulation used on the ET cannot develop sufficient ballistic momentum to catastrophically damage the RCC on the wing leading edge; and 2) the aerodynamics of the wings, the airflow around the wings, will carry debris around/away from the leading edges of the wings. Both assumptions proved wrong, despite the successful completion of over 100 flights that seemed to validate these assumptions.

The RTF TG is concerned that NASA not replicate the reliance on faulty assumptions and the results of analytical models to justify return to flight. For example, significant progress has been made by the ET Project in improving both the design of the tank and the processes for the manual application of foam. These actions should serve to significantly reduce the risk of the liberation of critical debris during Shuttle operations. Many of these changes were made on the basis of TPS impact testing and debris flow modeling which has significantly improved the characterization and knowledge base associated with debris.

However, the testing and modeling of the debris flow and impact will not provide statistically significant absolute values nor provide the basis for making on-orbit damage assessments. As such, the current models cannot be used to precisely determine “allowable” debris nor precisely assess the magnitude of risk reduction. For return to flight, given the current state of model development and the remaining test program, additional analytical modeling is unlikely to provide a sound basis for additional design, process, or operations changes.

Similarly, modeling of debris liberation, flow, and damage, while providing engineering insight, cannot provide for the “certification” of flight hardware unless the models themselves undergo a rigorous process of validation and certification. NASA’s determination of readiness and successful return to flight relies heavily on a full understanding of material condition, suitability for the intended operating environment, and clear assessment and acceptance of associated risk.

During a Program Requirements Control Board (PRCB) conducted April 15, 2004, the following definitions were presented as part of PRCB Directive S062235:

- **Certification –** A formal documentation of the verification and validation results. Certification requires review and assessment of verification and validation records by a certifying authority. A certification authority may impose additional inspection, test, analysis, or demonstration activities to close any gaps in requirements.
- **Validation –** Determination that an item meets its intended purpose in its operating environment. For models/analysis tools, design environments and simulations, validation is the determination that the item accurately reflects the subject being modeled (i.e., it is a valid model or database). For software, validation also is the determination that requirements are correct and complete (i.e., it is a valid requirement).
- **Verification –** Determination that an item meets its requirements.

These definitions generally reflect widely held engineering and industry standards, even though slight variations may exist among certain disciplines. Central to the safe and reliable conduct of high risk complex technical endeavors is rigorous and consistent understanding of, and adherence to, these terms and the processes they describe.

This understanding and adherence also applies to methods leading to the end state (i.e., models and analysis tools utilized during validation). As an example, if one is to assert "validation has been accomplished through probabilistic analysis," the analysis must rest upon fundamental mathematical principles and undergo unflinching rigor. This rigor must include a predefined validation process for the tools and models utilized. This validation process must be founded on objective success criteria and the plan for validation documented and approved prior to undertaking the validation process. NASA has yet to demonstrate the rigor of the models necessary to certify the integrity of the Space Shuttle TPS, including the ET. Without validation of models, they should not be used for certification or risk assessment.

The RTF TG notes in the aftermath of the Challenger accident, a verification committee required for any Reusable Solid Rocket Motor changes that could not be tested and which changed flight configuration, verification required "two independent analytical models with a factor of safety of greater than 2.0."

The RTF TG also notes critical debris modeling is not yet complete and many requirements and current assumptions are based on preliminary debris modeling.

<u>NASA's Determination of Readiness for Return to Flight</u>

Risk acceptance and management are fundamental to leadership in high risk technical activities and is the leaders' ultimate responsibility. Space flight in general, and Shuttle operations in particular, are of such a nature that it is impossible to drive the risk to zero. While return to flight activities can be shown to reduce the risk, Shuttle operations will always be "accepted risk" operations.  The basis for judgment on accepted risk relies upon a number of factors that are well accepted, understood, and documented.

NASA must be vigilant to prevent the development of a false sense of security by accepting faulty assumptions, or otherwise inappropriate analyses, to justify return to flight.

## INTRODUCTION

The Return to Flight Task Group

On April 14, 2003, the NASA Administrator, Sean O'Keefe, tasked Lt. Gen. Thomas Stafford, U.S. Air Force (Ret.), with conducting an independent assessment of NASA's actions to implement the recommendations of the CAIB. As a result, a RTF TG was chartered under the Federal Advisory Committee Act (FACA). Mr. Richard Covey and Lt. Gen. Stafford were asked to co-chair this committee. Using expertise from the Stafford-International Space Station Operational Readiness Task Force, personnel from the aerospace industry, federal government, academia, and the military, the RTF TG is reviewing the actions of the Agency in implementing the CAIB recommendations. They will report their evaluations to the Space Flight Leadership Council (SFLC) and deliver a final report to the NASA Administrator one month before the planned return to flight of the Space Shuttle. This report is strictly advisory to the Administrator and not a prerequisite for return to flight.

While the Task Group is ancillary to the CAIB, it is a modest enterprise by comparison—all RTF TG members are part-time; the support staff is significantly smaller; outside consultants will be rare; the impingement on NASA resources will be small; and the budget is a fraction of the CAIB's.

Federal Advisory Committee Act

NASA is among several federal agencies that currently enlarge their access to the insights and experiences of accomplished citizens by establishing advisory committees. FACA governs the creation, management, and termination of such advisory committees when they report directly to federal officials. The General Services Administration provides government-wide administrative guidance for FACA, while the Office of Government Ethics oversees "conflict of interest" matters as they impact the designation and conduct of advisory committee members.

The legislative history of FACA (Public Law 92-463, 1972) makes it clear that Congress intended, with this statue, to lift the "veil of secrecy" surrounding over 35,000 then-existing federal advisory committees, ensuring that such groups did not function for purposes other than "giving advice." Examples of "other purposes" which Congress sought to prevent included "lobbying programs and partisan political activity" and enabling persons from "outside the government and not answerable to the people or to Congress for their actions" to "assume the functions of directors or indirectly [to] usurp the managerial functions which are the responsibility of the governmental agency."

The federal administrative requirements associated with Agency use and management of advisory committees exist to preserve three fundamental principles that must govern the special access to federal decision-makers afforded to advisory committee members: public accountability, transparency, and assurances that advisory committee members serve in the public interest rather than for personal financial gain.

## Purpose and Duties of the Task Group

The RTF TG is performing an independent assessment of NASA's actions to implement the recommendations of the CAIB as they relate to the safety and operational readiness of STS-114. NASA remains responsible for the overall safety and operational readiness of STS-114. As necessary to Task Group activities, the RTF TG consults with former members of the CAIB. While the Task Group is not attempting to assess the adequacy of the CAIB recommendations, it is reporting on the progress of NASA's response to meet the intent. The Task Group may make other such observations on safety or operational readiness, as it believes appropriate. The RTF TG draws on the expertise of its members and other sources to provide its assessment to the Administrator. The Task Group holds meetings and makes site visits as necessary to accomplish its fact-finding. The RTF TG has been provided information necessary to perform its advisory functions, including activities of both the Agency and its contractors. The Task Group functions solely as an advisory body and complies fully with the provisions of the FACA. The RTF TG will terminate two years from the date of establishment, unless terminated earlier or renewed by the NASA Administrator.

## Panels and Sub-Panels of the Task Group

The RTF TG is comprised of three panels: the Technical Panel, the Management Panel, and the Operations Panel; and two sub-panels: the Editorial Sub-Panel and the Integrated Vehicle Assessment Sub-Panel (IVASP). These are shown in Appendix C.

### Technical Panel

The Technical Panel is focusing on NASA's compliance with the CAIB's findings and recommendations in the material condition of the Space Shuttle. This includes technical requirements (development of and compliance with), vehicle engineering, hardware and software development/verification, and overall vehicle certification status involved in the following:

CAIB Recommendations

- 3.2-1 External Tank Debris Shedding
- 3.3-1 Reinforced Carbon-Carbon Non-Destructive Inspection
- 3.3-2 Orbiter Hardening
- 4.2-1 Solid Rocket Booster Bolt Catcher
- 4.2-3 Closeout Inspection
- 6.4-1 Thermal Protection System Inspection and Repair – System Hardware Development Only

Management Panel

The Management Panel focuses on NASA's compliance with the CAIB's findings and recommendations in Space Shuttle Program (SSP) management, return to flight integrated schedule, and program/project risk management involved in:

CAIB Recommendations

6.2-1 Consistency with Resources
6.3-1 Mission Management Team Improvements
6.3-2 National Imaging and Mapping Agency Memorandum of Agreement
9.1-1 Detailed Plan for Organizational Change
- 7.5-1: Independent Technical Engineering Authority
- 7.5-2: Safety and Mission Assurance Organization
- 7.5-3: Space Shuttle Integration Office Reorganization

Operations Panel

The Operations Panel focuses on NASA's compliance with the CAIB's findings and recommendations in SSP crew/controller operations and procedures to support operations involved in:

CAIB Recommendations

3.4-1 Ground-based Imagery
3.4-2 Hi-resolution Images of External Tank
3.4-3 Hi-resolution Images of Orbiter
4.2-5 Kennedy Space Center Foreign Object Debris Definition
6.4-1 Thermal Protection System Inspection and Repair – Operations Only
10.3-1 Digitize Closeout Photos
SSP-3 Space Shuttle Program Action - Contingency Shuttle Crew Support

Integrated Vehicle Assessment Sub-Panel

This sub-panel combines insights from the Operations, Technical, and Management Panels to assess NASA's ability to perform an integrated vehicle external damage assessment based on a variety of imagery and sensor sources in support of decision-making during launch and flight. The IVASP is an advisory sub-panel to the RTF TG panels and will close recommendations jointly with them.

The IVASP focuses on crosscutting vehicle assessment actions, specifically including assessment of the TPS. The sub-panel assessment will consider the broad interactions of allowable debris, critical damage size, damage detection and assessment via imagery and sensors, and the development of the associated MMT improvements to support real-time operations. This sub-panel assesses NASA's ability to integrate the information from this critical, and heavily related, set of changes driven by the NASA Implementation Plan. The set of NASA actions considered by this sub-panel includes:

CAIB Recommendations

- 3.2-1 External Tank Debris Shedding
- 3.3-2 Orbiter Hardening
- 3.4-1 Ground-based Imagery
- 3.4-2 Hi-resolution Images of External Tank
- 3.4-3 Hi-resolution Images of Orbiter
- 6.4-1 Thermal Protection System Inspection and Repair – Integrated Data Flow Only
- 6.3-1 Mission Management Team Improvements
- SSP-3 Space Shuttle Program Action - Contingency Shuttle Crew Support

Two members of the sub-panel will review the operational aspects of NASA's response to CAIB Recommendation 6.3-2 that NASA modifies the Memorandum of Agreement with the National Imagery and Mapping Agency (subsequently named the National Geospatial Intelligence Agency).

Editorial Sub-Panel

The Editorial Sub-Panel coordinates preparation of RTF TG interim and final reports.

Conduct of the Inquiry

For all three panels, review and assessment of the NASA Implementation Plan items shall include those items the CAIB identified as mandatory prior to return to flight. Items that are not required for return to flight, but are in the NASA Implementation Plan, are considered to be open work items that will be passed on to the ASAP. On a very selective basis, the RTF TG will assess the non-return to flight SSP items, known as "raising the bar" items in the NASA Implementation Plan, after notifying NASA of this decision.

The diverse nature of the recommendations requires a unique approach to the evaluation of each item in the NASA Implementation Plan. This is a result of the presence of process changes, hardware changes, organizational changes, and documentation of all of these, often in a single item. However, the criteria for acceptance, and closure by RTF TG and NASA, are uniform and defined below.

In general, the lead panel conducts fact-finding by field trips to appropriate sites, meeting with NASA personnel, discussions with contractors, issuing formal Requests for Information (RFI's) to NASA, and consulting with other experts.

Requests for Information

The issuing and closing of RFI's is the formal process of requesting and receiving information from NASA. An RFI could be a simple request for existing facts, or a complex inquiry on operations. RFI's can include specific actions of NASA to develop information, such as conducting workshops or making specific presentations. A more complete explanation of the RFI process, including a flowchart and sample forms is included in Appendix G. Appendix E is a list of RFI's issued thus far and their status. All RFI's are required to be closed prior to the formal acceptance of the NASA Implementation Plan item for closure.

<u>RTF TG/NASA Closure Process</u>

While the panels are pursuing fact-finding activities, NASA is executing a detailed plan to implement the CAIB recommendations. These plans are differentiated from the NASA Implementation Plan by the level of detail. When NASA concludes it has a mature plan, NASA will present the plan, details specified below, to the appropriate panel(s) of the RTF TG. This submittal will be in the form of a Return to Flight Action Closure Package. This package and its supporting documentation are auditable documents that provide NASA's complete and comprehensive strategy for closing out the CAIB recommendation. Each Return to Flight Action Closure Package shall contain, as a minimum, the following elements:

1. Signatory Sheet
   a. Relevant element or project manager(s)
   b. Space Shuttle Program Manager
   c. Lead - Return to Flight Planning Team
   d. Deputy Associate Administrator for Space Station/Space Shuttle Programs
   e. Associate Administrator, Office of Safety and Mission Assurance
   f. SFLC Co-Chairs

2. Transmittal Letter from SFLC Co-Chairs to RTF TG Co-Chairs

3. Executive Summary of the Closure Rationale
   a. Background Information (to include assumptions and interpretation of the CAIB recommendation)
   b. Corrective Measures and Results
   c. Open Issues
   d. Verification

4. Chart Package for Closure Presentation to RTF TG (including back-up charts)

During the plenary meetings in April 2004, the RTF TG had the opportunity to exercise the closure process. It was further refined to reflect the following changes:

1. The definition of tasks, requirements, and results would be developed from the most recent release of the NASA Implementation Plan (currently Revision 3).

2. The metrics and audit trail specified above would include the use of the current Space Shuttle Program Office (SSPO) configuration management system to provide tracking on any required:
   a. Test plans, results and reports

b. Design data and documentation
c. Programmatic documentation, including Directives, Actions, and Change Requests
d. Documentation and documentation traceability, starting with the programmatic documentation, NSTS-07700
e. Detailed audit trail and plan for these activities, but not the completion of activities prior to submittal for approval

3. Agreement on the appropriate level at which to track, verify, and certify the activities to be included in the closure package

Risk Reduction Framework

The single most critical return to flight issue is eliminating critical ascent debris. A plan is in place for an ET to be delivered in time to support a May 2005 flight. The SSPO Safety and Mission Assurance Manager described the framework for TPS risk reduction to the RTF TG at the April 2004 plenary meeting. This approach to defining the core return to flight issue is well documented in NASA's Space Shuttle Methodology for Conduct of Space Shuttle Program Hazard Analyses, NSTS 22254, Revision B.

This framework, shown in Figure 1, starting with primary hazard controls, further delineates appropriate warning devices and special procedures required to mitigate the risk of the primary hazard control not being completely satisfied.

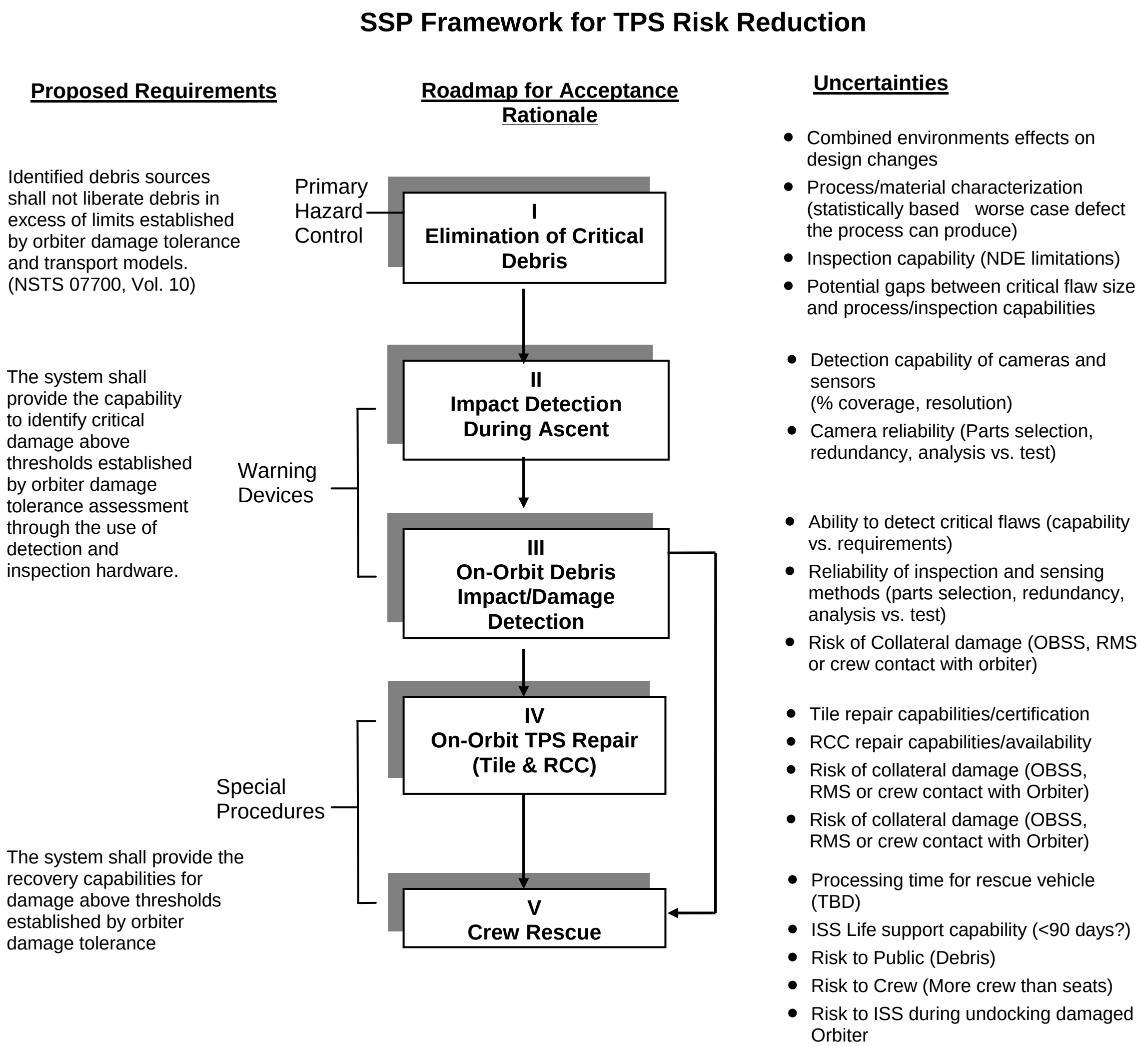



Figure 1 - SSP Framework for TPS Risk Reduction (NASA)

The RTF TG is satisfied with this “top-down” approach as applied to this hazard reduction program. This approach is being incorporated into the SSP risk deliberations and considerable progress has been made in incorporating risk reduction as part of program, element, and project activities. The RTF TG is interested in seeing this implementation specifically applied to all the NASA Implementation Plan items. Failure by NASA to do this will result in the inability to address the interfaces and interconnection between and among the items. Such missed opportunities created the perceived need in the RTF TG to institute the IVASP. This higher-level requirements recognition will assure the approach NASA implements will satisfy the issues that could not be addressed in a “bottom up” fashion.

Consideration might be given to a “top-down” requirements flow down as shown in Figure 2 and Figure 3 below. This approach recognizes the relationship between seemingly disconnected system elements that have crosscutting functional connectivity. The ability to construct this hierarchical diagram would only be possible if a “top-down” approach had been successfully developed.

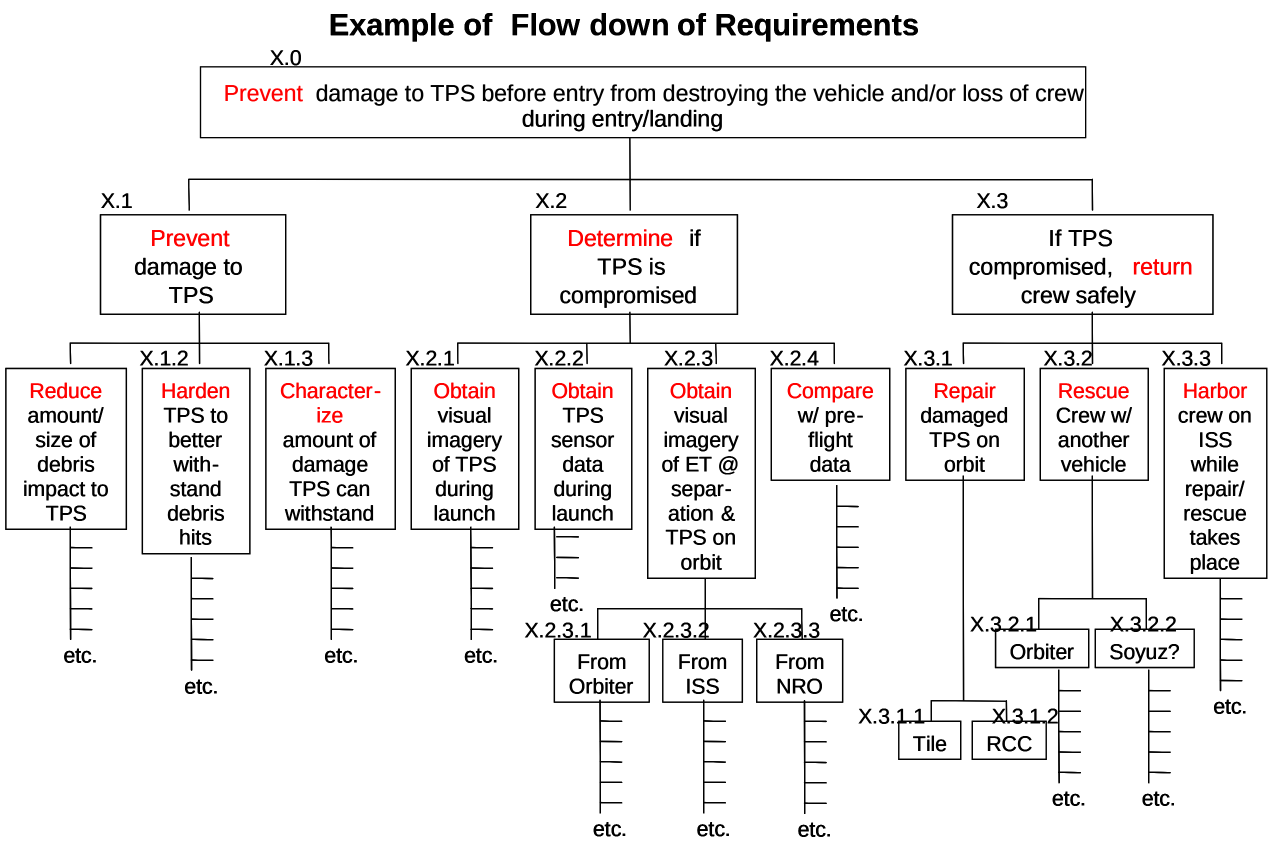



Figure 2 – Example of Flow down of Requirements (RTF TG)

(HAZARD SEVERITY LEVEL AND LIKELIHOOD OF OCCURRENCE WITH CONTROLS IN PLACE)

| LIKELIHOOD | MARGINAL | CRITICAL | CATASTROPHIC |
|---|---|---|---|
| PROBABLE | ACCEPTED RISKS | ACCEPTED RISKS | UNACCEPTABLE RISK |
| INFREQUENT | ACCEPTED RISKS | ACCEPTED RISKS | ACCEPTED RISKS |
| REMOTE | CONTROLLED | ACCEPTED RISKS | ACCEPTED RISKS |
| IMPROBABLE | CONTROLLED | CONTROLLED | CONTROLLED |

SEVERITY LEVELS

Figure 3 – Risk Matrix (NASA)

An excellent example from STS-107 would be the perceived versus the real risk to the Shuttle stack from ET debris. The Orbiter vulnerability to debris was specified and well documented. The historical TPS flight anomalies were also well documented. The persistent problems with foam issues and debris shedding from the ET were also well documented, although the source and root cause were not fully investigated. The prevailing logic was the debris was an ET problem that should be solved, but there was no criticality or elevated risk to the Orbiter or SRB's, since there was a programmatic history of acceptable damage to the Orbiter and SRB's.

The actual risk level at the launch of STS-107 was not aligned with the facts because the integrated analysis was not accurate. The perception of risk, which could be portrayed in Figure 3, was in the lower ACCEPTED RISK box, with catastrophic consequences, but with remote likelihood. In fact, the functionality and interface considerations of the Orbiter (in this case, potentially catastrophic damage, but with a probable likelihood) were misunderstood; their actual risk level was in the upper right corner, UNACCEPTABLE. Only with a "top-down" look across all the elements, associated requirements, and performance, could the actual unbiased risk level be ascertained. The RTF TG anticipates NASA will continue to expand this approach with the attendant positive results as the more complex NASA Implementation Plan items are brought forward for closure.

## Organization of this Report

This report is organized numerically by CAIB recommendation. First, the original language of the CAIB recommendation is provided followed by the RTF TG's interpretation of that recommendation. Next a summary of NASA's plans to address the CAIB recommendation is as stated in the document "NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond" coupled with the RTF TG's assessment of NASA's progress to date. The RTF TG's future plans for completing each evaluation are then overviewed. Finally, a current status is given for:

1. The detailed plan the RTF TG deems necessary for compliance with CAIB;
2. The status of the implementation of such a plan;
3. The status of formal RFI's; and
4. The overall status.

## Reporting

This interim report was prepared by the Editorial Sub-Panel consisting of Dr. Dan Crippen, Dr. Charles Daniel, and Dr. Rosemary O'Leary. The panels provided the primary substance of the report. The report was submitted for comments to the entire RTF TG and NASA (for technical comment only). RTF TG Co-Chair Richard Covey approved the final version.

**CAIB Recommendation 3.2-1 - External Tank Debris Shedding**

*Initiate an aggressive program to eliminate all External Tank Thermal Protection System debris-shedding at the source with particular emphasis on the region where the bipod struts attach to the External Tank.*

RTF TG Interpretation

Eliminate all sources of critical debris by eliminating the bipod strut foam and determine the void size that correlates with a debris size that is acceptable, based on the transport and energy analysis.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

Initiate a three-phase approach to eliminate potential for External Tank (ET) Thermal Protection System (TPS) debris loss. Phase 1 includes activities that will be implemented before return to flight. NASA will enhance or redesign areas of known critical debris sources including: redesign forward bipod fitting, eliminate ice from the liquid oxygen (LO2) feedline bellows, and eliminate debris from the liquid hydrogen (LH2) intertank flange closeout. Also as part of Phase 1 activities, there will be a reassessment of all TPS areas to verify TPS configurations, with special consideration given to LO2 and LH2 Protuberance Air Load (PAL) ramps. In addition, NASA will pursue a comprehensive testing program to understand the root cause of foam shedding and develop alternative design solutions to reduce the debris loss potential. This includes pursuing development of TPS Non-Destructive Inspection (NDI) techniques for LO2 and LH2 PAL ramps and the LH2 intertank flange manual closeout for engineering information.

Phase 2 of the plan includes debris elimination enhancements that can be incorporated into the ET production line as the enhancements become available, but are not considered mandatory to return to flight. NASA will pursue the redesign or elimination of the LO2 and LH2 PAL ramps and enhance the NDI technology to support use of NDI as an acceptance tool, enhance TPS application processes to optimize the application process and incorporate more stringent process controls, continue the investigation of a volume-fill material used to displace the liquid nitrogen present in the intertank "y-joint," and enhance the TPS thermal analysis tools.

Phase 3 of the plan represents potential long-term development activities that investigate redesign of the ET to further eliminate sources of debris shedding. Implementation of Phase 3 efforts will be weighed against plans to retire the Shuttle after the completion of the International Space Station.

Assessment

The ET Project Office has adopted a three-phase plan to respond to the CAIB recommendation. The current ET Project Return to Flight Plan is:

Phase 1: Develop, design, certify, and implement the required modifications to the ET that will allow for a safe return to flight, depicted in Figure 4. This is required for return to flight.

Phase 2: Develop, design, certify, and implement enhancements that would further reduce debris sources. These are continuous improvements that can be incorporated into the ET production line.

Phase 3: Activities that would explore the possibility of eliminating all debris. These efforts will be weighed against plans to retire the Shuttle at the end of the decade.

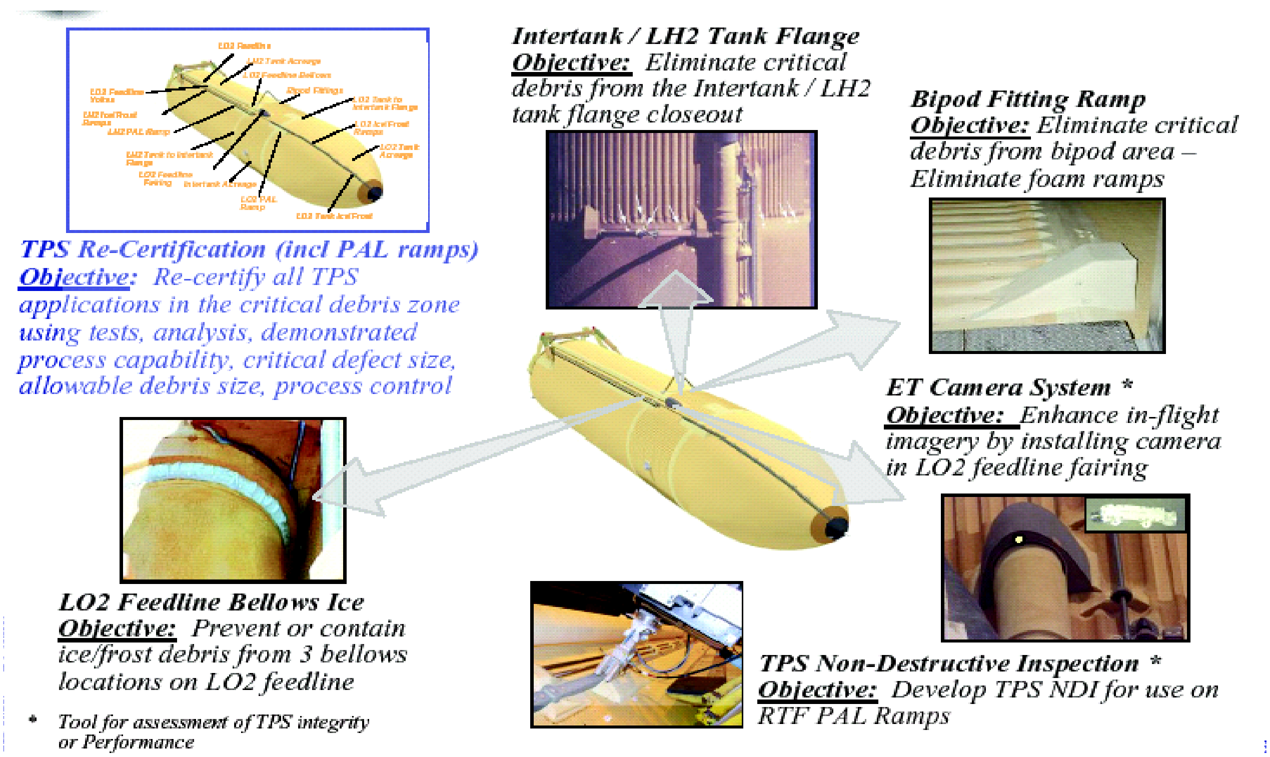



Figure 4 - ET Return to Flight Baseline (NASA)

For return to flight, the ET Project is employing a lead tank, trailing tank approach in support of the flight. ET-120 is planned to support the first return to flight mission and will be shipped prior to the final certification of the ET design. The ET-120 tank will also be shipped without incorporation of design features to eliminate the bellows ice debris. Should the present “drip lip” fail to reduce ice buildup to an acceptable level, additional design modifications may be incorporated on the tank at the Kennedy Space Center (KSC).

A phased design certification approach is being used to assess certification readiness of the ET prior to shipment to KSC. Design Certification Review (DCR) 1 was conducted on December 9-14, 2004, and included: Ground Umbilical Carrier Plate redesign, Solid Rocket Booster bolt catcher, camera system, non-TPS re-verification activities, redesigned non-TPS hardware, and status of closed Program Requirements Control Board actions.

DCR II is scheduled to begin on January 24 and continue through to the DCR Board on March 8, 2005. This second phase of the ET DCR includes redesigned TPS hardware, TPS re-certification, development flight instrumentation (ET-121) and any open certification from the ET Phase 1 DCR.

To mitigate the risk associated with this approach, the trail tank will not be shipped until final design certification/re-certification has been completed.

A major effort of Phase 1 is the plan for re-certification of the TPS hardware in the critical debris zone to the current debris allowable requirements. To date, the ET Project has certified the materials, though additional confidence tests are in progress. The ET Project has shown the TPS applications meet propellant quality, structural integrity, and ice/frost prevention requirements. During initial screening for debris allowable, most designs have been shown to meet the requirements based on preliminary data which were thermal/vacuum tests without cyro-ingestion. Those applications that did not meet the initial screening were identified for removal or replacement. These applications included the longeron, the bipod and Intertank/LH2 flange. The thermal/vacuum tests will continue with a cyro-ingestion load environment to detect critical defect size.

Future

The Technical Panel will continue to review NASA's Implementation Plan and assess the responses to outstanding requests for information. The Technical Panel will also follow closely the results of the DCR's and any issues that may arise from those reviews.

Status

Plan – Overall Established. Design Certification Review in progress

Implementation – In progress and/or review

Outstanding RFI's – 4

Overall Status – Open

**CAIB Recommendation 3.3-1 – Reinforced Carbon-Carbon Non-Destructive Inspection**

*Develop and implement a comprehensive inspection plan to determine the structural integrity of all Reinforced Carbon-Carbon system components. This inspection plan should take advantage of advanced non-destructive inspection technology.*

RTF TG Interpretation

Rebaseline Reinforced Carbon-Carbon (RCC) components by recycling through original inspection process, using advanced technology as appropriate.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

NASA is pursuing inspection capability improvements with newer technologies to allow Non-Destructive Inspection (NDI) of RCC without removal from the vehicle. The Space Shuttle Program must still assess commercially-available equipment and develop standards for use on flight hardware before being able to positively verify the structural integrity of RCC hardware while it is on the vehicle. Prior to return to flight, NASA will perform certification of all RCC panels by returning all the panels to the vendor's facility for comprehensive NDI. For the long term, NASA will develop NDI techniques and associated inspection criteria for RCC components.

Assessment

NASA has identified a three-phase approach for implementing the CAIB recommendation. Phase 1 is focused on return to flight. Phase 2 is to develop NDI methods for RCC inspection during turnaround and Orbiter Major Modification with a goal of developing and certifying an on-wing technique for use at the Kennedy Space Center (KSC). Phase 3 will continue evaluation of NDI technology for future improvements.

Excellent progress has been made in the development and implementation of an inspection plan for all RCC (Figure 5). Phase 1 is to quantitatively determine viability of each technique based on existing manufacturer acceptability testing capabilities and Leading Edge Support Structure localized convective oxidation NDI criteria. Phase 2 is to develop selected techniques into "turn-key" systems. NASA has evaluated three NDI technologies for on-vehicle RCC inspection between missions: thermography, x-ray, and eddy current. These technologies are in development and will be fielded at KSC to support downstream flights. The data produced will complement and enhance the protection against abnormal flight and processing damage offered by current visual and tactile inspections.

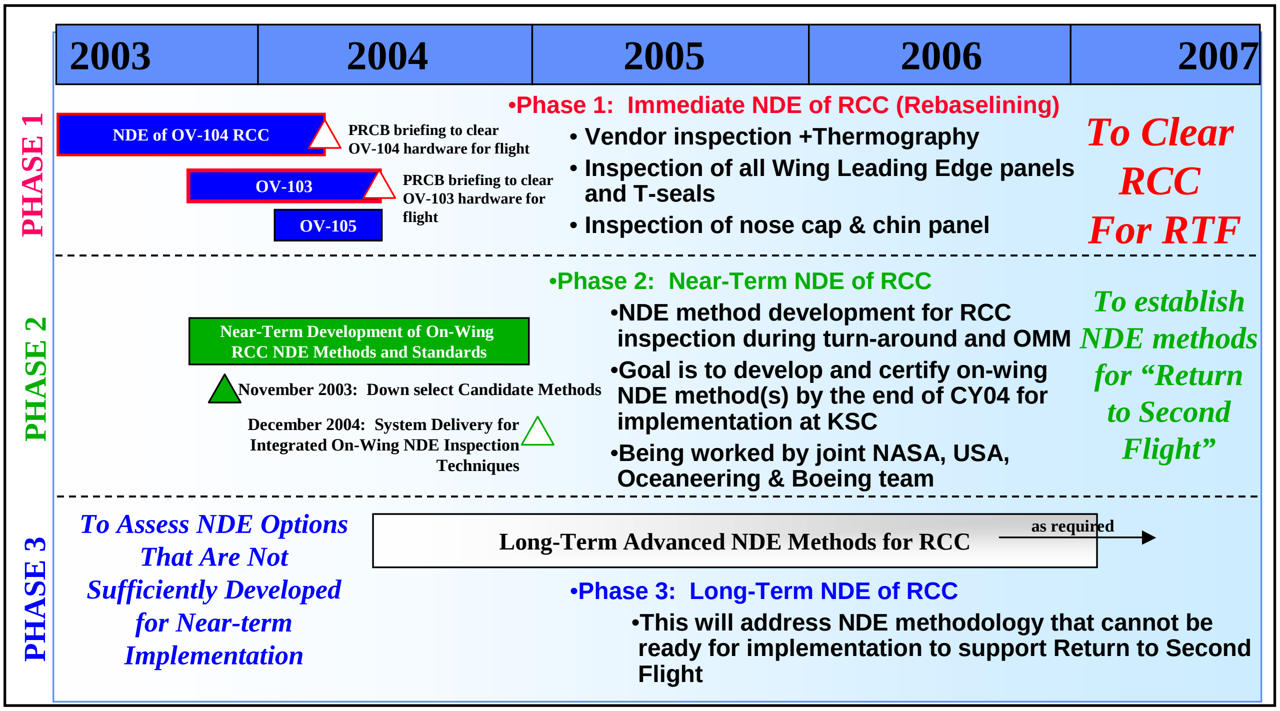



Figure 5 – NDI Inspection Plans (NASA)

The manufacturer has rebaselined all RCC components for OV-103 and OV-104, and thermography has also been completed at KSC (Figures 6 and 7). Endeavour (OV-105) components are in process. In the process of rebaselining, the original oxidation life reduction curves have been verified and the established schedules for refurbishing and replacing RCC panels and attach hardware have also been verified. No significant accumulated impact damage has been discovered in any RCC components. The manufacturer found a few minor voids that were introduced at manufacturing but went undocumented in the original acceptance screening. Some of these voids were analyzed in detail and found acceptable; others remain to be analyzed. Analysis is being performed to the heavy weight performance enhancement loads requirements.

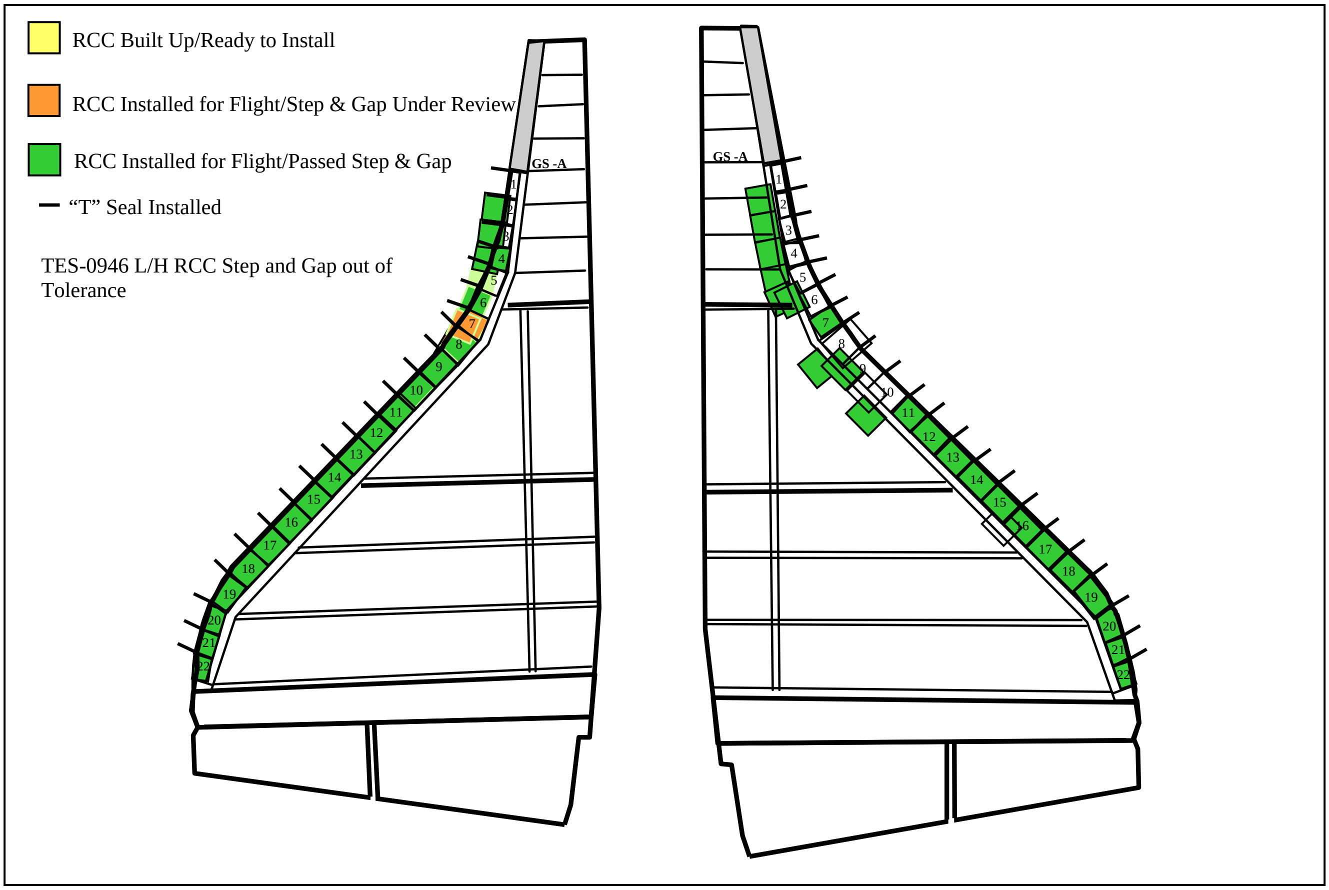



Figure 6 – OV-103 RCC Inspection and Installation Status (NASA)

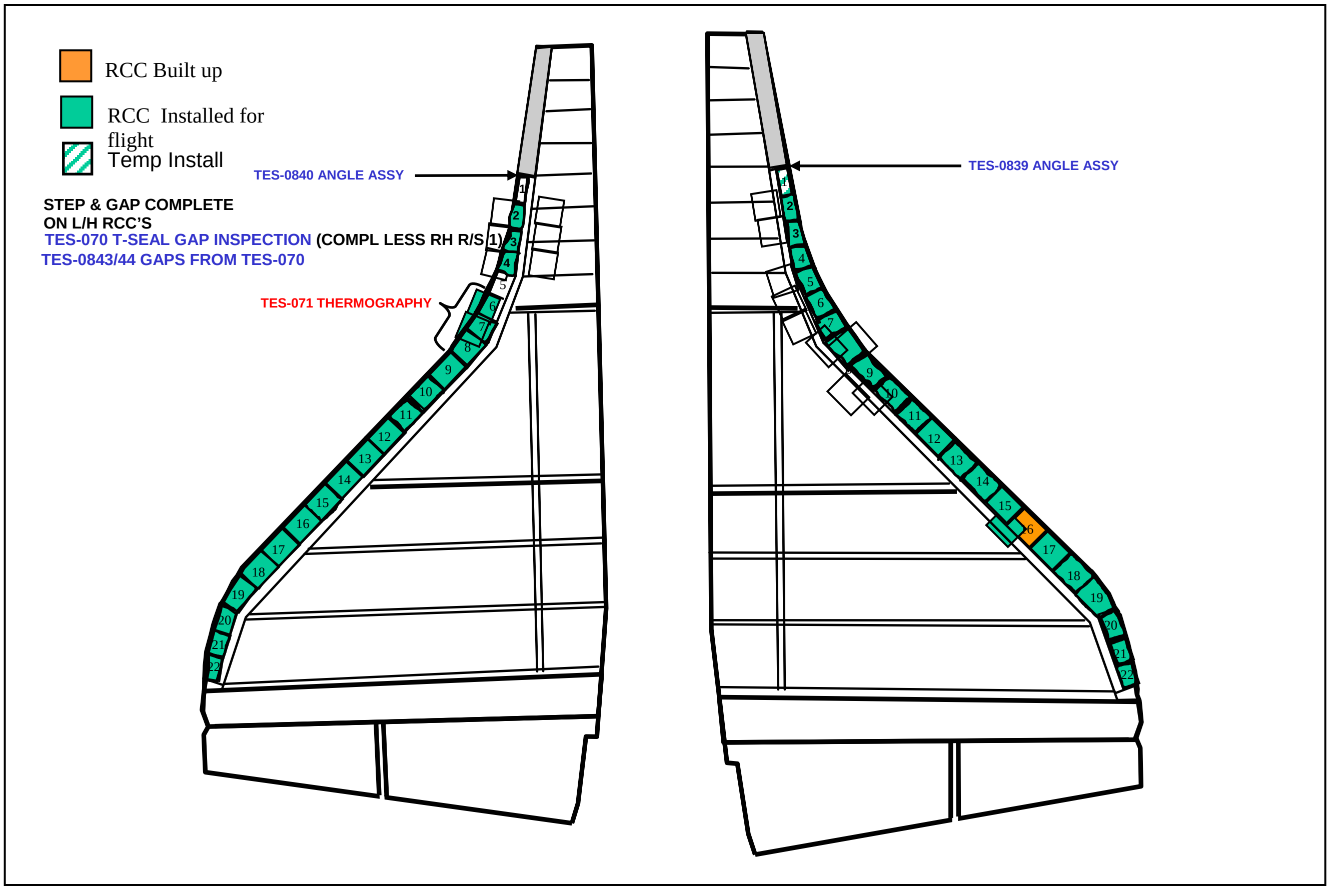



Figure 7 – OV-104 RCC Inspection and Installation Status (NASA)

After components are NDI-inspected at the vendor and shipped to KSC, an additional NDI technique, thermography, is being used to establish a baseline and compare to original NDI acceptance criteria. NASA's plan is to correlate the thermography data to the vendor NDI data and to other sensor data. To aid in the development of these technologies, NASA is establishing a server-based RCC NDI database for easy retrieval of stored data as well as developing a Data Fusion Visualization tool to accommodate the overlay of RCC NDI data onto Computer-Aided Three-dimensional Interactive Application Computer-Aided Design (CAD) model. This will enable visualization of NDI features using the structure CAD model, comparison of new NDI data with baseline data to evaluate changes in hardware condition, streamlining of data evaluation for Material Review/Problem Report (MR/PR) disposition, and remote access to NDI data via the NDI database server.

Future

The Technical Panel will evaluate any changes from the closeout package submitted by NASA.

Status

Plan – Inspection procedures in development. RCC standards in development (generic, technique-specific, validation process). Flaw detection requirements are being defined. Data storage, reduction and analysis process in development.

Implementation – Near and long-term technologies identified.  “Turn-key” systems for in-situ techniques are under development.

Outstanding RFI’s – None

Overall Status – NASA submitted a request for closure of this item.  Based on the closure package submitted, the status of the hardware tests, and its own fact finding, the RTF TG conditionally accepted closure of this recommendation.  The verification criteria for this item have been defined and will be monitored.  As of December 2004, the RTF TG received two of the items required for closure.  Received were the Program Requirements Control Board Directive and the RCC impact test data.  The Operations and Maintenance Requirements and Specifications Document updated for inspection of RCC panels and closure of all MR/PR’s from detailed RCC NDI inspection are scheduled to be delivered in late January 2005.  This recommendation remains conditionally closed.

**CAIB Recommendation 3.3-2 – Orbiter Hardening**

*Initiate a program designed to increase the Orbiter's ability to sustain minor debris damage by measures such as improved impact-resistant Reinforced Carbon-Carbon and acreage tiles. This program should determine the actual impact resistance of current materials and the effect of likely debris strikes.*

<u>RTF TG Interpretation</u>

Develop a detailed plan to define the hardening program including the detailed testing and modeling to determine the impact resistance of the Thermal Protection System (TPS). For the first Orbiter returning to flight, the actual impact resistance of installed material will be known. Implement hardware changes as defined in the hardening program.

<u>NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)</u>

The first part of this recommendation is for NASA to define candidate redesigns that will reduce impact damage risk to vulnerable TPS areas. This first part is broken into three phases: Phase 1 must be completed before return to flight. The four Phase 1 activities are: front spar "sneak flow" protection for the most vulnerable and critical Reinforced Carbon-Carbon (RCC) panels 5-13; Main Landing Gear Door (MLGD) corner void elimination; Forward Reaction Control System (FRCS) carrier panel redesign to eliminate bonded studs, and replacing side windows 1 and 6 with thicker outer thermal panes. Phase 2 was originally items that were possibly Phase 1 depending on debris sources and critical debris size, but has now been changed to be those activities that will be done during the next Orbiter Major Modification period for each vehicle. Currently, the two Phase 2 activities are "sneak flow" front spar protection for the remaining RCC panels 1-4 and 14-22, and MLGD enhanced thermal barrier redesign. Phase 3 items are those that are less mature but hold promise for increasing the robustness of the Orbiter. Implementation of Phase 3 efforts will be weighed against plans to retire the Shuttle after the completion of the International Space Station.

The second part of this recommendation is for NASA to determine impact resistance of RCC panels and tiles. NASA states this determination of impact resistance will be to the Orbiter without taking into consideration any of the hardening that will be done under the first part of this recommendation. Activities in support of this effort include identifying debris sources, performing transport analyses of debris sources, conducting test programs to determine impact resistance of RCC and tile to withstand External Tank foam and ice impacts, performing structural and thermal tests on damaged tile and RCC samples to determine what damage is survivable and what is not, and developing and verifying analytical models. NASA determined ablators do not constitute a critical debris source.

<u>Assessment</u>

The status of the Phase 1 activities is as follows:

- The front spar protection design certification review was conducted in December 2004.
- The main landing gear corner void elimination was certified by similarity and

modifications have been completed on OV-103 and OV-104.

- The FRCS carrier panel modifications were certified by analysis and test and modifications have been completed on OV-103 and OV-104.
- The window improvements have been certified by similarity to current analysis and OV-103 has been modified.

The two Phase 2 options, “sneak flow” front spar protection for RCC panels 1-4 and 4-22, and MLGD enhanced thermal barrier redesign, are currently in the certification phase. These are not being held as constraints to flight, but would enhance overall Orbiter hardening. Testing has cleared the MLGD thermal barrier design impact resistance as acceptable for return to flight. The enhanced thermal barrier design modification will reduce tile over-hang/lip and provide redundant thermal barriers and will begin to be implemented on OV-105 in July, 2005 after BRI-18 tiles become available and impact testing of this new thermal barrier design is completed.

Finally, the remaining Phase 3 options are those that are less mature but hold promise for increasing the robustness of the Orbiter. The development work for these projects has been initiated but the final implementation plans for the Phase 3 projects has yet to be developed.

Impact testing continues on both RCC and tile. Work has progressed on ice characterization issues. RCC flat panel testing for both foam and ice is nearly complete; the RCC panel 9L impact testing is only 15 percent complete. The RCC damage tolerance capability is scheduled to be defined in March 2005. The tile damage tolerance capability is scheduled to be defined in April 2005. The Debris Design Certification Review is scheduled for March 2005.

NASA has several impact assessment tools under development including those for rapid assessment; more detailed analysis and test data are needed to verify and validate these models. However, the Technical Panel has not yet seen the details of how the models will be combined with the test data and actual flight history data to produce these outputs. Due to the limited number of controlled test points and the relative uniqueness of the modeling activity (number and mathematical techniques), the Technical Panel does not yet understand the statistical significance of the planned results.

Future

The RTF TG plans to hold a fact-finding trip to Johnson Space Center in January 2005. The discussion during the trip will center upon the development and certification of the models used for debris damage assessment.

Status

Plan – The Orbiter hardening project is well defined. NASA has defined an extensive program of test and structural models to determine the actual impact resistance of current materials and the effect of likely strikes.

Implementation – Most of the engineering work for the Phase 1 projects has been released and modifications either completed or in work. The impact testing and model development are progressing.

Outstanding RFI's – 1

Overall Status – Open

**CAIB Recommendation 3.4-1 – Ground-Based Imagery**

*Upgrade the imaging system to be capable of providing a minimum of three useful views of the Space Shuttle from liftoff to at least Solid Rocket Booster separation, along any expected ascent azimuth. The operational status of these assets should be included in the Launch Commit Criteria for future launches. Consider using ships or aircraft to provide additional views of the Shuttle during ascent.*

<u>RTF TG Interpretation</u>

The CAIB image analysis was hampered by the lack of high-resolution and high-speed ground-based cameras. The existing camera locations were a legacy of earlier programs and were not optimum for the exit trajectory of Space Shuttle missions. Further, due to equipment problems, camera film was not always usable, as was the case for the Columbia launch. The CAIB was concerned about the need to have an adequate number of ground cameras located and operating properly to provide photographic coverage from more than one view of the Space Shuttle during the launch trajectory through separation of the Solid Rocket Boosters. Supporting this, the CAIB made the following finding:

**F3.4-4** *The current long-range camera assets on the Kennedy Space Center and Eastern Range do not provide best possible engineering data during Space Shuttle ascents.*

<u>NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)</u>

NASA is developing a suite of ground and airborne cameras to satisfy this recommendation. In addition to repairing existing cameras, significant additional cameras and locations were added to cover all phases of the Space Shuttle ascent trajectory from multiple different viewing angles. These cameras will provide short, medium and long-range images (see Figure 8) with hardware optimized for image quality during ascent. NASA has added Standard Definition Television and 35mm and 16mm motion picture cameras for quick-look imagery and fallback, respectively. High Definition Television (HDTV) is being added to selected ground locations.

In addition, NASA has approved the development and implementation of an aircraft-based imaging system called the WB-57 Ascent Video Experiment (WAVE) to obtain supplemental imagery for ascent and entry. In addition to providing higher resolution images, the WAVE can support multiple camera systems including HDTV and infrared. This technology is intended to provide imagery in conditions when ground cameras are obscured. This system is intended for experimental use and will be evaluated for relevance on future missions.

NASA has taken several steps to improve the underlying infrastructure for distributing and analyzing the additional photo imagery obtained from ground cameras. A new set of pre-launch equipment and data system checks will be conducted in the 48 hours prior to liftoff. These checks will be documented in Operations and Maintenance Requirements and Specifications Document.

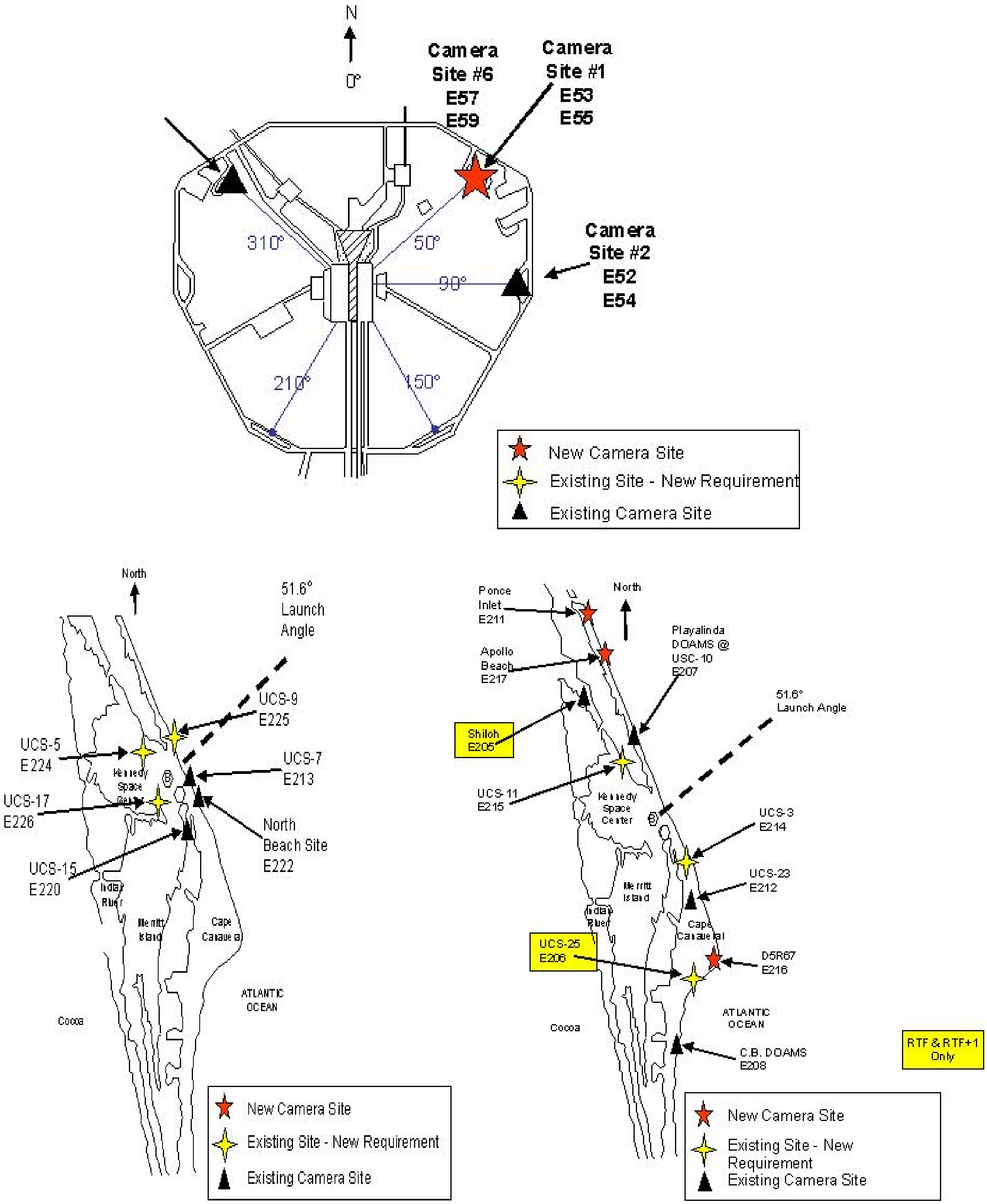



Figure 8 – Short, Medium and Long-Range Camera Sites (NASA)

In addition, launch commit criteria requirements have been added for those critical control systems and data collection nodes for which a power failure would prevent the operation of multiple cameras.

Assessment

NASA has made significant progress toward achieving an integrated suite of ground cameras to capture images of the Shuttle during ascent. NASA has significantly increased the number and capability of ground camera sites. While the total number of camera sites available at launch is to be determined, the requirements should ensure an adequate number to meet the CAIB intent for three useful views.

NASA is aware of the limitations inherent in its approach to ground imagery. Although the ground cameras provide important engineering data for the Shuttle, they cannot have the resolution and coverage necessary to definitively establish that the Orbiter has suffered no ascent debris damage. No real-time decisions will be based on ground imagery data. Rather, the comprehensive assessments of Orbiter impacts and damage necessary to ensure the safety of the vehicle and crew will be conducted using on-orbit inspection and analysis.

Future

Requirements are still being updated, hardware is being assembled, and procedures are being developed to accomplish the plan. The Space Shuttle Program is addressing hardware upgrades, operator training, and quality assurance of ground-based cameras according to the integrated imagery requirements assessment.

Prior to return to flight, NASA will add a redundant power source to the system which operates the launch pad cameras.

Status

Plan – Mature

Implementation – In work

Outstanding RFI's – 2

Overall Status – NASA submitted a request for closure of this item. Based on the closure package submitted, the status of planned self-evaluation by NASA, and its own fact finding, the RTF TG accepted conditional closure of this recommendation.

## CAIB Recommendation 3.4-2 – High-Resolution Images of External Tank

*Provide a capability to obtain and downlink high-resolution images of the External Tank after it separates.*

<u>RTF TG Interpretation</u>

Engineering quality imagery of the External Tank (ET) taken from Columbia would have been of great significance in the Columbia investigations. Columbia carried the standard on-board film still cameras installed in the two umbilical wells that provide images of the ET following separation from the Orbiter. The cameras provide images of sufficient quality and resolution to permit an engineering evaluation of the performance of the ET Thermal Protection System including foam shedding. Additionally, following ET separation, the Orbiter is maneuvered into a position that permits a crew member to take images, using a hand-held digital camera, of the ET that also provides data regarding foam shedding. Following landing, the film from the umbilical well and hand-held crew cameras is removed and developed for evaluation. None of these cameras were recovered from the Columbia debris. The CAIB investigators believed the images from these cameras would have provided valuable engineering information and would have helped in determining the cause of the accident. This triggered the following finding:

**F3.4-3** *There is a requirement to obtain and downlink on-board engineering quality imaging from the Shuttle during launch and ascent.*

<u>NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)</u>

NASA has revised procedures to optimize and facilitate crew hand-held camera imagery. In addition, NASA has replaced the 35mm film camera in one of the umbilical wells with a high-resolution digital camera. The images from both the umbilical well and crew cameras will be electronically retrieved and downlinked for evaluation following orbit insertion. These images will be used to identify potential ET anomalies.

<u>Assessment</u>

Appropriate cameras have been selected. NASA has accelerated the installation of the digital umbilical well camera to meet STS-114 milestones. All remaining work has been completed or scheduled that will allow this additional capability to be flown on STS-114.

<u>Future</u>

No further work is required.

<u>Status</u>

This recommendation is fully closed.

## CAIB Recommendation 3.4-3 – High-Resolution Images of Orbiter

*Provide a capability to obtain and downlink high-resolution images of the underside of the Orbiter wing leading edge and forward section of both wings' Thermal Protection System.*

RTF TG Interpretation

The CAIB investigations of the Columbia accident were hampered by the lack of high-resolution images of the launch ascent trajectory. The only images available were from ground cameras that were inadequate in number, placement, and resolution to permit a meaningful and timely engineering analysis of the External Tank (ET) Thermal Protection System (TPS) performance. Accordingly, the CAIB made the following findings:

**F3.4-3** *There is a requirement to obtain and downlink on-board engineering quality imaging from the Shuttle during launch and ascent.*

**F3.4-4** *The current long-range camera assets on the Kennedy Space Center and Eastern Range do not provide best possible engineering data during Space Shuttle ascents.*

**F3.4-5** *Evaluation of STS-107 debris impact was hampered by lack of high resolution, high speed cameras (temporal and spatial imagery data).*

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

To meet the requirement to assess the health and status of the Orbiter TPS, NASA will rely primarily on on-orbit inspections that will be augmented by on-vehicle ascent cameras. NASA will have cameras on the ET liquid oxygen feedline fairing and the Solid Rocket Booster (SRB) forward skirt. The ET liquid oxygen feedline fairing camera will take images of the ET bipod areas, the underside of the Shuttle fuselage, and the right wing from liftoff through the first 15 minutes of flight. These images will be transmitted in real-time to ground stations.

Beginning with STS-115, NASA will add additional cameras on the SRB's: aft-looking cameras located on the SRB forward skirt and forward-looking cameras located on the SRB ET attachment ring.

(For additional information, see NASA's response to CAIB Recommendation 6.4-1 in this volume.)

Assessment

On-vehicle ascent imagery will be a valuable source of engineering, performance, and environment data and will be useful for understanding in-flight anomalies. The new location of the ET camera will reduce the likelihood that its views will be obscured by the Booster Separation Motor plume. This on-vehicle ascent imagery suite, however, does not provide complete imagery of the underside of the Orbiter or guarantee detection of all potential impacts to the Orbiter.

NASA has removed the Orbiter Boom Sensor System (OBSS) and Wing Leading Edge (WLE) sensors from this recommendation and will address these items in CAIB Recommendation 6.4-1. Therefore, in order to acknowledge that NASA has met the intent of this recommendation, R3.4-3 and R6.4-1 will be reviewed jointly.

Future

NASA will provide data to answer this recommendation within the context of R6.4-1

Status

Plan – Backup is mature.  Pending review of OBSS and WLE sensor data

Implementation – In Progress

Outstanding RFI's – 1

Overall Status – Open

**CAIB Recommendation 4.2-1 – Solid Rocket Booster Bolt Catcher**

*Test and qualify the flight hardware bolt catchers.*

RTF TG Interpretation

Meaning of the CAIB recommendation is clear.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

In order to demonstrate compliance with factor of safety requirements, NASA will redesign and qualify the Solid Rocket Booster (SRB) bolt catcher by testing it as a complete system. This includes fabrication of the bolt catcher housing from a single piece of aluminum with no weld, selection of a new energy-absorbing material, reassessment of the bolt catcher thermal protection material, and redesign and resizing of the External Tank (ET) attachment bolts and inserts.

Assessment

The Technical Panel conducted several fact finding trips in support of the bolt catcher recommendation. The panel supported the Preliminary Design Review, Critical Design Review, and Design Certification Review processes.

The bolt catcher for the SRB to ET separation bolt (Figure 9) has been modified to correct the initial design, which did not demonstrate an adequate safety factor. The original design was a two-piece welded assembly and the new design is based on a one-piece forging. The energy absorber used to attenuate the bolt impact load has been redesigned as well. Additionally, the Thermal Protection System (TPS) has been changed from sprayed-on TPS to bonded cork. The NASA Standard Initiator (NSI) in the pressure cartridge had exhibited an ejection failure mode during several tests. This can result in damage to the energy absorber prior to bolt impact. This issue has been addressed by the incorporation of a locking ring assembly to aid in retention of the NSI.

During qualification testing, it was determined the longer energy absorber was not required; consequently, the Polymer Development Laboratory foam and counterbore was removed. The final design of the bolt catcher is found in Figure 10.

The SRB bolt catcher has successfully completed qualification testing and has demonstrated a minimum structural factor of safety of 1.86. Additionally, the NSI retention device has been determined to exhibit a minimum factor of safety of 2.3. The redesigned bolt catcher has successfully completed Level IV DCR.

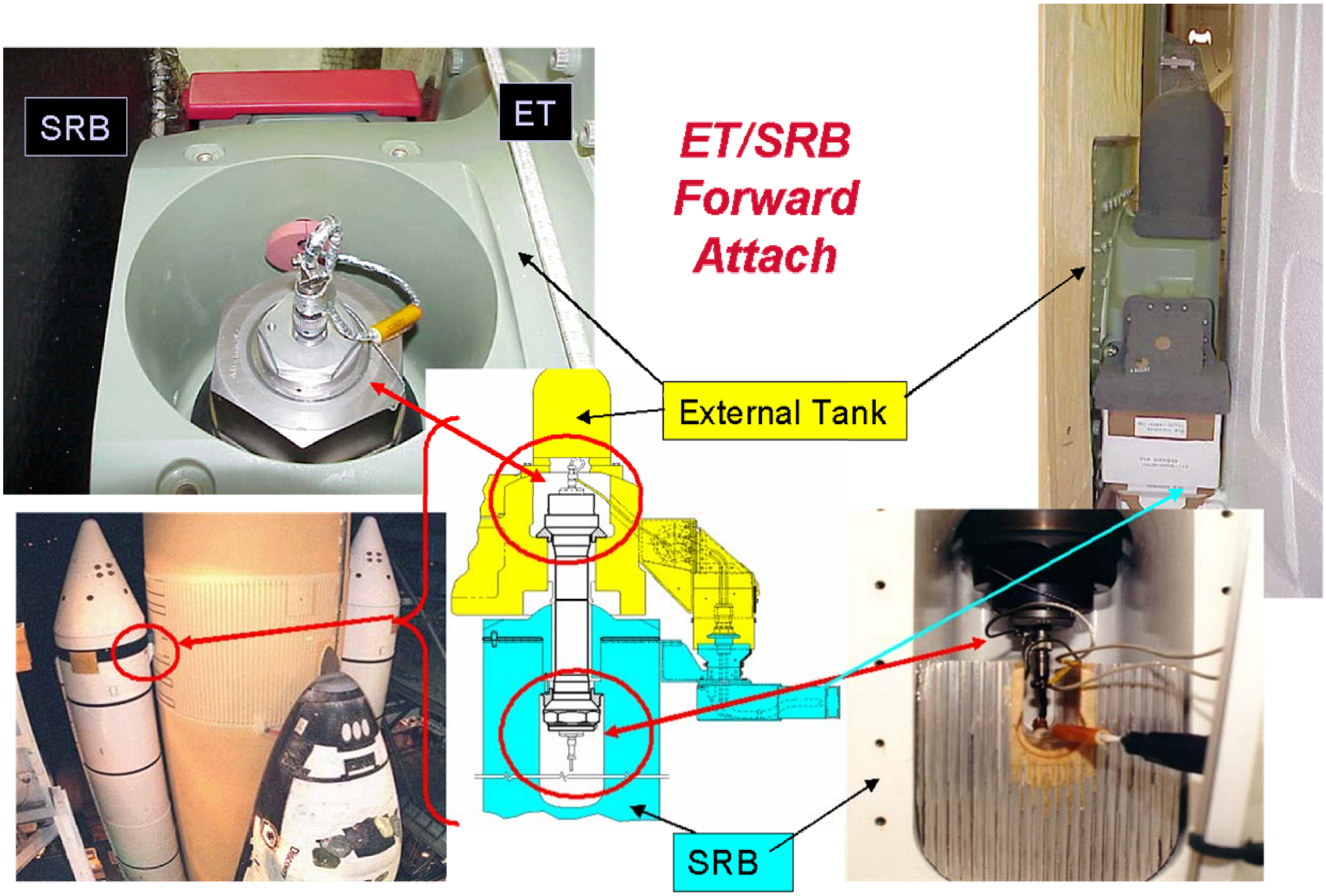



Figure 9 - SRB Bolt Catcher for the ET (NASA)

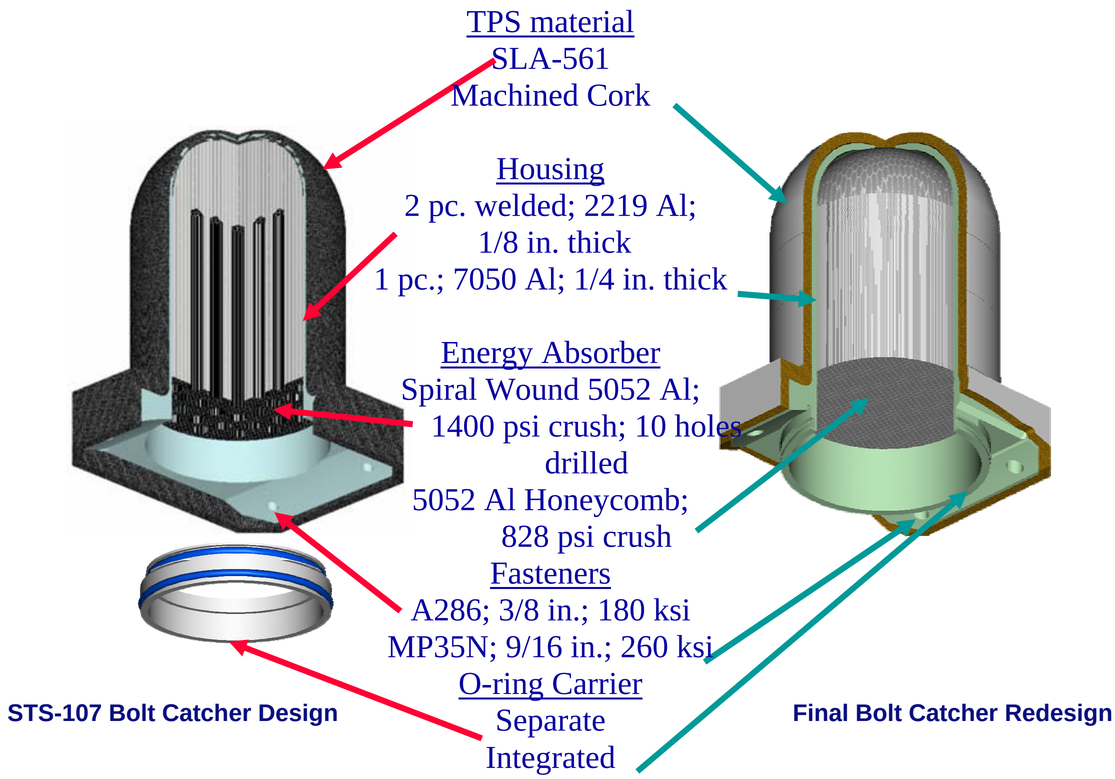



Figure 10 - SRB Bolt Catcher Design (NASA)

Future

No further work is required.

Status

This recommendation is fully closed.

**CAIB Recommendation 4.2-3 – Closeout Inspection**

*Require that at least two employees attend all final closeouts and intertank area hand spraying procedures.*

The CAIB subsequently provided the following clarification: This recommendation was intended to apply to the entire Space Transportation System for all types of closeouts. The External Tank (ET) intertank was specifically called out, but the recommendation was not limited to the tank.

RTF TG Interpretation

- NASA will review and update process controls
- Two trained and certified employees to attend all final closeouts and critical hand-spraying procedures
- At the Michoud Assembly Facility (MAF), Material Processing Procedures to be modified in accordance with two-person closeout requirement. Quality control and Government-mandated inspection points are also to be included in the processing procedures.
- Recent Space Shuttle Program Office (SSPO) direction (March 3, 2004), for each project manager to review/audit all flight hardware final closeouts at the Shuttle element manufacturing sites and during launch preparation at the Kennedy Space Center (KSC) is consistent with the Implementation Plan and CAIB intent.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

NASA has established a Thermal Protection System (TPS) Verification Team to verify, validate and certify all future foam processes. This includes a review and an update of the process controls applied to foam applications, especially the manual spray applications. The Material Processing Plan (MPP) will be revised to require, at a minimum that all ET critical hardware processes, including all final closeouts and intertank area hand-spray procedures, be performed in the presence of two certified production operations employees. The MPP's will also include a step to require technicians to stamp the build paper to verify their presence and to validate the work was performed according to plan. Additionally, quality control personnel will witness and accept each manual spray TPS application. Government oversight of TPS applications will be determined upon completion of the revised designs and the identification of critical process parameters. NASA has also widened the scope of this corrective action in response to a recommendation from the RTF TG to include all flight hardware projects. An audit of all final closeouts will be performed to ensure compliance with the existing guidelines that a minimum of two persons witness final flight hardware closures for flight for both quality assurance and security purposes.

Assessment

Excellent progress has been made with regard to two-person closeout of critical areas. In particular, the ET Project has amended all manufacturing processes and procedures to ensure that at least two employees, and in most cases several more, are present at all manufacturing steps. This includes manual foam applications and all other flight closeouts, both at MAF and at KSC. Furthermore, NASA is satisfying more stringent quality assurance requirements through additional employee training, certification, and work documentation of inspections and imagery, all of which have significant security benefits.

The scope of this action was widened to conduct a comprehensive audit of all processes and controls for all SSP projects and elements by the following letter from the SSP Manager to all hardware and processing elements:

> *"Columbia Accident Investigation Board Recommendation 4.2-3 Audit," Letter from SSP Manager to Flight Hardware Elements, dated March 3, 2004.*

The audit will review quality assurance closeout protocols and protection against non-compliance with technical requirements and/or willful damage. Attributes include: an audit conducted by Quality Assurance, Safety and Mission Assurance, and Engineering, and the results reviewed by each project manager, compiled and assessed by Program Integration and presented to the SSP Manager. Deficiencies identified will result in an SSP action to the responsible project, specifying each project individually. Audit results were received on December 8, 2004. Results presented in the closure package were satisfactory. This recommendation was conditionally closed via public meeting in April 2004. NASA has met all the conditions imposed by the RTF TG.

<u>Future</u>

No further work is required.

<u>Status</u>

This recommendation is fully closed.

## CAIB Recommendation 4.2-5 – Kennedy Space Center Foreign Object Debris Definition

*Kennedy Space Center Quality Assurance and United Space Alliance must return to straightforward, industry-standard definition of 'Foreign Object Debris' and eliminate any alternate or statistically deceptive definitions like "processing debris."*

RTF TG Interpretation

During their investigation and interviews with personnel involved with processing the Space Shuttle for flight, the CAIB determined that NASA, in 2001, generated new and non-standard definitions for Foreign Object Debris (FOD). The term "processing debris" was applied to debris found during the routine processing of the flight hardware. The term FOD applied only to debris found in flight hardware after final closeout inspections. These definitions were unique to the Space Shuttle Program at the Kennedy Space Center (KSC). Because debris of any kind has critical safety implications, these definitions are important. Accordingly, the CAIB wanted the standard, industry-wide definitions re-established for FOD. In support of this conclusion, the CAIB made the following finding:

**F4.2-18** *Since 2001, Kennedy Space Center has used a non-standard approach to define foreign object debris. The industry standard term "Foreign Object Damage" has been divided into two categories, one of which is much more permissive.*

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

KSC has adopted the FOD definition derived by National Aerospace FOD Prevention, Inc (a nonprofit educational organization recognized within industry as the authority for FOD matters) across all processing activities and has updated the operational procedures accordingly. Current metrics to measure such debris have been improved. In order to identify where and when FOD was discovered so that appropriate correction action can be taken, FOD will be noted as found: 1) at end of shift, 2) at closeout, or 3) in process. FOD is defined as unaccompanied foreign material. The revised definition will not alter the current policy of "clean as you go" but will result in more emphasis on the procedure of cleaning up the work area as the work progresses rather than cleaning up the work area after the work is completed. A joint KSC and United Space Alliance (USA) team visited Air Force aircraft modification centers, a Grumman Aerospace Facility, and the Gulf Stream aircraft factory to study how the FOD issue was addressed by those organizations. Lessons learned will be incorporated into the KSC procedures and processes. A major education effort regarding the revised definition has been undertaken in time to make sure the definitions and the accompanying rationale are understood by the entire KSC (NASA) and USA workforce.

Assessment

The FOD Program at KSC was very effective in the past. When the definition was modified to delineate between FOD-related to ground-processing versus that identified from external sources, the workforce was not sufficiently trained to understand the implications. This confusion was expressed to the CAIB members during their interviews at KSC. Therefore, to answer this question, KSC reevaluated the entire program and decided to enhance many layers of the program in their response to the CAIB recommendation. The RTF TG Operations Panel experts concluded fact-finding during a mini-Technical Interchange Meeting at KSC in May 2004. This complemented previous meetings with KSC quality assurance and USA personnel in 2003 and early 2004.

NASA has removed the misleading category of processing debris that caused concern. They have improved the training of the workforce. They have obtained buy-in at all levels for both NASA and all contractors. The revised program has implemented several improvements above and beyond the expectations defined in the CAIB recommendation. The FOD database has been made significantly more robust and captures a higher level of reporting detail than existed previously. NASA management has demonstrated their buy-in with participation in the planned walk-downs to inspect for FOD. It is very important for NASA management to provide positive incentives for the reporting of FOD and to avoid negative sanctions for those who self-report. The Task Group believes management is sufficiently sensitive to this need and will provide the proper positive and negative feedback to the workforce. An audit has been completed, and needed follow-on actions identified. Metrics defined and tracked by NASA will assure continued compliance with the new improved FOD Program. This recommendation was conditionally closed via public meeting teleconference in July 2004. NASA has met all the conditions imposed by the RTF TG.

<u>Future</u>

No further work is required

<u>Status</u>

This recommendation is fully closed.

**CAIB Recommendation 6.2-1 – Consistency with Resources**

*Adopt and maintain a Shuttle flight schedule that is consistent with available resources. Although schedule deadlines are an important management tool, those deadlines must be regularly evaluated to ensure that any additional risk incurred to meet the schedule is recognized, understood, and acceptable.*

<u>RTF TG Interpretation</u>

The CAIB explicitly recognized the legitimacy of the use of schedules to drive a process. They were concerned, however, when the line between "beneficial" schedule pressures and those that become detrimental cannot be defined or measured. In the case of Columbia, the CAIB discovered schedule pressure on the Shuttle was created by the schedule for construction of the International Space Station (ISS). Indeed, the February 2004 scheduled completion of Node 2 of the ISS was being touted as a measure of NASA's ability to maintain a schedule.

The CAIB further observed budget constraints inherently intensify the conflicts between schedule and safety. The meaning of the first sentence of the CAIB recommendation is clear: adjust the schedule to fit the available resources.

<u>NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)</u>

Among the activities NASA plans to undertake are more routinely assessing schedule risk (to minimize surprises), incorporating more margin into the schedule and manifest to accommodate changes, potentially adopting some of the risk management tools used for the ISS, and revising databases so schedule and risk indicators can be assessed real-time by managers. NASA Shuttle Processing and United Space Alliance Ground Operations management will use the Equivalent Flow Model to plan resources that are consistent with the Shuttle flight schedule provided in the Program Operating Plan guidelines in order to define an achievable schedule that is consistent with the available workforce needed to meet the technical requirements. To assess and manage the manifest, NASA has developed a process, called the Manifest Assessment System, for Space Shuttle launch schedules that incorporates all manifest constraints and influences and allows adequate margin to accommodate a normalized amount of changes. The NASA Maximum Work Time Policy (in document KHB 1710.2, section 3.4) includes daily, weekly, monthly, yearly, and consecutive hours worked limitations to assure workforce health in the face of schedule deadlines. If these time safeguards are approached, the schedule is adjusted to safely accommodate the added work.

Changes in NASA's management structure moves accountability for the ISS and Space Shuttle Program (SSP) from the Johnson Space Center to Headquarters to the Deputy Associate Administrator for ISS/SSP's, along with the authority to establish requirements, direct program milestones, and assign resources, contract awards, and contract fees. Quarterly Program Management Reviews have begun in Fiscal Year 2005 to assess program and project technical, schedule, and cost performance against an established baseline. These reviews are another tool to assure that the SSP is executed safely and reliably within available resources.

Assessment

The Management Panel has consistently explored the question of adequacy of resources in virtually every meeting with NASA personnel—from Headquarters staff to the workforce on the floor of the Kennedy Space Center. The answer has always been the same: "…there are sufficient budgetary resources for return to flight." For a time, there were concerns which the RTF TG shared that the availability of qualified personnel would be a constraint to return to flight. As the next flight has moved into the future, this concern seems to have abated.

However, recent press reports have claimed NASA personnel are concerned about resources and the possibility of workforce reductions. The Management Panel has not been able to confirm these reports and notes most were made prior to the finalization of NASA's budget, during a time when exercises were being conducted to assess the impacts of various alternative levels of spending.

Several weeks ago NASA's budget for the current fiscal year was finalized by Congress. NASA was one of the few federal agencies to receive full funding. Nonetheless, return to flight activities will require the reallocation of some funds from other NASA programs to the Shuttle, as well as reductions in NASA's Headquarters budget. Resource sufficiency is also tied to the scheduled retirement date for the Space Shuttle and will need to be evaluated if it stays in service longer than NASA's current retirement date of 2010. NASA's evaluation should include reassessment of actions and upgrades not undertaken by NASA when it determined after the CAIB issued its report, to retire the Space Shuttle in 2010 and any long term items already deleted from work and acquisition cycles, including Service Life Extension Program.

Any assessment of this requirement will consist of a snapshot—an evaluation at a point in time—that will vary dramatically. It will take continued vigilance, well beyond return to flight, to maintain a schedule consistent with resources.

Future

The Management Panel will continue monitoring the implementation of the budget to examine impacts on return to flight. Several Requests for Information (RFI's) will be issued to seek clarification of the effects of recent budget reductions to the NASA Engineering and Safety Center, Independent Technical Authority, and the Office of Safety and Mission Assurance on return to flight activities. An RFI will also be issued requesting data on some of the metrics NASA has said it will employ to detect schedule pressures; e.g., extent of overtime and the number of employees at the 60-hour-per-week maximum. We will also assess any relevant results from the efforts by Behavioral Science Technology to measure characteristics of NASA's culture.

Status

Plan – Ongoing

Implementation – In progress

Outstanding RFI’s – None

Overall Status – Open

## CAIB Recommendation 6.3-1 – Mission Management Team Improvements

*Implement an expanded training program in which the Mission Management Team faces potential crew and vehicle safety contingencies beyond launch and ascent. These contingencies should involve potential loss of Shuttle or crew, contain numerous uncertainties and unknowns, and require the Mission Management Team to assemble and interact with support organizations across NASA/Contractor lines and in various locations.*

<u>RTF TG Interpretation</u>

Mission Management Team (MMT) activities during the flight of Columbia have been widely criticized. Many of the additional capabilities embedded in other CAIB recommendations, such as imagery from various sources, are intended to support MMT activities for the next and subsequent flights. In addition to enhanced training for participants in the MMT, NASA will need to exercise these many new sources of data and information.

<u>NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)</u>

The first action by NASA was to form a team in June 2003 to address the recommendation. The team focused on revising MMT guidance and organizational issues to make more formal all MMT proceedings and meetings. The resulting updates to the MMT processes and organization will be captured in NSTS 07700, Volume III, Operations, Appendix D. In addition, the new organization is to "strengthen" the process for receiving and reviewing dissenting views concerning safety, operations, and engineering, and to expand the process of evaluation of problems that arise either during the MMT's prelaunch phase or after a Space Shuttle is launched. An integral part of the corrective actions is the development of a training approach focused on both individual and team effectiveness. The plan includes classroom sessions, individual study of recommended literature, and group dynamics training in the form of simulations involving the convening of the MMT. The team also focused on defining roles and responsibilities which represented a significant change to the MMT process.

<u>Assessment</u>

Strictly speaking, NASA has fulfilled this recommendation—they have developed a new training plan for the MMT. With the passage of time, we have been able to witness the implementation of most aspects of the plan. There have also been numerous simulations conducted to date including ten involving live, face-to-face exercises of various parts of the next mission. The Management Panel has observed seven of the ten live simulations.

Some of the training protocols were initially developed without clear objectives and techniques to assess the quality of training. Similarly, the first simulations lacked clear objectives and evaluation criteria. Further, lessons learned from prior simulations were not incorporated in subsequent exercises. With a maturing training program, many of the earlier deficiencies have been corrected and the MMT Training Plan is being updated to reflect formal evaluation requirements. However, not all aspects of the enhanced role of the MMT have been exercised, such as the use of the Contingency Shuttle Crew Support and a launch-on-need rescue mission

(STS-300) and the incorporation of all new sources of data and imagery (some of which are requirements for full closure of other recommendations).

Future

The Management Panel has communicated with the Space Shuttle Program a number of additional actions to undertake, including substantial documentation of what has been accomplished, before we close this recommendation. NASA has scheduled a complete end-to-end simulation for the end of February running into March that should complete most of the training we have requested.

Status

Plan – Mature

Implementation – In progress

Outstanding RFI's – 1

Overall Status – Open

**CAIB Recommendation 6.3-2 – National Imagery and Mapping Agency Memorandum of Agreement**

*Modify the Memorandum of Agreement with the National Imagery and Mapping Agency to make the imaging of each Shuttle flight while on orbit a standard requirement.*

RTF TG Interpretation

There was considerable public discussion of the decision during the flight of the Columbia to forego requesting the assistance of other federal agencies in assessing the condition of the Space Shuttle. In addition to changes in the Mission Management Team (MMT) discussed above, the CAIB wanted the Space Shuttle Program to have the procedures in place to get all possible data to investigate a potential problem.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

Per agreement with other federal agencies, NASA is seeking all available data that may in the future assist in the resolution of investigations. Plans for all required activities, communications, personnel security access, training, physical receipt and proper storage of classified material, hardware and software to analyze the data, are in place. The capability has been and will continue to be demonstrated in various stages during MMT simulations.

An engineering test of equipment, including an end-to-end system simulation involving participating personnel, has been conducted. Over 70 percent of the necessary security clearances are in place.

Final implementation details have been worked out in a lower level memorandum of understanding.

Assessment

The RTF TG has accepted NASA's documentation they have met the intention of the CAIB for this recommendation. This recommendation was conditionally closed via public meeting in April 2004. NASA has met all the conditions imposed by the RTF TG.

Future

No further work is required.

Status

This recommendation is fully closed.

**CAIB Recommendation 6.4-1 – Thermal Protection System Inspection and Repair**

*For missions to the International Space Station, develop a practicable capability to inspect and effect emergency repairs to the widest possible range of damage to the Thermal Protection System, including both tile and Reinforced Carbon-Carbon, taking advantage of the additional capabilities available when near to or docked at the International Space Station.*

*For non-Station missions, develop a comprehensive autonomous (independent of Station) inspection and repair capability to cover the widest possible range of damage scenarios.*

*Accomplish an on-orbit Thermal Protection System inspection, using appropriate assets and capabilities, early in all missions.*

*The ultimate objective should be a fully autonomous capability for all missions to address the possibility that an International Space Station mission fails to achieve the correct orbit, fails to dock successfully, or is damaged during or after undocking.*

RTF TG Interpretation

RTF TG Technical and Operations Panel members conducted fact-finding with former CAIB members on this issue in January 2004. Based on these discussions, the RTF TG members interpret "practicable capability" to mean "feasible," and "widest range of damage" to mean "widest range predicted by the Space Shuttle Program (SSP)."

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

NASA is striving to develop a plan for inspection and repair during Shuttle missions. In addition to the vehicle modifications to reduce the risk of critical debris and improved camera coverage discussed elsewhere in this document, NASA is taking the following steps:

- In order to determine the status of the Thermal Protection System (TPS) on orbit, NASA is adding Wing Leading Edge (WLE) impact sensors for debris detection.
- NASA has the ability to do on-orbit surveys of the TPS using the Shuttle Remote Manipulator System (SRMS) and the Space Station Remote Manipulator System cameras.
- NASA is developing the Orbital Boom Sensor System (OBSS) which is intended to allow for high resolution damage inspection on the Orbiter TPS. The OBSS will consist of a 50-foot extension to the SRMS and a dual senor system attached to the end of this boom. Custom software will be developed to aid in 3-Dimensional image resolution.
- NASA has the ability to implement International Space Station (ISS) crew observations during Shuttle approach and docking.
- Techniques for providing a limited level of repair capability for tile and Reinforce Carbon-Carbon (RCC) by extravehicular activity are under development.

NASA has defined preliminary critical damage inspection criteria that form the basis for TPS inspection and repair development work. Detailed criteria are evolving based on ongoing tests and analyses. The OBSS project is currently developing a sensor system that will be flown to inspect the WLE and nose cap. The OBSS sensor system will be used on the first two flights and be available for subsequent flights.

Maneuvers have been developed to position the Orbiter to enable ISS crew members to inspect the tile on the underside of the Orbiter before docking and to position the Orbiter for TPS repairs while docked to the ISS.

The RCC repair project is pursuing several repair concepts. A selection will be made by January 7, 2005, on which concept(s) will be used for STS-114. Current RCC potentially viable repair concepts being developed include plug repair (intended to address medium-sized holes in the WLE from 1 inch to 4 inches in diameter), crack repair (intended to fill cracks and missing coating areas in the WLE), and a flexible patch which could be directly applied over cracks and holes found on RCC panels.

Tile repair is focusing on developing credible tile repair processes and materials. During integrated testing between the repair material and the applicator hardware, instances of foaming or bubbling were experienced when the repair material was applied in a vacuum. The SSP has concerns that this will lead to small voids in the repair material in the microgravity environment. Testing and analysis planned for early 2005 will assess the impact of small voids in a repair during simulated entry conditions.

NASA is also developing a methodology to support decisions concerning where and when damage operations should be undertaken. This methodology will make use of historical data, mathematical and simulation analyses, and specific ground tests to simulate damage during re-entry. Model validation and correlation continues to be an issue of discussion within the Program.

Assessment

*Inspection*

An enormous amount of work has been accomplished concerning the development of timelines that support the collection of on-orbit inspection data. On the second day of flight, a full scan of the WLE and nose cap will be accomplished using the OBSS. On Flight Day 3, an R-bar pitch maneuver will be used to permit digital photography of the tile acreage by the ISS crew. On Flight Day 4, focused inspections will be implemented as required. Training is progressing and reports have been positive from the Shuttle and ISS crews, flight controllers, and the SSP. The OBSS has successfully completed modal testing and tests with the development units have shown resolution down to 0.02 inches. Qualification of the system is underway. Further testing may be required to establish the capability to discriminate between critical and non-critical damage.

*Tile and RCC Repair*

NASA has been pursuing multiple options for each RCC repair and tile repair and has made substantial progress in developing several concepts. There have been several challenges in both areas and a substantial amount of testing continues in order to characterize critical aspects of various repair options. Acceptance criteria for repair options have not yet been baselined for either RCC or tile repair, but are waiting on further capability testing.

NASA plans to down select among the RCC repair options to one best option. NASA also plans to down select among the tile repair options to one best approach to tile repair. Further work will be required by NASA to identify damage sizes that the selected repair options will be able to address. Also needed are guidelines for when to repair versus when to return with damaged tile.

Operations planning for repair is not well established due to the immature status of the technologies. However, operations plans are being worked in parallel with development activities to support numerous options being considered during mandated down select.

*Integrated Planning*

The SSP has published several versions of the STS-114 Operations Integration Plan (OIP) for TPS assessment developed by the Shuttle Engineering and Integration Office. The latest version, published in November 2004, includes an Annex that covers the Orbiter damage assessment process. See Integrated Vehicle Assessment on Page 64 for complete discussion.

<u>Future</u>

*Inspection*

NASA will continue to develop OBSS hardware and operational procedures. In addition, NASA will continue to develop WLE impact sensors.

*Tile and RCC Repair*

NASA needs to take a hard look at the risks associated with the RCC and tile repair options, address the concerns enumerated above, and weigh its options against the associated advantages.

<u>Status</u>

Plan – Orbiter maneuvers for inspection and repair and the TPS Readiness Determination Operations Concept are maturing. OBSS and WLE plans are in development. RCC repair and tile repair plans are in development.

Implementation – In progress where plan is defined. Baseline TPS OIP including its Damage Annex is under configuration management.

Outstanding RFI's – 9

Overall Status – Open

## CAIB Recommendation 9.1-1 – Detailed Plan for Organizational Change

*Prepare a detailed plan for defining, establishing, transitioning, and implementing an independent Technical Engineering Authority, independent safety program, and a reorganized Space Shuttle Integration Office as described in R7.5-1, R7.5-2, and R7.5-3. In addition, NASA should submit annual reports to Congress, as part of the budget review process, on its implementation activities.*

<u>RTF TG Interpretation</u>

The three specific recommendations—organizational changes to be incorporated in the plan—are addressed separately below. The Management Panel believes that embodied in Recommendation 9.1-1, however, are the many less tangible issues raised by the CAIB, including "culture." CAIB used the term "culture" liberally in its report although there are neither specific recommendations to change culture nor any suggestions on how it might be accomplished. Therefore "culture" is not specifically a return to flight issue. Nonetheless, the Management Panel has kept abreast of NASA's initiatives to institute cultural change.

<u>Assessment</u>

NASA has committed to strict compliance to create the "independence" and "integration" called for by the CAIB. NASA has also responded in ways not suggested or otherwise required by the CAIB Report. For example, the Director of the Goddard Space Flight Center has conducted an analysis of the applicability of the CAIB recommendations to the rest of NASA—the Diaz Team Report. In addition, NASA has employed Behavioral Science Technology, Inc. (BST) to assess the attitudes of NASA personnel and suggest a plan to institute change, with assessments along the way. BST has reported substantial progress, based on the criteria they established, for the NASA Centers where they have initiated training. Figure 11 illustrates the many initiatives underway to measure, change, and monitor "culture." NASA views this cultural change effort as "…an integration point to ensure that all the Agency's ongoing efforts related to culture change are aligned in a manner conducive to a comprehensive culture change."

<u>Future</u>

The Management Panel expects an interim report on NASA's activities for cultural change sometime before the next plenary, currently scheduled for March 2005. The panel expects to receive an updated version of NASA's "9.1-1 Plan" as referenced in the NASA Implementation Plan.

<u>Status</u>

Plan – Undergoing revision

Implementation – In progress

Outstanding RFI's – 4

Overall Status – Open

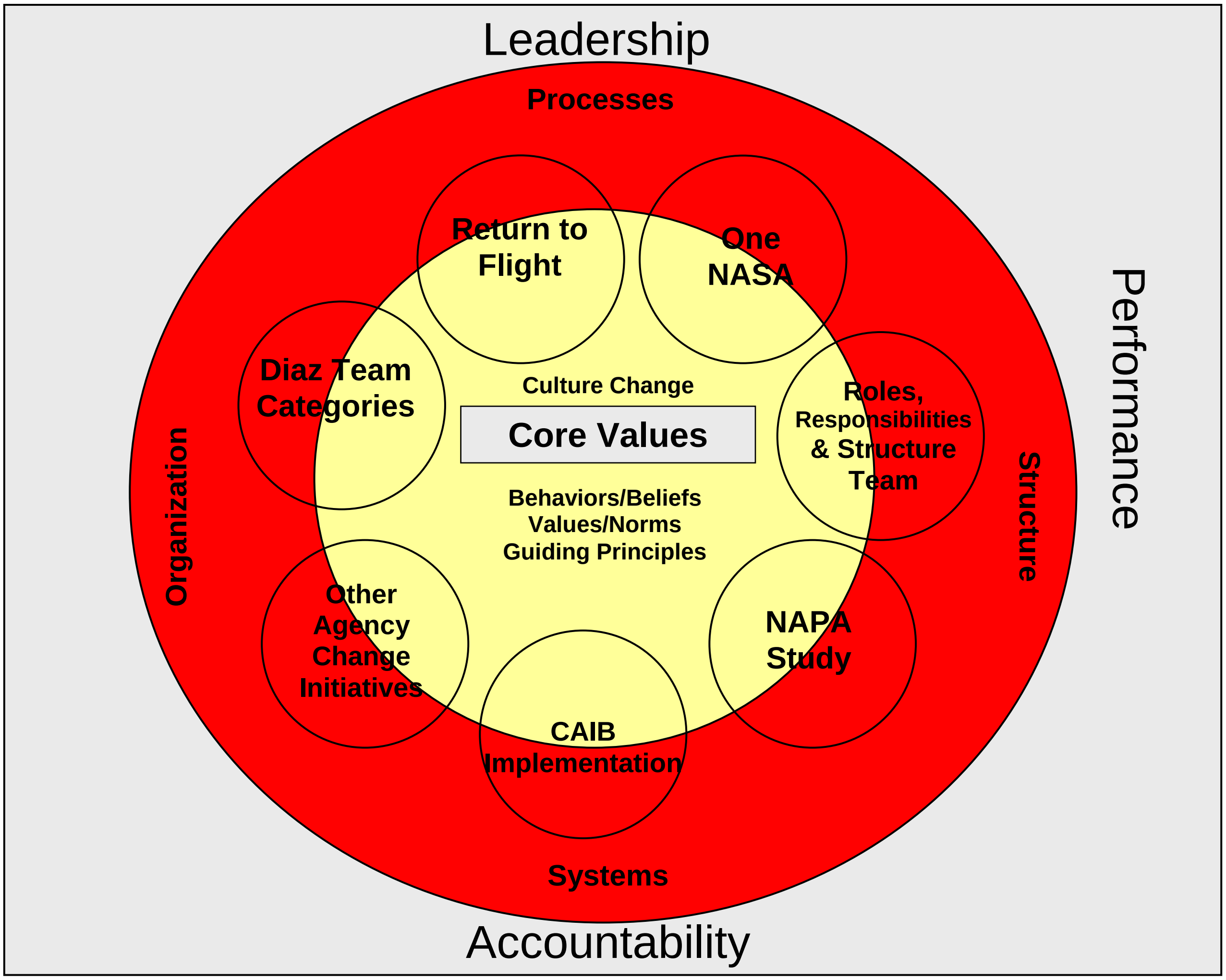



Figure 11 – NASA Culture Change (NASA)

**CAIB Recommendation 7.5-1 – Independent Technical Engineering Authority**

*Establish an Independent Technical Engineering Authority that is responsible for technical requirements and all waivers to them, and will build a disciplined, systematic approach to identifying, analyzing, and controlling hazards throughout the life cycle of the Shuttle System. The independent technical authority does the following as a minimum:*

- *Develop and maintain technical standards for all Space Shuttle Program projects and elements*
- *Be the sole waiver-granting authority for all technical standards*
- *Conduct trend and risk analysis at the sub-system, system, and enterprise levels*
- *Own the failure mode, effects analysis and hazard reporting systems*
- *Conduct integrated hazard analysis*
- *Decide what is and is not an anomalous event*
- *Independently verify launch readiness*
- *Approve the provisions of the recertification program called for in Recommendation R9.1-1*

*The Technical Engineering Authority should be funded directly from NASA Headquarters, and should have no connection to or responsibility for schedule or program cost.*

<u>RTF TG Interpretation</u>

Many of the CAIB's Space Shuttle Program (SSP) organization observations are reflected in this recommendation. The CAIB observed critical technical requirements are routinely waived. The CAIB concluded the inherent conflicts of schedule, cost, and safety—the balance for which resided essentially with the Shuttle Program Manager—need to be separated to provide safety an independent consideration.

There are several CAIB findings relevant to this recommendation:

**F7.4-2** *Safety and Mission Assurance organizations supporting the Shuttle Program are largely dependent upon the Program for funding, which hampers their status as independent advisors.*

**F7.4-4** *System safety engineering and management is separated from mainstream engineering, is not vigorous enough to have an impact on system design, and is hidden in the other safety disciplines at NASA Headquarters.*

**F7.4-12** *The dependence of Safety, Reliability & Quality Assurance personnel on Shuttle Program support limits their ability to oversee operations and communicate potential problems throughout the organization.*

It should be noted that while this recommendation (R7.5-1) calls for the establishment of the Independent Technical Engineering Authority (ITEA), the CAIB has not identified it as a return to flight requirement. R9.1-1 is a return to flight requirement, but only for the creation of a detailed plan for defining, establishing, transitioning, and implementing an ITEA. In discussion with the RTF TG, the CAIB Chair (Admiral Gehman) stated this position was taken with the understanding that full and effective implementation of R7.5-1 (as well as R7.5-2 and R7.5-3) would require a considerable time. Therefore, prior to return to flight, a well-defined plan would suffice. With the change in schedule, however, NASA has committed to implement significant portions of the plan with an eye toward handing off selected program activities to the Independent Technical Authority (ITA) before the next flight.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

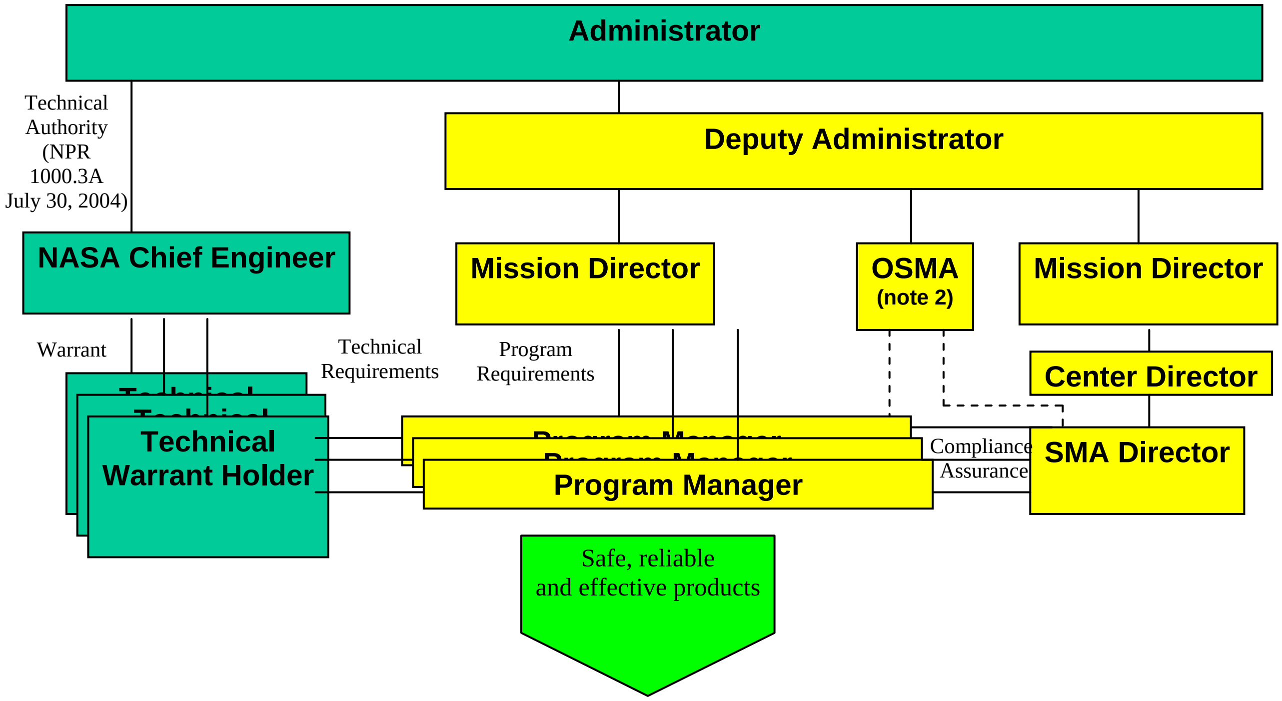
NASA is implementing an ITA which has the responsibility, authority and accountability to establish, monitor and approve technical requirements, products and safety. The NASA Chief Engineer, as the ITA, will govern and be accountable for technical decisions that affect safe and reliable operations and will use a warrant system to further delegate this technical authority (Figure 12). The Technical Warrant Holders will be proven subject matter experts with mature judgment who will operate with a technical authority budget that is independent from Program budgets and Program authority.

In the role of ITA, the NASA Chief Engineer also is charged with developing a technical conscience throughout the engineering community, that is, the personal responsibility to provide safe technical products coupled with an awareness of the avenues available to raise and resolve technical concerns.

The five key principles which govern the ITA are:

1. Must reside in an individual, not an organization;
2. Is clear and unambiguous regarding authority, responsibility, and accountability;
3. Is independent of Program Management;
4. Is executed using credible personnel, technical requirements, and decision-making tools; and
5. Makes and influences technical decisions through prestige, visibility, and the strength of technical requirements and evaluations.

# Technical Authority Flow




Notes: 1) Technical Authority flow for the NASA Chief Health and Medical Officer, as the NASA Technical Authority for all health and medical requirements, is similar to that of the Chief Engineer.
2) The NASA Chief Safety and Mission Assurance Officer, as head of the OSMA, is accountable to the Deputy Administrator for providing leadership, policy direction, functional oversight, assessment and coordination for all Safety Assurance and Mission Assurance processes and products.

Figure 12 – Technical Authority Flow (NASA)

The NASA Engineering and Safety Center (NESC) was conceived by the Administrator before finalization of the CAIB report, was chartered in the fall of 2003 and formally opened its doors on November 1, 2003. Initially, the NESC reported to the Chief of the Office of Safety and Mission Assurance (SMA) at Headquarters but was subsequently reassigned to the Chief Engineer. The NESC will provide support to the Chief Engineer to perform ITA activities as well as house many of the warrant holders.

Assessment

The Management Panel has concluded the current construct of the ITA meets the intent of the CAIB recommendation. Several panel members remain concerned the CAIB may have overstated the desirability of ITA's independence from the SSP and caution that the implementation not dilute the Shuttle Program Manager's ability to manage the Program nor confuse the Program's responsibility to produce a safe vehicle.

Future

The primary activity required before closure is the thorough and correct documentation of the ITA, its role and responsibilities, and its interface with SMA and System Engineering and Integration Office. In addition, NASA needs to determine the new ITA's role in return to flight. Finally, a report on the implementation of the waiver process and any waivers issued in the immediate future should be incorporated.

Status

Plan – Maturing

Implementation – Underway

Outstanding RFI's – 1

Overall Status – Open subject to documentation.

**CAIB Recommendation 7.5-2 – Safety and Mission Assurance Organization**

*NASA Headquarters Office of Safety and Mission Assurance should have direct line authority over the entire Space Shuttle Program safety organization and should be independently resourced.*

RTF TG Interpretation

The CAIB observed various parts of NASA were nominally responsible for "safety"; each NASA Center has safety organizations; each NASA program, including the Space Shuttle Program (SSP), has designated individuals responsible for safety; and, NASA has an Office of Safety and Mission Assurance (SMA) at Headquarters. This recommendation is intended to create clear lines of authority, responsibility and communication, and to help ensure independence of safety assurance by moving funding from the NASA Centers and programs to NASA Headquarters.

Among the CAIB findings supporting this recommendation is:

**F7.4-1** *The Associate Administrator for Safety and Mission Assurance is not responsible for safety and mission assurance execution, as intended by the Rogers Commission, but is responsible for Safety and Mission Assurance policy, advice, coordination, and budgets. This view is consistent with NASA's recent philosophy of management at a strategic level at NASA Headquarters but contrary to the Rogers' Commission recommendation.*

**F7.4-2** *Safety and Mission Assurance organizations supporting the Shuttle Program are largely dependent upon the Program for funding, which hampers their status as independent advisors.*

**F7.4-12** *The dependence of Safety, Reliability & Quality Assurance personnel on Shuttle Program support limits their ability to oversee operations and communicate potential problems throughout the organization.*

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

Independent safety organizations, which will report to Center Directors, have been established at all (space flight) Centers. The Chief SMA Officer (a Headquarters position) has explicit authority over selection, relief, and performance evaluation for key safety personnel at the Centers, the lead SMA managers for major programs including Space Shuttle and International Space Station, and the Directors of the Independent Verification and Validation Center, and is a voting member of the Institutional Council (a Headquarters committee that allocates overhead funding). The Chief of SMA also will provide a formal "functional performance evaluation" for each Center Director to their Headquarters Center Executive each year. Delegated to the Center Directors and their SMA Directors is "suspension authority," which applies to any program, project, or operation conducted at the Center or under that Center's oversight, regardless of whether the Center also has programmatic responsibility for that activity.

The Headquarters Office of Safety and Mission Assurance is also developing an enhanced process for review and assessment and a capability for performing more in depth compliance audits with requirements that are critical for safety and mission success.

With regard to the CAIB concern of lack of mainstreaming of system safety engineering, the SMA audit plan will include as assessment of the adequacy of system safety engineering by the audited project and/or line engineering organizations. Regarding the CAIB concern of lack of system safety visibility, the SMA has brought on a full-time experienced System Safety Manager who will be the Agency's dedicated senior system safety engineering policy expert.

Assessment

The CAIB was concerned about independence of the various NASA safety organizations, just as it was with the independence of technical authorities. The principal criteria for independence, in their view, was the source of funding; i.e., funding should not be controlled by the SSP. NASA has removed funding decisions from the Program and established service pools at each Center which will be used to fund the safety organizations. While the funds will be derived from the Program's budget (in order to maintain the principles of full-cost accounting), the Shuttle Program Manager will not control the amount or disbursement of the funds.

The CAIB also called for the Headquarters Chief of SMA to have "direct line authority over the entire SSP safety organization." The Chief of SMA has persuasively argued that the new personnel powers over hiring, retention, and annual performance reviews is sufficient for central control while keeping the Center Directors (to whom the SMA Directors will still report) directly responsible for maintaining safe operations.

NASA has initiated several actions to provide new incentives for personnel to join SMA organizations, once considered to be less desirable than line positions. Most notable is the new option for Senior Executive Service candidates to serve in SMA at their respective Centers rather than serve a temporary stint at another NASA Center.

Future

Just as with the documentation for Recommendation 7.5.1, the new SMA configuration needs explication, clarification, and correction. The Management Panel also believes the audit function of Headquarters SMA should be clarified (and enhanced) in order to ensure the continuation of independent (and competent) safety assessments. Any plans to do so should be included.

Status

Plan – Maturing

Implementation – In progress

Outstanding RFI’s – 1

Overall Status – Open subject to documentation.

**CAIB Recommendation 7.5-3 – Space Shuttle Integration Office Reorganization**

*Reorganize the Space Shuttle Integration Office to make it capable of integrating all elements of the Space Shuttle Program, including the Orbiter.*

RTF TG Interpretation

The CAIB found several aspects of Space Shuttle operations believed to be suffering from incomplete integration. Perhaps the most glaring was the apparent division of responsibility for addressing separation of foam from the External Tank (ET). Simplistically stated, the Orbiter Project thought it was up to those responsible for the tank to stop the shedding and the Tank Project assumed the shedding occurring was not injurious to the Space Shuttle because no one told them otherwise.

A more concrete example is the inability of various computer systems to share data across the NASA Centers, programs, and even elements within programs. Trends across flights were not thoroughly examined because of both of these reasons: 1) it was thought to be the responsibility of another part of the Space Shuttle operations; and 2) the databases could not be easily shared to perform the analysis.

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

The Space Shuttle Program (SSP) has established the Space Shuttle Systems Engineering & Integration Office (SEIO). This Office was established at the same level of the elements of Shuttle Program (Orbiter, Solid Rocket Booster, Reusable Solid Rocket Motor, Space Shuttle Main Engine, ET, and the Kennedy Space Center (KSC) Launch and Landing Project). The office is to be responsible for systems engineering and integration of flight performance of all Space Shuttle project elements, for all System Integration Plans and all Master Verification Plans and also now includes the Space Shuttle Flight Software organization. These plans have been developed for all major return to flight design changes that impact multiple Shuttle elements. The Office reports directly to the SSP Manager. The Space Shuttle Vehicle Engineering Office became the Orbiter Project Office and its charter has been amended to show that SEIO is now responsible for integrating all flight elements.

NASA has reorganized and revitalized the Integration Control Board (ICB). This board will review and approve recommendations and actions to ensure the appropriate integration of activities in the Shuttle Program. Orbiter changes that affect multiple elements must now go through the ICB process. Orbiter changes for return to flight that affect multiple elements, which were not previously reviewed and approved by the ICB, will be routed from the Program Requirements Control Board back to the ICB for review and approval prior to implementation.

All SSP integration functions at Marshall Space Flight Center, KSC, and Johnson Space Center are now coordinated through and receive technical direction from SEIO. The SEIO is also responsible for the all design certification reviews conducted before return to flight, including element and integrated designs.

Assessment

The Management Panel believes the systems integration function has been restored in a robust fashion, with a rapid buildup of resources and an impressive array of responsibilities. We remain concerned about over-reliance on analytical models in the return to flight efforts and caution against dependence on results that are not validated. We also note, as did Aerospace in an audit earlier this year, the lack of documentation of the SEIO imperils its future. Without adequate documentation, the integration function can too easily atrophy as it had in the recent past.

Future

In response to the need for documentation, the SEIO developed a plan to create proper materials. Much of the activity is scheduled for after return to flight, although some basic documents should be produced prior to that time. The following chart (Figure 13) details the proposed work and schedule. The Management Panel expects to receive everything scheduled through and including March 1. In addition, if it is not part of these documents, the Management Panel requires a clear and complete statement of role and responsibilities. Our concern is that before return to flight, others involved in the next flight need to understand the responsibilities being assumed by SEIO and how the interfaces are expected to operate.

Status

Plan – Incomplete

Implementation – In progress

Outstanding RFI's – 1

Overall Status – Open subject to documentation.

SEIO Management Plan Development
Schedule

| | |
|---|---|
| 1.0 Introduction: Background, Purpose and Scope, MS Charter, Mgmt. Plan Documentation Control | January 15, 2005 |
| 2.0 Space Shuttle System Engineering & Integration Office Overview: Goals & Objectives, Management Plan Documentation Requirements | February 1, 2005 |
| 3.0 Space Shuttle System Engineering & Integration Office Organization, Interfaces, Processes & Reporting: Organization & Interfaces, MS1, MS2, MS3, MS4 Tasks, Responsibilities, Processes, Requirements, Products, Services… | April 1, 2005(MS1)<br>May 1, 2005(MS2)<br>May 1, 2005(MS3)<br>May 1, 2005(MS4) |
| Management and Technical Processes: CoFR Process, Configuration Management Process, Risk Management, Safety Management Process, Management Boards & Technical Integration Groups, Quality System Process, Continuous Improvement, Personnel Training, Technical Processes | March 1, 2005 |
| 4.0 Space Shuttle System Engineering & Integration Office Work Management: Internal Work Process, Contractor Work Process, Contractor PDP, Contractor Surveillance, Flight Preparation Schedule/Template | June 1, 2005 |
| Review, Update, Approval and Signature Cycle | June 1- July 1, 2005 |
| SEIO Management Plan Final Delivery | July 1, 2005 |

Figure 13 – SEIO Management Plan (NASA)

## CAIB Recommendation 10.3-1 – Digitize Closeout Photos

*Develop an interim program of closeout photographs for all critical sub-systems that differ from engineering drawing. Digitize the closeout photograph system so that images are immediately available for on-orbit troubleshooting.*

RTF TG Interpretation

During the investigation, the CAIB encountered numerous engineering drawings that were inaccurate. Further, they discovered that a large number of engineering change orders had not been incorporated into the drawings. Tied in with this, CAIB investigators were not able to access needed closeout photography for several weeks. This resulted in the following finding:

**F10.3-3** *NASA normally uses closeout photographs but lacks a clear system to define which critical sub-systems should have such photographs. The current system does not allow the immediate retrieval of closeout photos.*

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

The NASA photo closeout team developed a two prong approach to address this recommendation. First, requirements were strengthened and hardware standardized and upgraded to increase the quantity and quality of closeout photographs. Second, the digital archive database, now called the Still Image Management System (SIMS), was modified to provide a user-friendly graphical interface for search and retrieval of images across the Program.

NASA reviewed existing requirements and corrected identified deficiencies. In addition to closeout photo requirements, they added a formal requirement that all Material Review Board (MRB) conditions are photographed and included in the SIMS. MRB conditions are hardware discrepancies that cannot be returned to original design specifications. Quality documentation has been updated to incorporate revised requirements. High resolution digital cameras were procured and will be used for all closeout and MRB imagery. Training and certification, as required, have been developed and implemented to ensure the new requirements are met. Continuous audits of imagery will maintain consistent quality standards.

SIMS has been designed to include a drill-down capability which facilitates image searches. Hardware reference drawings were added to help users identify hardware locations by zones. Computer-based training modules have been developed to ensure users understand full capabilities of the new system.

Assessment

Photographs have been archived by Kennedy Space Center (KSC) for closeout and significant configuration changes in a database throughout the Program. This database was primarily used by the KSC engineering community and searches were made based on the work authorization document that requested the photograph. Previously, thorough knowledge of the availability of this data was not adequate to ensure use during real-time mission operations. A large number of non-standardized cameras were used resulting in arbitrary resolution of critical images.  In addition, there were no clear requirements to photograph all critical closeouts or MRB images which indicate changes to the configuration.  Since drawing updates take some time, these images became much more critical during mission evaluation of Orbiter configuration.

RTF TG Operations Panel experts concluded fact-finding concerning the SIMS database in two separate instances early in 2004.  These efforts complemented previous meetings with KSC staff and their contractors to review their response to the CAIB recommendation in 2003.  New standardized 6.1 megapixel cameras have been selected for use in closeout and configuration photography.  Generic and return to flight-specific closeout photo requirements have been obtained from program elements and documented.  Photography of areas already closed has been deemed adequate.  NASA has identified which SIMS enhancements were required and necessary upgrades are complete.  Updated training material has been developed for users of the SIMS database and users have or will receive training at KSC, Johnson Space Center, and Marshall Space Flight Center from local trainers.  The training staffs at these centers have completed this training.  Through several integrated launch countdown simulations, the Space Shuttle Program staff has confirmed the modifications to the SIMS database satisfy their needs.  This recommendation was conditionally closed via public meeting teleconference in July 2004.  NASA has met all the conditions imposed by the RTF TG.

<u>Future</u>

No further work is required.

<u>Status</u>

This recommendation is fully closed.

**SSP-3: Space Shuttle Program Action – Contingency Shuttle Crew Support**

*NASA will evaluate the feasibility of providing contingency life support on board the International Space Station (ISS) to stranded Shuttle crew members until repair or rescue can be accomplished.*

RTF TG Interpretation

Although not a specific recommendation by the CAIB, the possibility of rescue or repair once a Shuttle is launched is discussed in two sections in the CAIB Report. Section 6.4 of the CAIB report explores the possibility of repairing damage to a Reinforced Carbon-Carbon panel or tile on orbit via a "space walk." The same section assesses the possibility of rescuing a crew by launching another Shuttle. Section 9.1 of the CAIB Report lists, as one of several necessary measures for safe flight, the exploration of "all options for survival, such as provisions for crew escape systems and safe havens."

NASA Implementation Plan (December 3, 2004, Volume 1, Revision 3)

NASA is evaluating the feasibility of providing contingency life support on board the ISS to stranded Shuttle crew members until repair or rescue can be affected. The idea of Contingency Shuttle Crew Support (CSCS) capability has evolved from best-effort basis to a concrete contingency rescue plan (backup Shuttles for STS-114 and STS-121). The Launch On Need (LON) capability established for the first two missions will not modify the ground processing requirements in existence today. An accelerated schedule will be used to meet the NASA-imposed requirement for no gap to exist between ISS capability to accommodate both crews and LON Shuttle arrival at ISS. CSCS is deemed a secondary risk control and will not impose additional requirements for fault tolerance than currently exist.

NASA's Mission Operations Directorate has developed a comprehensive plan to undock a stranded Orbiter and return it unmanned into an uninhabited oceanic area.

NASA has developed a robust analysis of ISS system support for a "safe haven" crew mix with all available consumables to provide an estimate for maximum available CSCS duration. This analysis identifies both a best and worst-case estimate, as well as the engineering estimate to be used for the launch decision. This estimate takes into consideration credible failures that would impact duration without being overly conservative.

A Memorandum of Agreement has been documented between the Shuttle and ISS Programs to document their respective responsibilities with respect to CSCS.

Assessment

Prudently, NASA has developed analyses and plans so that CSCS will offer a viable emergency capability for crew rescue. CSCS is not a certified capability with redundancy and cannot justify flying a Shuttle otherwise deemed unsafe. Given NASA's determination that CSCS is an emergency plan of last resort, NASA has pursued development of this capability appropriately. It has developed a robust analytic methodology for estimating the available CSCS duration at the time of launch.  For the next two flights (STS-114 and STS-121), NASA has committed to ensuring that a rescue Shuttle (STS-300 and STS-301) can be launched if needed.  Procedures and training have been developed demonstrating NASA's capability to safely de-orbit the stranded Orbiter.

Future

NASA is currently working to incorporate CSCS plans and analysis into its prelaunch process and into mission management decision-making during flight.

Status

Plan – Analysis is mature; Processes and decision tree are evolving

Implementation – In progress

Outstanding RFI's – 9

Overall Status – Open

**Integrated Vehicle Assessment**

The RTF TG established this sub-panel to combine the insights from the Operations, Technical, and Management Panels to assess NASA's ability to perform an integrated vehicle external damage assessment in support of decision-making during launch and flight. The Integrated Vehicle Assessment Sub-Panel (IVASP) charter is focused on a subset of the recommendations:

- 3.2-1 External Tank Debris Shedding
- 3.3-2 Orbiter Hardening
- 3.4-1 Ground-based Imagery
- 3.4-2 Hi-resolution Images of External Tank
- 3.4-3 Hi-resolution Images of Orbiter
- 6.4-1 Thermal Protection System (TPS) Inspection and Repair
- 6.3-1 Mission Management Team (MMT) Improvements
- SSP-3 Space Shuttle Program (SSP) Action - Contingency Shuttle Crew Support

In addition to these unclassified actions, two members of this sub-panel will review the operational aspects of NASA's response to CAIB recommendation to modify the Memorandum of Agreement with the National Imagery and Mapping Agency (6.3-2).

(NOTE: This Sub-Panel is not a CAIB recommendation or a return to flight CAIB requirement.)

The purpose of the Sub-Panel is to assess NASA's process development to obtain and integrate external ascent damage data, which is mostly imagery. Historically, ascent imagery has never been a factor in decision making within NASA Shuttle missions. Those data are then translated into integrated vehicle assessments that are based on a variety of data sources, in direct support of the decision-making process for real-time Shuttle operations.

RTF TG Interpretation

Related CAIB recommendations must be integrated. This integration not only serves to assure adequate response to the individual CAIB items, but assures the full exploration by NASA of the intent of the CAIB phraseology "to the extent practicable," particularly in the areas of data acquisition, handling, and integration for management decision-making for TPS risk management.

NASA Implementation Plan

Plans for the integration of CAIB recommendations are not specifically included in the current NASA Implementation Plan. However, the following are recent NASA activities in the areas of the CAIB recommendations covered in the IVASP charter.

The SSP has published several versions of the STS-114 Operations Integration Plan (OIP) for TPS assessment. The latest version, published November 15, 2004, includes an Annex that covers the Orbiter damage assessment process. As stated in the plan, "the OIP is the agreement on the responsibilities and tasks which directly relate to the integration activities associated with the successful system engineering, integration, and verification of the Space Shuttle return to flight activities associated with the assessment of the TPS. These operations are intended to provide the processes for transforming data from the TPS assessment systems into information that can be used by SSP MMT to make a timely TPS entry readiness, repair, or safe haven determination."

As part of this development process, the OIP development team has conducted many paper simulations of different components of the process. NASA has used the results of these simulations to inform the development process and have revised their plans accordingly. In November 2004, they included a TPS assessment scenario in a MMT simulation.

To support the OIP, NASA has developed several new analysis tools. Some of these tools are modifications of existing models that allow them to take advantage of the new information that will be available as a result of the return to flight initiatives. Some of these tools are designed to compile, organize, and present the large amount of data that will be available from the many cameras and sensor systems that are baselined for STS-114. All of this information will be available to the decision makers through a web-based display tool.

Assessment

The OIP is becoming mature. Beginning from scratch, NASA has evolved a process that holds the promise of integrating a variety of new and disparate types of data into information that can support complex decision making during a Shuttle flight. To accomplish this, the developers had to work across NASA boundaries to identify the best organization to be the "data supplier." The responsibility for each data source was established. The OIP team had to secure commitments from these organizations to produce data analysis reports on a specified timeline and to share those reports through the OIP. They have also identified and established new positions of authority required to set priorities on data collection and analysis to meet emerging real-time needs. The NASA team will conduct an aggressive training plan that will exercise each component of the assessment process in the planned "component sims," and ultimately in the MMT's, by the use of these "component sims" sub-processes.

Finally, they are fully documenting the process so it can be evolved as the data sources change, studied by new participants in the process, and evaluated by outside observers such as IVASP. These fully documented processes are also under configuration management of the Program Requirements Control Board and will be approved by both the System Engineering and Integration Office (SEIO) and SSP Managers. This is a very significant development that has occurred since the Second Interim Report in April 2004.

There are still some important unknowns to be answered before OIP can be completed. For example, NASA must complete its critical damage and critical debris assessments, which are being done under CAIB Recommendation 6.4-1. These results are central to all the analyses conducted as part of the OIP. The NASA Operations Team needs to exercise the process until they are comfortable with the evolution of the formats of those data they have developed, the amount of data they will be managing, and, most significantly, the prioritization of decisions they will have to make to effectively analyze the most relevant information as events unfold. NASA needs to be certain that all of the roles and responsibilities of the many participants in the process are clearly understood and accepted throughout the debris/damage community. The IVASP will continue to assess the OIP as it evolves though the remaining simulations planned.

<u>Future</u>

The Sub-Panel recognizes the OIP will continue to mature. As the NASA Process Development Team learns more about those data received, its utility, and the decisions they will need to support, they will evolve their processes and analysis tools into a robust, integrated operational process. The IVASP believes that the accomplishments of the OIP Development Team, and the TPS OIP could serve as a model for tackling other integration challenges that NASA faces on the Shuttle Program.

NASA needs an ability to manage risk during a Shuttle flight. The CAIB recommendations identified specific data necessary to better understand the risk to the Orbiter of a debris impact. The OIP was developed to integrate data from the new data sources developed for return to flight. The IVASP sees OIP as having potential that goes beyond the specific TPS assessment sources developed for STS 114. It represents an approach that pulls information together from across NASA work-group boundaries into a consolidated, integrated "whole." There will likely be other anomalous situations during flight where such an approach could help the decision makers assess and manage risk.

The Sub-Panel has conducted several fact-finding meetings with the developers. We have also observed some of the paper sims and the November MMT. For each major revision of the OIP, IVASP has provided the authors comments and feedback on the plan. The future fact-finding sessions and the support of the "component sims" will be coordinated with the Technical and Operations Panels to assure adequate coverage.

The Sub-Panel recommends that the OIP development process be maintained and even expanded, after the flight tests of STS-114 and STS-121. This approach should be used as a model for cross-NASA information integration in support of complex risk-intensive management decisions. This model certainly applies to future tasks where SEIO has total systems integration responsibility that translates into the ownership of the Mission Evaluation Room functionality and its interface to the Mission Control Center, which is owned by SSP.

<u>Status</u>

Plan – In work. The process and associated tools will be assessed as part of the integrated closure criteria for R6.4-1 and R6.3-1 against the criteria set by R3.2-1 and R3.3-2.

Implementation – Baseline process in TPS OIP including its Damage Annex is under configuration management.

Outstanding RFI's – None

Overall Status – Significant progress since last Interim Report.

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# Appendix A - Return to Flight Task Group Charter

## ESTABLISHMENT AND AUTHORITY

The NASA Administrator, having determined that it is in the public interest in connection with performance of the Agency duties under the law, and with the concurrence of the General Services Administration, establishes the NASA Return to Flight Task Group, pursuant to the Federal Advisory Committee Act (FACA), 5 U.S.C. App. §§ 1 et seq.

## PURPOSE AND DUTIES

1. The Task Group will perform an independent assessment of NASA's actions to implement the recommendations of the Columbia Accident Investigation Board (CAIB), as they relate to the safety and operational readiness of the next flight. As necessary to its activities, the Task Group will consult with former members of the CAIB.
2. While the Task Group will not attempt to assess the adequacy of the CAIB recommendations, it will report on the progress of NASA's response to meet the intent.
3. The Task Group may make other such observations on safety or operational readiness, as it believes appropriate.
4. The Task Group will draw on the expertise of its members and other sources to provide its assessment to the Administrator. The Task Group will hold meetings and make site visits as necessary to accomplish its fact-finding. The Task Group will be provided information necessary to perform its advisory functions, including activities of both the Agency and its contractors.
5. The Task Group will function solely as an advisory body and will comply fully with the provisions of the FACA.

## ORGANIZATION

The Task Group is authorized to establish panels in areas related to its work. The panels will report findings and recommendations to the Task Group.

## MEMBERSHIP

1. In order to reflect a balance of views, the Task Group will consist of non-NASA employees and one NASA non-voting, ex officio member, the Deputy Associate Administrator for Safety and Mission Assurance. In addition, there may be associate members selected for Task Group panels. The Task Group may also request appointment of consultants to support specific tasks. Members of the Task Group and panels will be chosen from among industry, academia, and Government with recognized knowledge and expertise in fields relevant to safety and space flight.

2. The Task Group members and the co-chairs of the Task Group will be appointed by the

Administrator. At the request of the Task Group, associate members and consultants will be appointed by the Associate Deputy Administrator (Technical Programs).

**ADMINISTRATIVE PROVISIONS**

1. The Task Group will formally report its results to NASA on a continuing basis at appropriate intervals, including a final written report.
2. The Task Group will meet as often as required to complete its duties and will conduct at least two public meetings. Meetings will be open to the public, except when the General Counsel and the Agency Committee Management Officer determine that the meeting or a portion of it will be closed pursuant to the Government in the Sunshine Act or that the meeting is not covered by FACA. Panel meetings will be held as required.
3. The Executive Secretary will be appointed by the Administrator and will serve as the Designated Federal Officer.
4. The Office of Space Flight will provide technical and staff support through the Task Group on International Space Station Operational Readiness. The Office of Space Flight will provide operating funds for the Task Group and panels. The estimated operating costs total approximately $2 million, including 17.5 work years for staff support.
5. Members of the Task Group are entitled to be compensated for their services at the rate equivalent to a GS 15, step 10. Members of the Task Group will also be allowed per diem and travel expenses as authorized by 5 U.S.C. § 5701 et seq.

**DURATION**

The Task Group will terminate two years from the date of this charter, unless terminated earlier or renewed by the NASA Administrator.

_______________________________________ ______________________

Sean O'Keefe (signature on file at NASA Headquarters) Date
Administrator

# Appendix B - RTF TG Membership

## Co-Chairman of the Return to Flight Task Group

Lt. Gen. Tom Stafford USAF (Ret), Chairman, NASA Advisory Council Task Force on International Space Station Operational Readiness (Stafford Task Force), President, Stafford, Burke & Hecker Inc., Astronaut (Gemini 6A, Gemini 9A, Apollo 10, CDR of the Apollo-Soyuz Test Project)
Mr. Richard Covey, Vice President, Support Operations, Boeing Homeland Security and Services, Astronaut (STS-51I, STS-26, STS-38, and STS-61)

## Task Group Members

Colonel James Adamson, U.S. Army (Ret.), CEO, Monarch Precision, LLC, Astronaut (STS-28 & 43)
Major General William Anders U.S. Air Force (Ret.), Retired Chair and CEO of General Dynamics Corporation, Astronaut (Apollo 8)
Dr. Walter Broadnax, President, Clark Atlanta University
Dr. Kathryn Clark, President Docere Company, Consultant in science and education
Mr. Benjamin Cosgrove, Senior Vice President, Boeing Commercial Airplane Group (Retired)
Dr. Dan Crippen, Former Director of the Congressional Budget Office, Member Aerospace Safety Advisory Panel
Mr. Joe Cuzzupoli, Vice President and K-1 Program Manager, Kistler Aerospace Corporation
Dr. Charles Daniel, Engineering Consultant, Stafford – Anfimov Task Force
Dr. Amy Donahue, Assistant Professor of Public Administration, University of Connecticut, Member Aerospace Safety Advisory Panel
General Ronald Fogleman, U.S. Air Force (Ret.), President and COO of Durango Aerospace Incorporated
Ms. Christine Fox, President, Center for Naval Analyses
Mr. Gary Geyer, Aerospace Consultant, Served for 26 years with the NRO
Colonel Susan Helms, U.S. Air Force, Vice Commander 45th Space Wing, Patrick Air Force Base, Florida, Astronaut (STS-54, STS-64, STS-78, STS-101, and ISS 2)
Mr. Richard Kohrs, Chief Engineer, Kistler Aerospace Corporation
Mrs. Susan Livingstone, Former Under Secretary of the Navy
Mr. James Lloyd (Ex Officio Member), Deputy Chief Safety and Mission Assurance Officer, NASA Headquarters
Lieutenant General Forrest McCartney, USAF (Ret.), Aerospace Consultant, Former Director of Kennedy Space Center
Dr. Rosemary O'Leary, Distinguished Professor of Public Administration, Syracuse University
Dr. Decatur Rogers, Dean, Tennessee State University College of Engineering, Technology and Computer Science
Mr. Sy Rubenstein, Aerospace Consultant, Former President, Rockwell International Space Systems Division
Mr. Robert Sieck, Aerospace Consultant, Former Director of Shuttle Processing, Kennedy Space Center
Mr. Thomas Tate, Retired former Vice President of Legislative Affairs for the Aerospace Industries Association
Dr. Kathryn Thornton, Professor, University of Virginia School of Engineering & Applied Science, Astronaut (STS-33, STS-49, STS-61)
Mr. William Wegner, Consultant, Former Deputy Director to Admiral Rickover in Nuclear Navy Program

## Task Group Support

Executive Secretary: Mr. Vincent Watkins
Astronaut Representative: Col. Michael Bloomfield USAF

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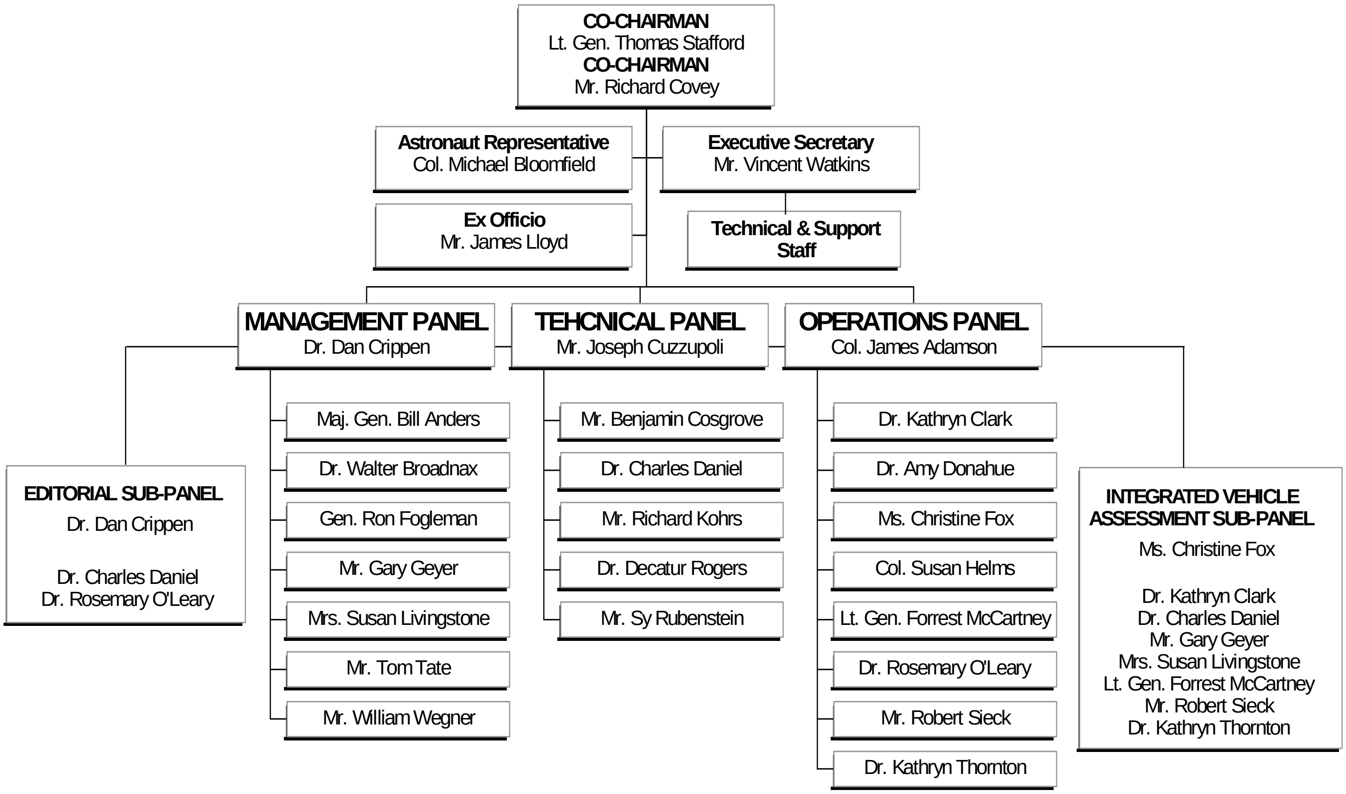
# Appendix C - Return to Flight Task Group Organization



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# Appendix D - RTF TG Fact-Finding Activities

## August 2003

| | |
|---|---|
| August 5-7, 2003 | Kennedy Space Center (KSC), Plenary Session, Public Meeting |
| August 18, 2003 | Johnson Space Center (JSC), NASA-National Imagery and Mapping Agency (NIMA) Memorandum of Understanding (MOU). Mr. Geyer |
| August 19-20, 2003 | JSC discussions with SSPO, USA, and Boeing Management . Dr. Crippen |
| August 21, 2003 | Videoconference, Space Flight Leadership Council (SFLC) Meeting |
| August 25, 2003 | KSC, Ground-based Imagery Discussions. Lt. Gen. McCartney, Mr. Sieck |
| August 27, 2003 | Lockheed Martin Missiles and Fire Control, Dallas, TX, RCC NDE. Technical Panel |
| August 28, 2003 | Michoud Assembly Facility (MAF), New Orleans, LA, External Tank (ET) RTF Status. Technical Panel |

## September 2003

| | |
|---|---|
| September 2, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| September 9, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| September 9-11, 2003 | JSC, Plenary Session |
| September 16, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| September 17, 2003 | House Science Committee (HSC) Members and Senior Staff visit. Mr. Tate, Mr. Covey, and Lt. Gen. Stafford |
| September 18, 2003 | JSC, Extravehicular Activity Tile and Reinforced Carbon-Carbon (RCC) Repair. Mr. Cuzzupoli, Dr. Clark |
| September 23, 2003 | NASA Headquarters. Management Panel |
| September 24, 2003 | KSC, Foreign Object Debris (FOD) and Non-Destructive Evaluation (NDE). Lt. Gen. McCartney, Mr. Sieck |
| September 28, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| September 30, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| September 30, 2003 | MAF, New Orleans, LA, ET RTF Status. Mr. Kohrs and Dr. Rogers |

## October 2003

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|---|---|
| October 3, 2003 | Videoconference, SFLC Meeting |
| October 7, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |

| | |
|---|---|
| October 8, 2003 | KSC, Waivers and Deviations for KSC Ground Support Equipment (GSE). Lt. Gen. McCartney and Mr. Sieck |
| October 14, 2003 | Washington, D.C., NASA-NIMA MOU. Mr. Geyer |
| October 14, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| October 15, 2003 | JSC, Space Shuttle Program Systems Engineering and Integration Office organization workshop. Mr. Geyer |
| October 17, 2003 | Teleconference, Management Panel Bi-weekly Tag Up |
| October 20, 2003 | KSC, Ground-based Imaging. Lt. Gen. McCartney and Mr. Sieck |
| October 20, 2003 | HSC Senior Staff visit. Mr. Tate and Mr. Wegner |
| October 22-23, 2003 | Ogden, UT, Program Managers Review. Mr. Cuzzupoli and Mr. Cosgrove |
| October 23, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| October 27-28, 2003 | NASA Headquarters, Submarine Safety Colloquium. Management Panel |
| October 28-30, 2003 | JSC and Southwest Research Institute, San Antonio, TX, Thermal Protection System Meetings |
| October 29-30, 2003 | Cape Canaveral, Shuttle Service Life Extension Program Summit. Lt. Gen. McCartney, Mr. Sieck and Mr. Lengyel |
| October 30, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| October 31, 2003 | Atlantis Nosecap NDE Telecon. Technical Panel |
| October 31, 2003 | Teleconference, Management Panel Bi-weekly Tag Up |

**November 2003**

| | |
|---|---|
| November 4, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| November 5-30, 2003 | Marshall Space Flight Center, Bolt-catcher Critical Design Review. Dr. Daniel |
| November 14, 2003 | Teleconference, Management Panel Bi-weekly Tag Up |
| November 18, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| November 20, 2003 | JSC, Management Meetings. Dr. Crippen |
| November 20, 2003 | JSC, Mission Management Team (MMT) Normal Accident Theory. Mr. Tate |
| November 21, 2003 | JSC, SFLC Meeting |
| November 25, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| November 28, 2003 | Teleconference, Management Panel Bi-weekly Tag Up |

## December 2003

| | |
|---|---|
| December 1-5, 2003 | JSC, MMT Simulation (Flight 12A.1). Mrs. Livingstone |
| December 2, 2003 | MAF, New Orleans, LA, ET Status. Technical Panel |
| December 3, 2003 | KSC, Digital Closeout Imagery. Lt. Gen. McCartney and Mr. Sieck |
| December 4, 2003 | Teleconference, Task Group Tag Up. Leadership and Core Staff |
| December 9-11, 2003 | JSC, Plenary Session |
| December 11-12, 2003 | JSC, Editorial Sub-Panel |
| December 16, 2003 | NASA Headquarters SFLC. Management Panel |

## January 2004

| | |
|---|---|
| January 09, 2004 | Technical Panel Telecon |
| January 09, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| January 13, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| January 15, 2004 | Johnson Space Center, STS-114 Flight Techniques Panel |
| January 20, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| January 22, 2004 | Telecon with Mr. Steve Wallace (CAIB member) regarding R3.4-1 thru -3 and 6.4-1, Imagery and TPS Inspection/Repair. Operations Panel |
| January 26, 2004 | Telecon with Code Q/Bryan O'Connor regarding R9.1-1. Management Panel |
| January 27, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| January 28-30, 2004 | Kennedy Space Center, SEIO Summit II. Mr. Kohrs |
| January 29, 2004 | Subnominal Bond TIM. Mr. Cuzzupoli, Mr. Cosgrove |

## February 2004

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|---|---|
| February 03, 2004 | Michoud Assembly Facility, RFI Mini-TIM. Mr. Cuzzupoli Mr. Cosgrove |
| February 03, 2004 | Integrated Vehicle Assessment Sub-Panel Organizational Telecon. Ms. Fox, Lt. Gen. McCartney, Mr. Sieck, RADM Cantrell |
| February 03, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| February 04, 2004 | Johnson Space Center, DTO 848 PDR. Mr. Cuzzupoli, Mr. Cosgrove, Mr. Rubenstein, Dr. Clark |
| February 02-05, 2004 | Kennedy Space Center, Launch and Landing Imagery PRD Requirements Review. Mr. Sieck and Lt Gen. McCartney |
| February 04, 2004 | NASA Headquarters, ITEA Meeting. Mrs. Livingstone |
| February 05, 2004 | Johnson Space Center, STS-114 Joint Operations Panel #9 Telecon. Dr. Thornton. |

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|---|---|
| February 05, 2004 | Technical Panel Telecon |
| February 06, 2004 | Kennedy Space Center, Solid Rocket Booster Thermal Protection System Mini-TIM. Dr. Daniel, Lt Gen. McCartney |
| February 09, 2004 | Management Panel Telecon |
| February 10, 2004 | Johnson Space Center, Imagery TIM. Dr. Sieck and Lt. Gen. McCartney |
| February 10, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| February 11, 2004 | Johnson Space Center, 12A MMT simulation |
| February 10, 2004 | Telecon with JSC MER personnel regarding SIMS Database. Mr. Sieck and Lt. Gen. McCartney |
| February 12-13, 2004 | Debris Summit II Summit at the Johnson Space Center |
| February 17-18, 2004 | SLEP II Summit at Galveston, TX. RADM Cantrell |
| February 19, 2004 | Johnson Space Center, SFLC Meeting. Mr. Covey and RADM Cantrell |
| February 18-19, 2004 | Johnson Space Center, NASA/NIMA MOA Meeting. Mr. Geyer and Dr. Donahue |
| February 20, 2004 | Johnson Space Center, Integrated Vehicle Assessment Sub- Panel Meeting |
| February 20, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| February 23, 2004 | Management Panel Telecon |
| February 24-25, 2004 | NASA Headquarters, Management Panel Meetings |
| February 27, 2004 | Co-Chair/Panel Leads/Staff Telecon |

**March 2004**

| | |
|---|---|
| March 08, 2004 | Management Panel Telecon |
| March 11, 2004 | Kennedy Space Center, FOD and Digital Closeout Imagery. Lt. Gen. McCartney, Mr. Sieck, and Dr. Thornton |
| March 16, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| March 22, 2004 | Management Panel Telecon |
| March 23, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| March 23-24, 2004 | Johnson Space Center, OBSS Status Meeting. Mr. Bruckman |
| March 30, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| March 30, 2004 | Johnson Space Center, STS-114 Joint Operations Panel #12 Telecon. Dr. Thornton |
| March 31, 2004 | Sandia Labs, Albuquerque, NM., OBSS Status Meeting. Mr. Bruckman |

## April 2004

| | |
|---|---|
| April 01, 2004 | Kennedy Space Center, External Tank Monthly Review. Mr. Cuzzupoli, Mr. Kohrs, Dr. Daniel, Mr. Rubenstein |
| April 02, 2004 | Kennedy Space Center, Two-Person Closeout, Orbiter Hardening, and RCC NDI Briefings. Mr. Cuzzupoli, Mr. Kohrs, Dr. Daniel, Mr. Rubenstein |
| April 02, 2004 | Kennedy Space Center, Pre-Launch MMT Simulation. Mrs. Livingstone |
| April 05, 2004 | Management Panel Telecon |
| April 06, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| April 09, 2004 | Two-Person Closeout, Orbiter Hardening, and RCC NDI Dry Run Briefings. Mr. Cuzzupoli, Mr. Cosgrove, Mr. Kohrs, Dr. Daniel, Mr. Rubenstein |
| April 12-16, 2004 | Johnson Space Center (JSC) Plenary Session |
| April 16, 2004 | Public Meeting, Webster Civic Center |
| April 20, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| April 27, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| April 28-30, 2004 | Bolt Catcher Delta Critical Design Review (CDR) at the Marshall Space Flight Center (MSFC) regarding CAIB Recommendation 4.2-1. Dr. Daniel, Mr. Armstrong |

## May 2004

| | |
|---|---|
| May 4, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| May 11, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| May 14, 2004 | Foreign Object Debris and Digital Closeout Imagery Status Review at KSC regarding CAIB Recommendations 4.2-5 and 10.3-1. Mr. Sieck and Gen. McCartney |
| May 19, 2004 | Bolt Catcher/NSI Pressure Cartridge CDR Pre-board. Mr. Armstrong |
| May 20, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| May 26, 2004 | MMT Simulation #5 at JSC. Mrs. Livingstone, Mr. Geyer, and Mr. Mueller |
| May 27, 2004 | Reinforced Carbon-Carbon (RCC) Plug Repair Preliminary Design Review at JSC Regents Park. Mr. Armstrong |
| May 27, 2004 | Bolt Catcher/NSI Pressure Cartridge CDR at MSFC. Dr. Daniel |
| May 27, 2004 | Co-Chair/Panel Leads/Staff Telecon |

## June 2004

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| June 8, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| June 8-9, 2004 | LDRI Orbiter Inspection System CDR at JSC. Mr. Diegelman |
| June 9, 2004 | Space Flight Leadership Council in Ogden, Utah. Mr. Covey, Dr. Daniel, Gen. Engle, Mr. Armstrong and Mr. Drachlis |
| June 10, 2004 | Engineering Test Motor Firing at ATK-Thiokol. Dr. Daniel, Mr. Armstrong, and Mr. Drachlis. |
| June 14-15, 2004 | Systems Engineering & Integration Office Summit at KSC. Mr. Geyer, Mr. Wegner, Mrs. Mauzy, and Mr. Diegelman |
| June 15, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| June 17, 2004 | Operations Panel Fact-Finding Telecon with Space Shuttle Program regarding CAIB Recommendation 6.4-1. Dr. Clark, Ms. Teague, and Mr. Watkins |
| June 22, 2004 | Management Panel visit to NASA Langley Research Center's NASA Engineering and Safety Center regarding CAIB Recommendations 6.2-1, 7.5-1 and 7.5-2. Dr. Crippen, Mr. Geyer, Mr. Wegner, Mrs. Livingstone, Mr. Tate, Mr. Mueller, and Ms. Rogers |
| June 23, 2004 | Management Panel visit to NASA Headquarters regarding CAIB Recommendations 6.2-1, 7.5-1 and 7.5-2. Mr. Covey, Dr. Crippen, Mr. Geyer, Mr. Wegner, Mrs. Livingstone, Mr. Tate, Mr. Mueller, Mr. Drachlis, and Ms. Rogers |
| June 24, 2004 | Integrated Vehicle Assessment Sub-Panel Leads visit regarding sub-panel roles and required products for assessment. Mr. Diegelman and Mr. Watkins |
| June 25, 2004 | External Tank Monthly Review with Technical Panel at Michoud Assembly Facility and Stennis Space Center regarding CAIB Recommendation 3.2-1. Mr. Cuzzupoli, Mr. Cosgrove, Mr. Kohrs, and Mr. Armstrong |
| June 28, 2004 | Tile Test Article Review at JSC regarding CAIB Recommendation 6.4-1. Mr. Rubenstein and Mr. Armstrong |
| June 28, 2004 | RCC Repair Status Review at JSC regarding CAIB Recommendation 3.3-1. Mr. Rubenstein and Mr. Armstrong |
| June 29, 2004 | SIMS Production Tool Demo (Closeout Photos Graphical Interface) at KSC. Gen. McCartney, Mr. Sieck, Ms. Teague |
| June 29, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| June 30, 2004 | MMT Simulation #6 at KSC. Mrs. Livingstone, Dr. Thornton, Mr. Mueller |

## July 2004

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| July 8, 2004 | Operations Panel Fact-Finding at Kennedy Space Center (KSC) on |

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| | Space Shuttle Program-3 (SSP-3), Contingency Shuttle Crew Support (CSCS) “Safe Haven.” Dr. Donahue, Col. Helms, and Ms. Teague |
| July 8, 2004 | Fact-Finding Telecon with SSP on Closure of Columbia Accident Investigation Board (CAIB) Recommendations 4.2-5 and 10.3-1 at KSC. Operations Panel |
| July 8, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| July 15, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| July 16, 2004 | Technical Panel Fact-finding Telecon with SSP on CAIB Recommendation 3.2-1. Mr. Cuzzupoli, Mr. Kohrs, Mr. Watkins, and Mr. Armstrong |
| July 22, 2004 | Teleconference Plenary, Public Meeting, and Media Teleconference for Conditional Closures to CAIB Recommendations 4.2-5 and 10.3-1 |
| July 26-27, 2004 | Technical Panel Reinforced Carbon-Carbon (RCC) Test Article Review at the Johnson Space Center (JSC). Mr. Armstrong, Mr. Watkins, Ms. Mauzy, and Ms. Teague |
| July 27-28, 2004 | Mission Management Team (MMT) Simulation #7 at JSC. Ms. Fox, Mr. Geyer, Mr. Mueller, and Mr. Diegelman |
| July 27-28, 2004 | Integrated Vehicle Assessment Sub-Panel (IVASP) Fact-finding Meeting with Simulation Planning Team, MMT training community, and System Engineering and Integration Office on Thermal Protection System (TPS) Integrated Operations Plan. Ms. Fox and Mr. Diegelman |
| July 28, 2004 | Technical Panel Fact-finding Telecon with SSP on Integrated Risk Assessment for CAIB 3.2-1. Mr. Cuzzupoli, Mr. Kohrs, Dr. Daniel, Mr. Rubenstein, Mr. Cosgrove, Gen. McCartney, Mr. Lloyd, Mr. Armstrong, Ms. Mauzy, Ms. Teague, and Mr. Watkins |

**August 2004**

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| August 5, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| August 10, 2004 | Operations Panel Fact-finding at KSC on SSP-3, CSCS “Safe Haven” for Environmental Control and Life Support. Dr. Donahue, Col. Helms, and Ms. Teague |
| August 10-12, 2004 | Technical Panel Attend SSP Impact Testing and Debris Summit. Dr. Daniel, Mr. Rubenstein, Dr. Clark, Mr. Armstrong, and Mr. Diegelman |
| August 12, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| August 13, 2004 | CAIB Recommendation 6.4-1 Strategy Session at JSC. Dr. Daniel, Dr. Clark, Gen. Engle, Ms. Mauzy, Ms. Teague, Mr. Diegelman, Mr. Armstrong and Mr. Watkins |
| August 16, 2004 | Technical Panel Internal Telecon Review of CAIB Recommendation 4.2-1 Closure |

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| August 18, 2004 | Management Panel Fact Finding with SSP on CAIB Recommendations 6.3-1 and 7.5-3. Dr. Crippen and Mr. Mueller |
| August 18-19, 2004 | External Tank (ET) TPS Certification Technical Interchange Meeting. Ms. Teague |
| August 19, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| August 25, 2004 | ET Monthly Review at KSC. Gen. McCartney, Ms. Mauzy and Mr. Watkins |
| August 30, 2004 | Management/Operations Panels Fact-finding at KSC with SSP Workforce on CAIB Recommendations 6.2-1 and 7.5-3. Dr. Crippen, Mr. Wegner, Gen. McCartney, Mr. Sieck, and Mr. Mueller |
| August 30-3, 2004 | ET Flange Critical Design Review. Ms. Teague |
| August 31-1, 2004 | Orbiter Boom Sensor System (OBSS) System Design Review at JSC. Mr. Diegelman |

**September 2004**

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| September 1, 2004 | Space Flight Leadership Council (SFLC) at Marshall Space Flight Center (MSFC). Mr. Covey, Dr. Daniel, Mr. Wegner, Gen. McCartney and Gen. Engle |
| September 2, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| September 3, 2004 | Debris Summit Debrief/Tile Telecon. Dr. Clark, Dr. Daniel, Mr. Rubenstein, Mr. Cosgrove, Dr. Thornton, Gen. McCartney, Gen. Engle, Ms. Mauzy, Ms. Teague, and Mr. Diegelman |
| September 13, 2004 | Tile Repair System Design Review at JSC. Mr. Cuzzupoli, Dr. Clark, Ms. Mauzy, and Ms. Teague |
| September 13, 2004 | IVASP Fact Finding on TPS Integrated Operations Plan. Ms. Fox, Mrs. Livingstone, Mr. Geyer, Dr. Clark, Mr. Diegelman, Ms. Teague and Mr. Watkins |
| September 14-16, 2004 | JSC Plenary Session. |
| September 22-23, 2004 | On-Orbit MMT Simulation at JSC. Mrs. Livingstone, Mr. Mueller, and Ms. Mauzy |
| September 23, 2004 | Co-Chair/Panel Leads/Staff Telecon |

**October 2004**

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| October 1, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| October 5-6, 2004 | RCC Plug Repair TIM for R3.3-1 at Utah. Ms. Fletcher and Ms. Mauzy |
| October 7, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| October 19-20, 2004 | RCC Crack Repair PDR for R6.4-1 at MSFC. Ms. Fletcher |
| October 20-21, 2004 | ET TPS Certification TIM at MAF for R3.2-1. Dr. Daniel |

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| October 21, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| October 25-26, 2004 | Ground Camera Ascent Imagery Project CDR at R3.4-1 at KSC. Mr. Sieck, Gen. McCartney, Ms. Teague |
| October 27, 2004 | Technical Panel Telecon on Verification, Validation and Certification Definitions. Mr. Cuzzupoli, Dr. Daniel, Mr. Rubenstein, Mr. Kohrs, Mr. Grove, Col. Adamson, Ms. Fletcher, Ms. Mauzy, Mr. Mueller, Mr. Diegelman, Ms. Teague and Mr. Watkins |
| October 28, 2004 | RTF TG Leadership Meeting at HQ. Mr. Covey, Gen. Stafford, Col. Adamson |
| October 28-29, 2004 | RTF Flight Operations Progress Review at JSC. Ms. Teague and Ms. Fletcher |
| October 29, 2004 | Space Flight Leadership Council (ViTs). Mrs. Livingstone, Mr. Tate, Mr. Geyer, Mr. Sieck, Gen. McCartney, Dr. Daniel, Ms. Mauzy, Ms. Teague, Mr. Mueller, Ms. Rogers and Mr. Watkins |

**November 2004**

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| November 2, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| November 8-10, 2004 | SSP Impact Testing Debris Summit at JSC for R3.3-2. Dr. Clark, Dr. Daniel, and Ms. Mauzy |
| November 9-10, 2004 | External Tank TPS Certification Status Briefing for R3.2-1 at MAF. Mr. Covey, Mr. Cuzzupoli, Dr. Crippen, Mr. Lloyd, Mr. Cosgrove, Mr. Kohrs, Mr. Rubenstein, Mr. Drachlis, Ms. Fletcher, and Ms. Byerly |
| November 15, 2004 | Management Panel Briefing to Aerospace Safety Advisory Panel at JSC. Maj. Gen. Gideon, Mr. Erminger, Mrs. Livingstone, Mr. Geyer, Mr. Mueller and Mr. Watkins |
| November 16, 2004 | Management Panel Fact Finding with Wayne Hale on R6.3-1. Mrs. Livingstone, Mr. Geyer and Mr. Mueller |
| November 16-18, 2004 | Bolt Catcher DCR Onsite Documentation Review at MSFC for R4.2-1. Ms. Fletcher |
| November 16-19, 2004 | STS 114 On-Orbit MMT SIM at JSC. Mrs. Livingstone, Mr. Geyer, Mr. Mueller and Mr. Diegelman |
| November 16, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| November 18, 2004 | Telecon with SSP on R3.3-2. Mr. Cuzzupoli, Mr. Rubenstein and Mr. Watkins |
| November 22, 2004 | SSP Presents R3.3-2 and 4.2-1 Closures to Technical Panel/IVA Sub-Panel |
| November 23, 2004 | NASA Headquarters Deputy Chief Engineer Presents R7.5-1/9.1-1 Closures to Management Panel |
| November 23, 2004 | Co-Chair/Panel Leads/Staff Telecon |

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| November 30, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| November 30, 2004 | SSP Presents R3.4-1, 3.4-2, 3.4-3 Closures to Operations Panel and IVASP |
| November 30-1, 2004 | RCC Plug Repair TIM #3 at JSC. Ms. Fletcher |
| November 30, 2004 | Catcher DCR Pre-Board at MSFC for R4.2-1. Dr. Daniel |

**December 2004**

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| December 2, 2004 | Cure-In-Place Ablator CDR at JSC. Ms. Fletcher |
| December 3, 2004 | Bolt Catcher DCR Board at MSFC for R4.2-1. Dr. Daniel |
| December 7, 2004 | Co-Chair/Panel Leads/Staff Telecon |
| December 9, 2004 | Space Flight Leadership Council ViTS. Mr. Covey, Gen. McCartney, Dr. Daniel, Mr. Tate, Ms. Mauzy, Ms. Teague, Mr. Mueller, Ms. Rogers and Mr. Watkins |
| December 10, 2004 | Bolt Catcher DCR Delta Board at MSFC for R4.2-1. Dr. Daniel |
| December 13, 2004 | IVASP Fact Finding on TPS Integrated Operations Plan. Ms. Fox, Lt. Gen. McCartney, Mr. Sieck, Dr. Clark, Dr. Daniel, Mr. Geyer, Mr. Diegelman, Ms. Mauzy, Ms. Fletcher, and Mr. Watkins |
| December 14-16, 2004 | MSFC Plenary Session, Public Meeting, and Media Teleconference |
| December 15, 2004 | SSP Fact Finding on R6.4-1 at JSC. Dr. Clark, Dr. David, Mr. Cuzzupoli, Mr. Kohrs, Mr. Cosgrove, Mr. Rubenstein, Dr. Thornton, Ms. Mauzy, Gen. McCartney, Mr. Sieck, Ms. Teague, Ms. Mauzy and Ms. Fletcher |

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# Appendix E - RFI Status Matrix

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
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| Tech-039 | GMIP's Independent Assessment | SSP-1 | RTF TG Technical Panel requests a copy of the NASA Independent Assessment Report on GMIP's. | CLOSED |
| Ops-016 | ISS Consumable, Sparing and Configuration for 2-Member Crew | SSP-3 | Provide current and projected consumables (water, propellant, CO2 removal capability, food and other crew provisioning) for current 2-member crew with projected needs on Russian assets (e.g. Soyuz rotations, crew rotations, Progress missions, etc.) for extended on-orbit maintenance of ISS without Shuttle availability. Also provide data on critical ORU sparing to maintain minimum acceptable habitability and mechanisms for providing that sparing without Shuttle. | CLOSED |
| Ops-017 | Contingency Shuttle Crew Support Data and Supporting Analysis | SSP-3 | Provide minimum ISS system requirements, consumables, etc. to maintain crew of 6-10 for contingency support of the Shuttle crew. Provide plans for use of Soyuz to bring down partial crew and length of time remaining crew can survive on ISS. Provide plans and timeframes for sending additional Soyuz and/or Shuttle rescue missions to retrieve remaining crew members. Provide forward work to verify feasibility of this concept and reliance on Russian segment and assets. | CLOSED |
| Ops-018 | ISS Safe Haven and ISS Extended Duration Orbiter Study Results | SSP-3 | Provide study results from ISS Program led analysis of the ISS as a safe haven to provide larger on-orbit crew size with limited Soyuz return capability. Also provide study results from ISS Program led analysis of use of EDO Shuttle missions to provide a larger crew for utilization. Both study results should discuss ISS minimum system capability, consumables projections, number of crew supported as a function of time, and reliance on Russian segment and other assets | CLOSED |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Ops-058** | **ISS ECLS Systems Training Manuals** | SSP-3 | Provide: 1) Russian manuals (in English):<br>a. Vozdukh<br>b. BMP<br>c. Electron<br>d. ACY (toilet)<br>e. CRBK (Water supply system)<br>2) US manuals:<br>a. CDRA b. CCAA<br>3) Also provide an overview of the ability to supply O2/N2 from the ISS airlock to ISS ambient atmosphere - namely, whether it's possible and if so, a comparison between O2 used for 1 ISS EVA and what that same O2 amount would provide for ISS Safe Haven duration extension.<br>4) Is there a manual/overview on the US-provided water bags (CWC) that are used to supply water to the Electron, etc? | **CLOSED** |
| **Ops-104** | **SSP-3: Decision Process/Launch Commit Criteria for CSCS and associated rescue mission** | SSP-3 | 1.Supply documentation of the decision process/Launch Commit Criteria associated with CSCS and the relationship to systems functionality and flight crew support cargo, including but not limited to:<br>a. Define the circumstances under which a launch would be stood down and who's involved in the decision.<br>b. Define who will be the final decision authority.<br>2. Supply the documentation of the decision process/Launch Commit Criteria associated with the rescue mission. | **OPEN** |
| **Ops-105** | **SSP-3: Program and Operations Requirements** | SSP-3 | 1.Supply operational modifications and flight rules (new or current) that directly relate to:<br>a. rescue operations (Shuttle and Soyuz, as applicable)<br>b. extending the duration of CSCS<br>c. de-manning or sacrifice of ISS<br>d. unmanned undock/d-orbit of orbiter<br>e. system failures/anomalies causing degradation of critical support capability for CSCS if any others that directly correlate to a CSCS event<br>2.Supply modifications to NSTS 07700 and subordinate SSP documents to define CSCS and Rescue Operations<br>3.Supply modifications to SSP 50200-X, SSP 41000-X, SSP 50261-01, SSP 54100 to define CSCS and Rescue Operations | **OPEN** |
| **Ops-106** | **SSP-3: CSCS Simulation plan** | SSP-3 | 1.Supply the simulation plan for demonstrating, validating, and exercising the MMT decision process with regard to CSCS | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
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| **Ops-107** | **SSP-3: MMT Evaluation Process Demonstration** | SSP-3 | 1. Demonstrate the MMT process to weigh and evaluate the risk of CSCS relative to other options in an integrated simulation.<br>a. Demonstrate how the MMT will build a rationale for launching the rescue vehicle.<br>b. Demonstrate the MMT, MER and FCT process to evaluate and consider unintended consequences resulting from calling CSCS. | **OPEN** |
| **Ops-108** | **SSP-3: Impacts to stowage and habitability on ISS with CSCS** | SSP-3 | 1.Explain the integrated assessment of stowage impact on ISS to meet requirements and constraints defined for CSCS<br>a. Hardware and Consumables<br>b. Pre-launch and prior to undock/de-orbit event<br>2. Explain the consequences to stowage and environmental stability (e.g. air flow and thermal condition) of the transfer of cargo from the damaged orbiter prior to undock and de-orbit.<br>3.Identify what spares are required for CSCS and method to supply these to ISS<br>4. Provide analysis that shows how the ISS systems are affected and the impacts on habitability when the metabolic environment is raised from two to nine people, both before and after the shuttle departs.<br>a. Explain the role expected from the International Partners relating to this environmental assessment, both pre-launch and on-orbit, if implemented | **OPEN** |
| **Ops-109** | **SSP-3: Inter-Program coordination** | SSP-3 | 1. Explain how the analysis and decision-making on SSP-3 is being coordinated/deconflicted across SSO and ISSP.<br>2. Provide evidence that both programs have a common view of what the objectives are, and that both can support them.<br>3. Explain how the impacts of failures/contingencies aboard ISS on CSCS capabilities are to be vetted through both ISS and ISSP. | **OPEN** |
| **Ops-110** | **SSP-3: CSCS and Undock/De-orbit procedures** | SSP-3 | 1. Supply the Flight Data File/Stations Operations Data File (FDF/SODF) procedures to support the undock and de-orbit of the shuttle and any changes to ISS control procedures. Demonstrate the procedures to safely undock and de-orbit an abandoned orbiter with a high level of confidence<br>2. Supply FDF/ODF procedures that support CSCS tasks, including any modifications to current procedures | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
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| **Ops-111** | **SSP-3: Assessments of risk and assumptions for conditions of CSCS** | SSP-3 | 1. Provide assessments performed that address unintended consequences of executing CSCS.<br>2. Provide assessments that demonstrate that the full body of choices made with regard to critical debris abatement, TPS inspection and repair and CSCS are mutually enabling in terms of risk mitigation<br>3. Articulate assumptions made regarding CSCS. Provide results of evaluations and sensitivity analysis applied to these assumptions<br>4. Explain process to define pre-conditions that must exist to support CSCS. Explain in detail the circumstances under which and indictment of CSCS would be raised. | **OPEN** |
| **Ops-112** | **SSP-3: Crew Reports with environment comments** | SSP-3 | 1. Provide all ISS or Shuttle crew reports that comment on apparent impacts to the health and habitability of the ISS environment when the nominal crew size was increased due to a visiting vehicle. | **OPEN** |
| **Ops-113** | **SSP-3: Role of International Partners (IP)** | SSP-3 | 1.Describe the role of the IP in pre-mission planning for STS-114<br>2.Describe how Launch Commit Criteria are vetted through the IP when they concern or are relevant to CSCS<br>3.Describe the role of the IP in the Shuttle FRR and LRR | **OPEN** |
| **Tech-031** | **SSME Controller Software Independent Verification and Validation (IVV), Other no Rec.** | SSP-13 | Request clarification of the Space Shuttle Program Policy for IVV and descried the IVV process for the SSME controller software. Background: The Technical Panel Lead discussed SSME controller software IVV with Rocketdyne's Chief engineer. The Chief Engineer to describe a process that indicated that the IVV of the Rocketdyne development software was also performed by Rocketdyne. Normal practice for IVV is to use an independent IVV contractor. | **CLOSED** |
| **Tech-052** | **RSRM TPS Application Assurance** | SSP-13 | TPS application and assurance for SRB Nose Cap, Frustrum, Forward Skirt and Aft Skirt. RSRM TPS application and assurance. Failure mechanisms for TPS (what factors would cause liberations of debris). SRB and RSRM debris source identification provided to Level II. | **CLOSED** |
| **Tech-053** | **Tile/SIP Peel Strength** | SSP-13 | Provide rational or technical approach to OV 105 Tile/SIP Peel Strength issue for OV103 and OV104 orbiters. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
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| Tech-004 | Wind Tunnel Testing on External Tank | 3.2-1 | Per our discussion, I would like to understand what wind tunnel cases are being run for the ET bi-pod and PAL ramp. I understand that these are ET only configurations. I am interested in MACH numbers, angle of attack, beta angle, etc. I am also interested in what CFD analysis or planned mated vehicle tests are planned to understand the effects of any changes. I am concerned that the changes to the ET may affect the system unless we understand the mated aero effects. | CLOSED |
| Tech-007 | Additional Instrumentation for vehicles ET FOAM (R3.2.1) | 3.2-1 | What additional instrumentation will be added to the vehicles to obtain engineering data to verify pre-flight predictions, primarily concerning RCC and tank debris? Also, please provide the PRCB status addressing adding instrumentation to record impacts to the RCC leading edge and data availability near real-time to the ground and the program's position on implementation. | ClOSED |
| Tech-008 | Additional Instrumentation for ET for Pre-Launch and Launch (R3.2.1) | 3.2-1 | The technical team is interested in what additional instrumentation is planned to be added to the External Tank (ET) to measure the environments during pre-launch and launch. The removal of the bipod ramps, and potentially the removal of the PAL ramps, and the uncertainty of the internal intertank environment of the LH tank interface creates the justification to add instrumentation to obtain engineering data and to facilitate the verification process. | CLOSED |
| Tech-009 | Ascent Profile | 3.2-1 | Would like to see a typical ascent profile that shows alpha, beta thrust bucket, propellant consumption, altitude and velocity. | CLOSED |
| Tech-010 | ET Finite Element Model (FEM) | 3.2-1 | Provide results from FEM analysis on ET. Identify the model, assumptions, data targeted, uncertainty, how data was used, load(s), etc. | CLOSED |
| Tech-045 | Nominal Ascent Data | 3.2-1 | Reference Tech 009: ascent profile data was provided for a nominal mission in Tech-009. Request nominal ascent data for the ET LH2, L02 ullage temperatures and ambient outside air temps from T-20 seconds to MECO. The measurements of interest T41T1755A (L02 Ullage temp); T41T1705A (LH2 Ullage temp) | ClOSED |
| Tech-047 | Combined Loads | 3.2-1 | Request that ET Office explain how they combine design environments to generate combined loads for stress analysis, in particular, with respect to bi-pod redesign. | CLOSED |
| Tech-048 | Combined Loads Design Environments | 3.2-1 | Request Level 2 Systems engineering and Integration to describe how level 2 ensures that design environments are properly combined into combined loads for use by the Projects. | OPEN |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
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| **Tech-049** | **3.2-1 TPS Verification Validation and Certification** | 3.2-1 | The Tech Panel held a review of the ET return to flight activity at MAF on 05, Dec. 2003. These requests were made to provide additional information to the panel. This item was discussed at the review. NASA stated that in-flight vibration and flexure loads did not contribute to foam loss. Request the data be provided supporting this statement. Please indicate dynamic response frequency and induced loads. | **OPEN** |
| **Tech-051** | **3.2-1 TPS Verification Validation and Certification – Integrated Plan for TPS Verification** | 3.2-1 | The Tech Panel held a review of the ET return to flight activity at MAF on 05, Dec. 2003. These requests were made to provide additional information to the panel. This item was discussed at the review: Request NASA provide an integrated plan for the TPS verification, validation and certification activity. | **OPEN** |
| **Tech-054** | **3.2-1 Bellows Debris Elimination** | 3.2-1 | The Tech Panel held a review of the ET return to flight activity at MAF on 05, Dec. 2003. These requests were made to provide additional information to the panel. This item was discussed at the review: Request NASA provide the venting analysis of the bellows/gasket to assure the gasket will not degrade the design venting requirements and will not separate and become a debris source | **CLOSED** |
| **Tech-055** | **3.2-1 INTERTANK/LH2 Flange Enhancement** | 3.2-1 | The Tech Panel held a review of the ET return to flight activity at MAF on 05, Dec. 2003. These requests were made to provide additional information to the panel. This item was discussed at the review: Request NASA provide analysis showing that fastener leakage could not be a contributing cause of foam loss in other areas, including the bi-pod area on STS-107. The analysis will support root cause determination. | **CLOSED** |
| **Tech-056** | **3.2-1 NDE Techniques** | 3.2-1 | The Tech Panel held a review of the ET return to flight activity at MAF on 05, Dec. 2003. These requests were made to provide additional information to the panel. This item was discussed at the review: Request NASA provide a narrative description (white paper) of the two NDE techniques being used for the foam inspection. Please indicate the acceptance criteria for NDE. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
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| **Tech-057** | **Physics of ET Foam Failure** | 3.2-1 | At the last Tech Panel meeting at MAF, presentations covered the failure mechanisms associated with foam liberation. The presentations explained the "how", but not the "why" of failure at voids. The root cause, "why", (or the physics of failure), of the breakdown at voids is needed to assess corrective action. Request a presentation giving MAF's understanding of the "why" (or the physics of failure) of breakdown of ET foam at voids. | **OPEN** |
| **Tech-001** | **R3.3-1 Rationale for Retaining OV104 Nose Cap Rather than Testing** | 3.3-1 | Provide the rationale for retaining the OV104 nose cap in place rather than performing the tests being performed on the OV103/OV105 nose caps. | **CLOSED** |
| **Tech-046** | **Impact Test Data** | 3.3-1 | The Technical Panel would like an assessment of the tests and periodic (twice/ monthly) basis. In particular a summary of the:<br>1) Number of Tests conducted by kinetic energy<br>2) Impacts on establishing the design allowable<br>3) Impact on the repair requirements. | **OPEN** |
| **Tech-002** | **R3.3-2 Tile Improvements for First Flight** | 3.3-2 | What are the tile improvements for the first flight? If the improvements were selected to reduce risk please explain the rationale or testing underway to demonstrate why the changes are not required. | **CLOSED** |
| **Tech-003** | **R3.3-2 Tile Improvements Testing** | 3.3-2 | What testing (schedule and type) will be done to demonstrate the tile repair prior to first usage? | **CLOSED** |
| **Tech-005** | **R3.3-2 Testing Information on RCC and tile Testing** | 3.3-2 | Provide an integrated schedule of testing to support R.3.3-2, "…a program designed to increase the orbiters ability to sustain minor debris damage by measures such as improved impact resistant RCC and acreage tiles." Please explain the approach to demonstrate the margin between the ET shedding and the Orbiter damage tolerance. Provide information for the RCC and tile testing. | **CLOSED** |
| **Ops-070** | **3.4-1: Requirements Documentation and System Performance Specifications** | 3.4-1 | 1. Supply all documents containing the NASA requirements associated with ground based imagery, including the system performance and maintenance requirements documentation.<br>2. Supply all documentation describing the process / plan for the KSC and Range launch readiness certification of the ground imagery assets. | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| Ops-071 | **3.4-1: Launch Commit Criteria for revised and upgraded imagery assets** | 3.4-1 | 1. Supply documentation of the Launch Commit Criteria for launch weather, and the relationship with the improved ground imagery assets (including airborne /ship based if and where applicable).<br>2. This documentation should include the decision process / Launch Commit Criteria for unavailability or inoperable assets, and associated safety of flight risk assessment | **OPEN** |
| Ops-072 | **3.4-1: Integrated Schedule for the completion and the RTF TG review of Ground Imagery** | 3.4-1 | Schedule for all work / products / documentation / briefings for ground imagery requirements and implementation plans – including any work which will be accomplished after RTF. Schedule must be presented in sufficient time to allow the TG to assess the appropriateness of the improvements made pre and post RTF (STS-114) | **CLOSED** |
| Ops-092 | **3.4-1 Response to Congressman Rohrabacher memo on imagery technology** | 3.4-1 | Provide response to official Congressional letter dated May 7, 2004 by Dana Rohrabacher to Sean O'Keefe. Clearly explain rationale for selection of cameras. Letter is attached. | **CLOSED** |
| Ops-073 | **3.4-2: Imagery Downlink – Completion of the flight Milestone for the Umbilical Well Camera Pt.1** | 3.4-2 | Documentation or verification of the completion of the qualification milestone (test, documentation, etc) for flight for the Umbilical Well Camera for RTF (STS-114). | **WITHDRAWN** |
| Ops-074 | **3.4-2: Imagery Downlink – Completion of the flight Milestone for the Umbilical Well Camera Pt. 2** | 3.4-2 | 1.Review of the procedures, and documentation for:(a)Check out of all cameras systems (b)Test, calibration and readiness of camera systems (c)Review of the Training prospectus for the Crew (hand held camera)and the ground operations personnel<br>2. Review of the Launch Commit Criteria against findings from Item #1 above. | **CLOSED** |
| Ops-075 | **3.4-2: Imagery Downlink – Completion of the flight Milestone for the Umbilical Well Camera Pt. 3** | 3.4-2 | 1. Review of Total Data Handling process from Shuttle vehicle orbit insertion, to evaluation on the ground, of the images collected by the camera systems.<br>2. Review of the resolution, if possible by sample data, to assure the images will provide the desired decision information | **CLOSED** |
| Ops-076 | **3.4-2: Downlinked Imagery from previous Missions for ET, ET Umbilical, and Handheld camera** | 3.4-2 | A summary of the previous shuttle missions performance of the ET Film Cameras in the ET Umbilical Cavity and the Handheld Camera – specifically the reliability of these systems, the quality of the resolution, the performance against specifications, and the anticipated deltas associated with any changes made for the post RTF imagery | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| Ops-068 | **3.4-3: On-vehicle Imagery – Camera system Qualification / Certification (for Return to Flight)** | 3.4-3 | 1. Review of the Check Out procedures to assure operational status of the on-board cameras.<br>2.Review of Launch Commit Criteria against the operational status of the on-board cameras | CLOSED |
| Ops-069 | **3.4-3: On-vehicle Imagery – Camera system Qualification / Certification (for continuing flights)** | 3.4-3 | 1. Review of the qualification / certification data for the total suite of the cameras on-board the Vehicle.<br>2. Review of the Check out procedures to assure operational status of the cameras. | OPEN |
| Tech-011 | **SRB Bolt Catcher Finite Element Model** | 4.2-1 | Provide the results from the FEM used to analyze the SRB bolt catcher assembly. Identify model, assumptions, loads, uncertainty, data targeted, etc. | CLOSED |
| Tech-084 | **4.2-1 Request for Data Packages in Support from CDR on the SRB Bolt Catcher** | 4.2-1 | The SRB Project is requested to provide the following information:<br>1. Data packages from the delta-CDR on the SRB Bolt Catcher and the associated NSI.<br>2. RIDs and dispositions from this delta CDR. | CLOSED |
| Tech-022 | **Wiring Inspection and Repair (R4.2-2)** | 4.2-2 | What wiring inspection and repair will not be performed on OV-104 prior to return to flight? Provide rationale. | CLOSED |
| Tech-050 | **4.2-3 Two Person Closeout** | 4.2-3 | The Tech Panel held a review of the ET return to flight activity at MAF on 05, Dec. 2003. These requests were made to provide additional information to the panel. This item was discussed at the review: Request NASA provide copies of the implementation plan as objective evidence for closure of the CAIB recommendation. | CLOSED |
| Ops-066 | **4.2-5: Foreign Object Debris (FOD) Processes – New Work Processes** | 4.2-5 | Plans and schedules for education of the workforce in the use of the new procedures and work instructions, focused on the impacts of the new definition of FOD. Confirmation of the education initiative via training sessions and meetings with the workforce, via metrics, and participation records. | CLOSED |
| Ops-067 | **4.2-5: Foreign Object Debris (FOD) Processes – New Definition and Standards review** | 4.2-5 | Review applicable standards, references, and information, to develop a new definition of FOD with the intent of:<br>1. Consistency against FOD standards, particularly relevant industry and DOD standards.<br>2. Benchmark DOD and industry facilities that perform similar processing activities<br>3. Consistent with the standards and practices, develop a new set of metrics, with the intent of establishing and sustaining a more robust FOD control program | CLOSED |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Ops-081** | **4.2-5: Foreign Object Debris Processes – Audits and Interviews** | 4.2-5 | 1. Review of the improvements made under all the RFI's in this NASA Implementation Plan section, concluding in an audit. The results will be recorded as an RTF TG finding.<br>2. Conduct random interviews with the workforce after the closure of all RFI's, action items, and the audit is completed. The results will be documented for comparison with training records. | **CLOSED** |
| **Man-026** | **Budget Impact on Scheduling and Resources 6.2-1** | 6.2-1 | 1. Debrief of FY04 budget process.<br>2. Notional budget allocation process.<br>3. Changes in budget allocation process resulting from Columbia mishap.<br>4. How Level 2 tools are used to fulfill Level 1 requirements.<br>5. Copy of benchmarking.<br>6. Present results of Organization/Fault tree analysis conducted by SSPO at Dec. plenary. | **CLOSED** |
| **Man-101** | **Personnel Staffing Status, R6.2-1** | 6.2-1 | 1. List number of new billets by skill and grade at JSC, KSC, MSFC, and Stennis (coordinated by Office of Space Operations) created as a result of RTF activities.<br>2. List number of open RTF billets remaining by skill and grade at JSC, KSC, MSFC, and Stennis (coordinated by Office of Space Operations).<br>3. List hiring source and numbers (e.g., spaceflight contractors, new hires, interns, etc.) filling RTF billets by skill and grade at JSC, KSC, MSFC, and Stennis (coordinated by Office of Space Operations | **CLOSED** |
| **Man-025** | **MMT Training Plan And Schedule RE CAIB 6.3-1** | 6.3-1 | 1. NSTS 0700 Volume VIII with changes pertaining to MMT annotated.<br>2. Schedule for MMT exercises and drills.<br>3. Simulation control group organization plan.<br>4. Outline of individual and team training for scheduled exercise.<br>5. MMT POC and read-ahead materials for RTF TG December plenary | **CLOSED** |
| **Man-030** | **Lessons Learned from First MMT Simulations, R6.3-1** | 6.3-1 | 1. Report on lessons learned from first MMT simulation.<br>2. Quick look results from second MMT simulation. | **CLOSED** |
| **Man-042** | **MMT Additional Lessons Learned, Outside Evaluation Reports, and Other CAIB Rec. Exercise, R6.3-1** | 6.3-1 | 1. Report on Lessons Learned from second MMT simulation.<br>2. Provide Parker and Van Eynde evaluations of first and second MMT simulations.<br>3. List aspects of other CAIB RTF recommendations exercised in MMT simulations.<br>4. List aspects of CAIB non-RTF recommendations exercised in MMT simulations | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-028** | **NASA/NIMA MOA Plans and Documentation R6.3-2** | 6.3-2 | 1. Master schedule for development, coordination, publication and implementation (to include simulation and test)<br>2. MOA (classified)<br>3. Clearance list/process description<br>4. Description of NASA STRATCOM/Interface<br>5. Presentation of plan to Incorporate STRATCOM ground based assets<br>6. Standard operating procedures<br>7. Training plan<br>8. Integrated simulation/evaluation results | **CLOSED** |
| **Man-097** | **MMT Follow Up and MOU Evaluation, R6.3-1 and R6.3-2** | 6.3-2 | 1. Provide Shuttle Deputy Manager MMT Summary letters, including copies of all external evaluations for the sixth through all remaining pre-RTF MMT simulations.<br>2. Describe authority and responsibility in determining pre-launch and in-flight anomalies. Describe NASA revisions to the in-flight anomaly system. Include description of the ITA's role in the anomaly process.<br>3. Describe changes to responsibilities and capabilities of the Mission Evaluation Room (MER) since the STS-107 mishap, including relationship to and responsibilities of the Program Integration Team (PIT) and the PIT Boss/Manager.<br>4. Who has final authority to prioritize input from the MER and the PIT to the MMT?<br>5. Describe anticipated MMT awareness of post-STS-107 Design Certification Review (DCR) results. Are there any concerns about, and will simulations explore, possible seams between DCR, FRR, and the first pre-launch STS-114 meeting?<br>6. List NASA RTF Implementation Plan SSP Actions affecting the MMT; whether these have been, or will be, tested in simulation; and accompanying results.<br>7. Provide integrated simulation/evaluation results documenting exercise of CAIB R6.3-2 and R10.3-1, which were conditionally closed subject to MMT simulation. | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Ops-015** | **TPS Inspection/Repair Media Day Demo and KC-135 Test Video and Transcripts** | 6.4-1 | Provide videos and transcripts for the following:<br>1. Tile and RCC inspection and repair explanations and EVA tool/techniques demonstrations provided by JSC in Building 32 on either September 17 or 18, 2003 for Media Day.<br>2. Video tapes of KC-135 tests from 1979-1981 and some representative videos from more recent test in 2003 for tile repair techniques and material testing. These videos should illustrate basic tools, techniques and materials that were studied. | **CLOSED** |
| **Ops-019** | **TPS Repair/Inspection Points of Contact and Concept of Operations** | 6.4-1 | Provide contact information for the Program manager, operations lead, technical lead, and integrator (Program or otherwise; person who is insuring various parallel path items are coming together) for TPS repair/inspection techniques, testing, training and verification. Provide a summary of the concept of operations for any and all TPS repair/inspection techniques under evaluation and provide methodology for certifying for flight. | **CLOSED** |
| **Ops-020** | **TPS Repair/Inspection Test Reports (part 1)** | 6.4-1 | Provide copies of all test reports for any methods of TPS repair/inspection techniques and application processes under evaluation with any applicable crew consensus reports. | **CLOSED** |
| **Ops-021** | **TPS Repair/Inspection Test Reports for future tests - Part 2** | 6.4-1 | Provide copies of all test reports for any methods of TPS repair/inspection techniques and application processes under evaluation with any applicable crew consensus reports for future planned tests. | **OPEN** |
| **Ops-038** | **Sensor/Optics Product Integration for Real-Time Ops Mission Support** | 6.4-1 | 1. Diagram and describe the integrated technical and operations effort to satisfy:<br>(a) Imaging the Orbiter during ascent from the KSC/Canaveral ground sites;<br>(b) Imaging the Orbiter from external tank/SRB-mounted cameras;<br>(c) Imaging the external tank from wheel-well cameras and crew hand-held cameras;<br>(d) Imaging the Thermal Protection System (TPS) using boom-mounted laser; and<br>(e) Imaging the TPS using ground/space-based assets.<br>2. Diagram and describe how the products from items 1a-1e above will be integrated to support real-time operations decisions. | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Ops-059** | **TPS Inspection/Repair Procedures and Flight Products** | 6.4-1 | 1) Current list of EVA procedures and flight products related to the Shuttle TPS repair.<br>2) SRMS RCC wing leading edge survey procedures.<br>3) Option-1 (Shuttle attached to ISS PMA-2 with SRMS) robotic procedures for Shuttle tile repair while attached to ISS.<br>4) ODF procedures for imagery during Shuttle pitch maneuver for tile survey during ISS approach.<br>5) Current and continuing flight plans for STS-114, particularly the EVA TPS repair DTO. | **OPEN** |
| **Ops-060** | **Tile Repair Stabilization Point** | 6.4-1 | 1) Provide a list of the tile areas that can not support a 5psi generic work restraint or stabilization point for the tile repair EVA.<br>2) Provide workarounds planned for repair in areas that can not support an astronaut restraint or stabilization point. | **OPEN** |
| **Ops-061** | **Observe Crew Training Sessions for RPM and Wing Leading Edge Inspection** | 6.4-1 | Description: Task Group Members wish to observe a crew training session for:<br>1) The shuttle R-bar pitch maneuver and tile photographic inspection during Orbiter approach to ISS.<br>2) The SRMS inspection of the wing leading edge for RCC damage. | **OPEN** |
| **Ops-062** | **Observe Human Thermal Vacuum Tests (Cold Case and Hot Case)** | 6.4-1 | Task Group members wish to observe the HTV tests (Cold case primarily but possibly Hot case) for tile repair testing | **OPEN** |
| **Ops-063** | **Complete History of Tile Damage** | 6.4-1 | Provide: A complete history of damage that the shuttle has sustained and landed with | **CLOSED** |
| **Ops-064** | **Observe a suited Tile Repair NBL training run** | 6.4-1 | A task group member wishes to observe a crew EVA tile repair training session in the NBL. | **CLOSED** |
| **Ops-065** | **Critical Damage to RCC Definition** | 6.4-1 | Define the RCC upper and lower critical damage limits (and the methodology for determining those limits) that can be patched and still survive re-entry, including the significant RCC failure modes and the behavior of each during entry (e.g., pass through holes versus delaminations versus cracks, etc.). | **OPEN** |
| **Tech-006** | **TPS Repair Testing Reports Including Astronaut Crew Consensus Report** | 6.4-1 | Pre "Press Day" Inspection and Demos of Tile and RCC repair tools. Informal Q&A and follow-up discussions. Glove Box demonstration for selected TG members. TG fact finding & planning session. | **WITHDRAWN** |
| **Tech-012** | **Tile Repair Materials** | 6.4-1 | 1. Provide material specifications for 511 materials.<br>2. Provide material specification on silicon material. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Tech-013** | **Environment Testing of Tile Repair Materials** | 6.4-1 | Provide briefing to Tech Panel describing the combined environments testing on the tile repair material, i.e. vacuum, temperature, loads, etc. | **CLOSED** |
| **Tech-014** | **Briefing - Tile Repair Materials Procedure** | 6.4-1 | Provide briefing to Tech Panel explaining how tile repair material and procedures will account for and control material expansion protecting for 1/4" step. | **CLOSED** |
| **Tech-023** | **Pull Test on High Temperature Tiles (R6.4-1)** | 6.4-1 | Are there any plans to perform either a sampling or a 100% pull test on high temperature tiles/TPS prior to return to flight? Provide rationale. | **CLOSED** |
| **Tech-041** | **Conduct an "Integrated Imagery/Sensor Inspection" Workshop** | 6.4-1 | 1) Ground-Based Sensors Status<br>2) ET/SRB Sensors Status<br>3) OBSS Status<br>4) Umbilical Well Camera Status<br>5) Hand-Held Camera Status<br>6) Inspection Requirements, Standards, Criteria<br>7) Integrated Risk Assessment<br>8) NASA/NIMA Operational Approach<br>9) Resolution Requirements<br>10) Inspection Timeline & Decision Making Process (MMT)<br>11) Collection/Integration of Sensor Products/Data<br>12) Real-Time Ops Procedures<br>13) Training (crew, Controller, MMT)<br>14) DTO's<br>15) Contract(s) Structure<br>16) Integration with Other Instrumentation<br>17) Revision to NSTS Requirements Documents<br>18) Budget<br>19) Integrated Schedule/Critical Path/Key Milestones<br>20) Role of SEIO<br>21) Integration of Inspection with EVA Repair<br>22) Non-Advocate Review Plans This workshop should include outside experts in Optics, Laser, Software Integration, and Classified Data Gathering/Integration from Government, Industry, and/or Academia. Detailed minutes should be kept. | **CLOSED** |
| **Ops-093** | **R6.4-1: Damage Criticality Maps and Decision Tree for TPS damage evaluation** | 6.4-1 | Develop, document and implement process to provide current damage criticality map and decision tree, and subsequent revisions as available, to TG | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Ops-094** | **R6.4-1: Detailed data request and reporting process for TPS Damage assessments** | 6.4-1 | 1. Provide overall and system level process for how data will be requested from NASA organizations, how this data will be shared among teams and how and who makes the decisions that go to the MMT.<br>2. Describe where this process will be documented for real-time use.<br>3. Demonstrate this process in an integrated simulation | **OPEN** |
| **Ops-095** | **R6.4-1: Process for evaluation of flow field parameters and downstream impacts** | 6.4-1 | Describe process and any tools that will be used to evaluate downstream impacts resulting from damage that perturbs the flow upstream and causes higher heating at downstream locations | **OPEN** |
| **Ops-102** | **6.4-1 Thermal analysis for nominal entry** | 6.4-1 | 1. Provide thermal analysis for nominal entry from a 51.6 degree orbit. Identify changes to input parameters used in this model.<br>2. Provide results from arc jet testing that demonstrate a gradual build-up of heat compared to the immediate high heat models currently in use.<br>3. Provide assessment of return with damage capability for these scenarios. Rationale: Critical debris for abort modes is valid to define design limits on ET. For this case, no safe haven or inspection/repair capability can be implemented. (this would constitute a 2nd fault the 1st one drove the vehicle to the abort mode). The thermal environment for nominal entry is less severe than for abort modes, and should be taken into account when defining critical debris for inspection and repair. | **OPEN** |
| **Ops-103** | **6.4-1 TPS Flight Data vs. Model Correlation** | 6.4-1 | 1. Provide documentation that correlates flight data (including associated flight profiles) with model data for tile and RCC damage.<br>2. Indicate where flight data do not apply in this correlation activity and why. (i.e. different material was used) | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-044** | **Changes to NASA and SSP Waiver Processes, R7.5-1 and R7.5-2** | 7.5-1 | If the Space Shuttle External Tank (ET) sheds foam and requires waiver(s) before flight, describe:<br>1. Waiver(s) required.<br>2. Process flow.<br>3. Who, by billet, decides at each level in the process flow?<br>4. Who, by billet, is ultimately responsible for granting waiver(s)?<br>5. Who, by billet, has veto authority?<br>6. How are cognizant organizations funded? - Describe processes as they existed at the time of the Columbia mishap and as envisioned in Option 1A presented by NASA's Code Q to members of the RTF TG on 10 December 2003. | **OPEN** |
| **Man-088** | **ITA Implementation, R7.5-1 (rolls into 9.1-1)** | 7.5-1 | 1. Detail roles, responsibilities, respective authority, and relationship of HQ elements (e.g., Code Q, Code D, etc.) Center Directors, SSP PM, and projects with respect to ITA's.<br>2. List NASA HQ (particularly Codes Q and D) minimum essential evidence or criteria for evaluating, auditing, changing, and sustaining 7.5-1.<br>3. Describe how multiple Center-based ITA's will arrive at integrated and timely decisions for their required functions (e.g., resolving technical issues across multiple program elements such as Orbiter Vehicle and ET interfaces).<br>4. Describe specific ITA responsibilities and commensurate authority while meeting minimum responsibilities outlined in R7.5-1.<br>5. List which, if any, additional ITA responsibilities and commensurate authority beyond the minimum required by R7.5-1. | **CLOSED** |
| **Man-083** | **7.5-2 NNBE Application to Code Q Review and Assessment Division Processes** | 7.5-2 | Update evolution of the OSMA/QV (Review & Assessment Division - established in December 03) to strengthen NASA SMA independent assessment and review capability including:<br>1. Infusion of SUBSAFE-like audit and review processes into NASA culture.<br>2. Update current NNBE activities, progress reports and efforts to establish a Safety-Critical Decision Making - Training Initiative at NASA (evolved from NNBE Report Volume I and CAIB discussion in Chapter 7).<br>3. Discuss efforts to establish a strengthened independent OSMA SSP-PAR process within the context of an overarching restructured OSMA safety-critical program and pre-operations review process | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-087** | **S&MA Implementation, R7.5-2 (rolls into 9.1-1)** | 7.5-2 | 1. Define NASA's understanding of the following phrases contained in CAIB R7.5-2: "should have direct line authority over the entire Space Shuttle safety organization should be independently resourced.<br>2. Detail, by number, which CAIB findings and recommendations are used as the basis of NASA's implementation of R7.5-2.<br>3. Detail independent funding and independent HR (hire, fire, reporting, and evaluation) aspects of NASA's R7.5-2 direct line authority, including matrix personnel.<br>4. Provide NASA's response to the CAIB comment NASA never provided sufficient independence to its safety organization. | **CLOSED** |
| **Man-029** | **Space Shuttle Systems Engineering Office (MS) Reorganization plans, resources, and documents, R7.5-3 (rolls into R9.1-1)** | 7.5-3 | 1. MS reorganization milestones and master schedule<br>2. MS meeting and workshop schedules, agendas and presentation materials<br>3. MS organization and process documents (e.g., white papers, memoranda, etc.)<br>4. Presentation of MS reorganization budget and resources | **CLOSED** |
| **Man-086** | **Space Shuttle Systems Engineering Office (MS) Charter, Documentation, Roles and Responsibilities, R7.5-3** | 7.5-3 | 1. Provide MS Charter, Statement of Work (SOW), and roles and responsibilities for each of the following SEIO organizations: JSC MS, MS2, MS3, and MS4; MSFC MP71; and KSC MK-SIO.<br>2. Provide existing, or identify, planned MOA/MOU's establishing mutual support requirements between MS and SSP projects.<br>3. Provide list of Program level documentation SE&I is responsible for.<br>4. Provide SE&I Management Plan governing SE&I element integration process or identify plan for providing such documentation.<br>5. Provide report from Aerospace's SE&I organization audits.<br>6. Provide documentation showing extent of MS compliance with Program Manager's Expectations on SE&I identified at SE&I January 28-30 Summit at KSC. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-027** | **Human Resources, Organization and Culture 6.2-1 and 9.1-1** | 9.1-1 | 1. Presentation of NASA's Strategic Human Capitalization Plan.<br>2. Presentation of Succession Plan.<br>3. How NASA has gathered feedback from the workforce regarding moral, views on culture, etc.<br>4. Presentation of NASA's plan to balance civil service and contractor workforce.<br>5. Presentation of NASA's Conflict Management Plan.<br>6. Impact of NESC stand up on line organizations.<br>7. Forward plan for civil service workforce structure (e.g., percentage of increase and decrease per skill and grade, increase and decrease of temporary and permanent positions).<br>8. Code F and NAWAT interfaces and functional relationships. | **CLOSED** |
| **Man-032** | **CAIB Agency Wide Action Team (CAWAT) Status, R6.2-1 and 9.1-1** | 9.1-1 | 1. Brief CAWAT's current status.<br>2. CAWAT Master Schedule.<br>3. CAWAT benchmarking/milestones<br>4. Address CAWAT's conceptual approach to enable NASA's compliance with CAIB recommendation, particularly R6.2-1 and R9.1-1. | **CLOSED** |
| **Man-033** | **Detailed Organization Plan, R9.1-1** | 9.1-1 | 1. Status of Organization Plan.<br>2. Brief of notional approach.<br>3. Presentation of metrics, milestones, and Master Schedule.<br>4. Rationale for separating R7.5-3 from R9.1-1, R7.5-1, and R7.5-2 in Implementation Plan.<br>5. Rationale for assignment of overall responsibility for R9.1-1 implementation to a center individual vice HQ Code, particularly in light of Code Q responsibility for R7.2-1 and R7.5-2.<br>6. Schedule for periodic briefs to RTF TG Management Panel and presentation of options development, risk/benefit analyses, decisions, and progress. | **CLOSED** |
| **Man-034** | **Organization Plan Interdisciplinary Assessment Team, R9.1-1** | 9.1-1 | 1. Personnel assigned, parent organization(s), and team structure.<br>2. Team charter and reporting chain.<br>3. Meeting schedules, locations, agendas, and coordinator's contact information.<br>4. Meeting minutes, presentation material, and supporting documentation.<br>5. Team recommendation and dates of completion and final report. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-035** | **ITEA and S&MA Concepts, R7.5-1, R7.5-2, and R9.1-1** | 9.1-1 | 1. How does NASA define "independent" and "independently" as referred to in R7.5-1 and R7.5-2?<br>2. Notional approach to contractor technical expertise vis-à-vis "independence" criteria and anticipated contract modifications.<br>3. Notional concept separating technical authority from other programmatic functions (e.g., corollary to NAVSEA's warrants/veto authority).<br>4. Risk/benefit analysis of separating final technical and safety authority from line management. Address distinction between centralized safety line authority and "safety is everyone's responsibility."<br>5. NASA's plan to address "High Reliability Theory" versus "Normal Accident Theory" referred to in the CAIB Report. | **CLOSED** |
| **Man-036** | **NASA HQ S&MA Line Authority, R7.5-2 and R9.1-1** | 9.1-1 | 1. Present pre-mishap Shuttle safety responsibility and authority (specifying levels of final accountability), to include contractor roles.<br>2. Present annotated changes to number 1, above, delineating specific improvements and rationale for change. Include interfaces and functional relationships with NESC. | **CLOSED** |
| **Man-037** | **ITEA and NESC Status, R7.5-1 and R9.1-1** | 9.1-1 | 1. Brief status of 14 common themes and concerns delineated in September 2003 White Paper subsequent to NESC tour, as well as other concerns raised during briefings to Congress.<br>2. Brief current NESC staffing, personnel acquisition sources, and budget and funding source(s).<br>3. Provide NESC oversight matrix, organizational interfaces, and functional relationships.<br>4. Discuss lessons learned/observations from 27 October Submarine Safety Colloquium, including planned incorporation into NESC's organization and operational concepts.<br>5. Assessment of NESC's added value to a notional Columbia mishap scenario.<br>6. Is NESC NASA's response to R7.5-1? If not, present NASA's response to R7.5-1 as delineated in R9.1-1. | **CLOSED** |
| **Man-043** | **NASA JSC Workforce Stress Level Survey Results, R6.2-1 and R9.1-1** | 9.1-1 | 1. Provide results from 2000 JSC Stress Survey and actions initiated to reduce identified stress levels.<br>2. Provide results from most recent JSC Stress Survey mentioned in JSC HR e-mail from JSC Center Director, dated 24 October 2003, and any additional actions contemplated to reduce identified stress levels. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-085** | **Space Shuttle Systems Engineering Office (MS) Organization, Staffing, and Schedule, R7.5-3 (rolls into R9.1-1)** | 9.1-1 | 1. Identify MS Office organizational structure and list personnel supporting each. Also list contractor and peer groups supporting each office.<br>2. Provide staffing plans, which identify current and planned personnel needs, organized by skill categories, for each of the SE&I organizations.<br>3. Provide list of Boards, Tech Panels, and Working Groups utilized to resolve SSP integration issues. | **CLOSED** |
| **Man-089** | **ITA and S&MA Implementation Interface, R7.5-1 and R7.2-1 (rolls into 9.1-1)** | 9.1-1 | 1. Differentiate particular S&MA functions included separately and distinctly in R7.5-1 and R7.5-2 implementation, including safety and shutdown responsibilities (e.g., difference between ITA S&MA and R7.5-2 S&MA responsibilities).<br>2.Detail how technical, safety, mission assurance, and warrant/waiver authority will work vis-à-vis R7.5-1 and R7.5-2 implementation and NASA process, with associated timelines, to determine which specific technical standards, specifications, and requirements belong to whom, as well as initiation of warrant/waiver authority.<br>3. Detail any differences in independent funding and personnel policies between R7.5-1 and R7.5-2 implementation. | **CLOSED** |
| **Man-090** | **Organization and Report to Congress Plan, R9.1-1** | 9.1-1 | 1. List specific definition, scope, and applicable distinctions for the following terms used in the most current R9.1-1 Implementation Draft Plan: technical, technical requirements, technical standards and specification, engineering, safety, mission assurance, S&MA, independent, HQ funded, and authority.<br>2. Define institution, institutional side and Enterprise, including center and program roles.<br>3. List proposed success criteria for R9.1-1 and 7.5-1, in particular, vis-à-vis cultural/organizational/leadership change.<br>4. Describe plan to audit, sustain, and annually report R9.1-1 implementation to Congress.<br>5. Describe how the R7.5-1/2/3 implementation structure would help to preclude problems identified in Chapter 7 of the CAIB Re-port, particularly failure to identify the urgency of engineering concerns.<br>6. Provide a matrix and explanation assigning CAIB findings and observations to NASA's R9.1-1and R7.5-1/2/3 implementation response. | **OPEN** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-091** | **Program Manager Authority vis-à-vis ITA and S&MA Implementation, R9.1-1)** | 9.1-1 | 1. Describe measures ensuring Program Managers retain adequate authority to effectively manage their programs and discharge responsibilities during NASA's implementation of CAIB recommendations regarding ITA and S&MA.<br>2. How does NASA intend to identify and deal with counterproductive work stoppages and delays hampering prudent and efficient program execution during NASA's implementation of CAIB recommendations regarding ITEA and S&MA? | **OPEN** |
| **Man-096** | **Clarity Team Report and Cultural Change, R9.1-1** | 9.1-1 | 1. Cross reference Clarity Team Report findings and recommendations to NASA implementation of CAIB RTF R9.1-1, including any impacts upon NASA implementation of CAIB R7.5-1, R7.5-2, and R7.5-3.<br>2. Provide copy of Behavioral Sciences Technology (BST) 5 Month Report on NASA cultural change results as soon as possible.<br>3. Regarding the CAIB Report and SSP, what is NASA's problem statement for cultural characteristics requiring reinforcement, change, or improvement?<br>4. Briefly explain how NASA is incorporating contractor managers, supervisors, and workforce into desired SSP cultural changes.<br>5. Detail how NASA will formally incorporates Clarity Team Report findings into the Implementation Plan. | **OPEN** |
| **Man-098** | **Safety Critical Decision-Making (SCDM) Training Initiative, R9.1-1** | 9.1-1 | 1. Provide briefing materials/media, dates, and locations of NASA Administrators' All Hands briefing to NASA employees referenced in the 24 February 2004 NASA SCDM Training Initiative brief to the RTF TG Management Panel.<br>2. Provide dates, locations, agendas, training materials, and results of Senior Leadership Seminars referenced in brief of item 1 above.<br>3. Provide dates, locations, agendas, training materials, and results of Senior Management Workshops referenced in brief of item 1 above.<br>4. Provide dates, locations, agendas, training materials, and results of Program/Project Team Workshops referenced in brief of item 1 above. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| **Man-099** | **NASA Functional Audit Process, R9.1-1** | 9.1-1 | 1. Provide general implementation status of NASA's Institutional and Functional audit process.<br>2. Provide results of QS requirements scrub process bringing no-brainer requirements into Institutional and Programmatic areas referenced in NAVSEA SUBSAFE Functional Audit Process PHNSY & IMF brief dated 13 February 2004 and provided by NNBE NASA Team members to the RTF TG Management Panel 24 February 2004.<br>3. Provide results derived from using requirements data base to back-index proposed Green Book and Orange Book audit elements to requirements referenced in brief of item 1 above.<br>4. Describe implementation of support contractor acquisition activities enabling QV implementation of Institutional & Programmatic audit process referenced in brief of item 1 above.<br>5. Describe results of discussion of proposed audit processes with NASA SMA Directors, Center Directors, and Enterprise AA's referenced in brief of item 1 above. | **CLOSED** |
| **Man-100** | **Diaz Team Brief Follow Up, R9.1-1** | 9.1-1 | 1. Provide results of Diaz Team programs review by Mr. Fred Gregory, scheduled for the August 2004 timeframe, mentioned by Mr. Al Diaz in his brief to the RTF TG Management Panel 24 February 2004.<br>2. Describe the Independent Technical Assessment Governing Organization (ITAGO) mentioned by Mr. Al Diaz in the brief of item 1 above. List ITAGO's activities and accomplishments.<br>3. Provide current systems management staffing status at Goddard Space Flight Center (GSFC). Describe progress since February 2004 shortfall identified by Mr. Diaz in brief of item 1 above, existing gaps, and get well plan. | **OPEN** |
| **Tech-024** | **Vehicle Re-certification & Hardware Qualifications/Certification Limits** | 9.2-1 | CAIB recommendations 9.2-1 to conduct a vehicle re-certification. SSP action 13 also discusses NASA's plan for hardware to assess whether the hardware is being operated within the qualification and certification limits. The Technical Panel would like a briefing describing the details of the process and plan for implementing these two activities. | **CLOSED** |

| Number | Title | CAIB Rec. | Description | OPEN / CLOSED |
|---|---|---|---|---|
| Ops-077 | **10.3-1 Closeout Photography** | 10.3-1 | 1. Review the baseline the new definition of "closeout photography", and the applicability to the vehicle assembly / processing against defined work instructions, and new processes.<br>2. Review of the requirements, and design specifications for the SIMS software indexing changes that reflect the requested improvements stated in the implementation plan. Schedule for accomplishing these activities is to be supplied as the first deliverable item, and is due 2 weeks after acceptance of this action. | CLOSED |
| Ops-078 | **10.3-1: Close Out Photography Processes – Integration of JSC and MSFC Work Processes** | 10.3-1 | 1. Review of requirements and work processes from JSC and MSFC. Document and / or resolve any discrepancies or conflicts affecting these work documents.<br>2. Provide sufficient evidence that the MMT / MER staff can access the SIMS data base in a timely manner from all required locations.<br>3. Define any process / tool improvements that will be accomplished after the RTF milestone has been passed.<br>4. Provide schedule for training of MER and MCC personnel on SIMS usage. | CLOSED |
| Ops-079 | **10.3-1: Close Out Photography Processes – Documentation and Schedule for Improvements** | 10.3-1 | 1. Document the results of the KSC lead Photo Team evaluation of the KSC equipment, and develop an implementation plan, and schedule to effect the Team's recommendations before RTF.<br>2. Closed loop demonstration of the total photography system process to the RTF TG prior to RTF (STS-114). This demonstration would be considered a RTF TG finding. | CLOSED |
| Ops-080 | **10.3-1: Close Out Photography Processes – Physical Configuration Audit (PCA)** | 10.3-1 | Review of a typical KSC Problem Report and Maintenance Report package process to assure photos of as Built configuration vs. the Engineering Drawings is acceptable for flight. The metrics of this comparison would be considered an RTF TG finding | CLOSED |
| Ops-082 | **R10.3-1: MER Usage of SIMS Database for Access to Closeout Imagery** | 10.3-1 | This RFI documents a Fact Finding meeting being arranged between MER folks (MV6/D. Moyer and SX/D. Smith) and Ops Panel members to discuss MER usage of the SIMS database to access Shuttle closeout imagery. Past experience, issues with user interface and access and involvement in KSC efforts to enhance access capabilities will be discussed. Any other imagery databases planned for use by the MER will also be discussed. | CLOSED |

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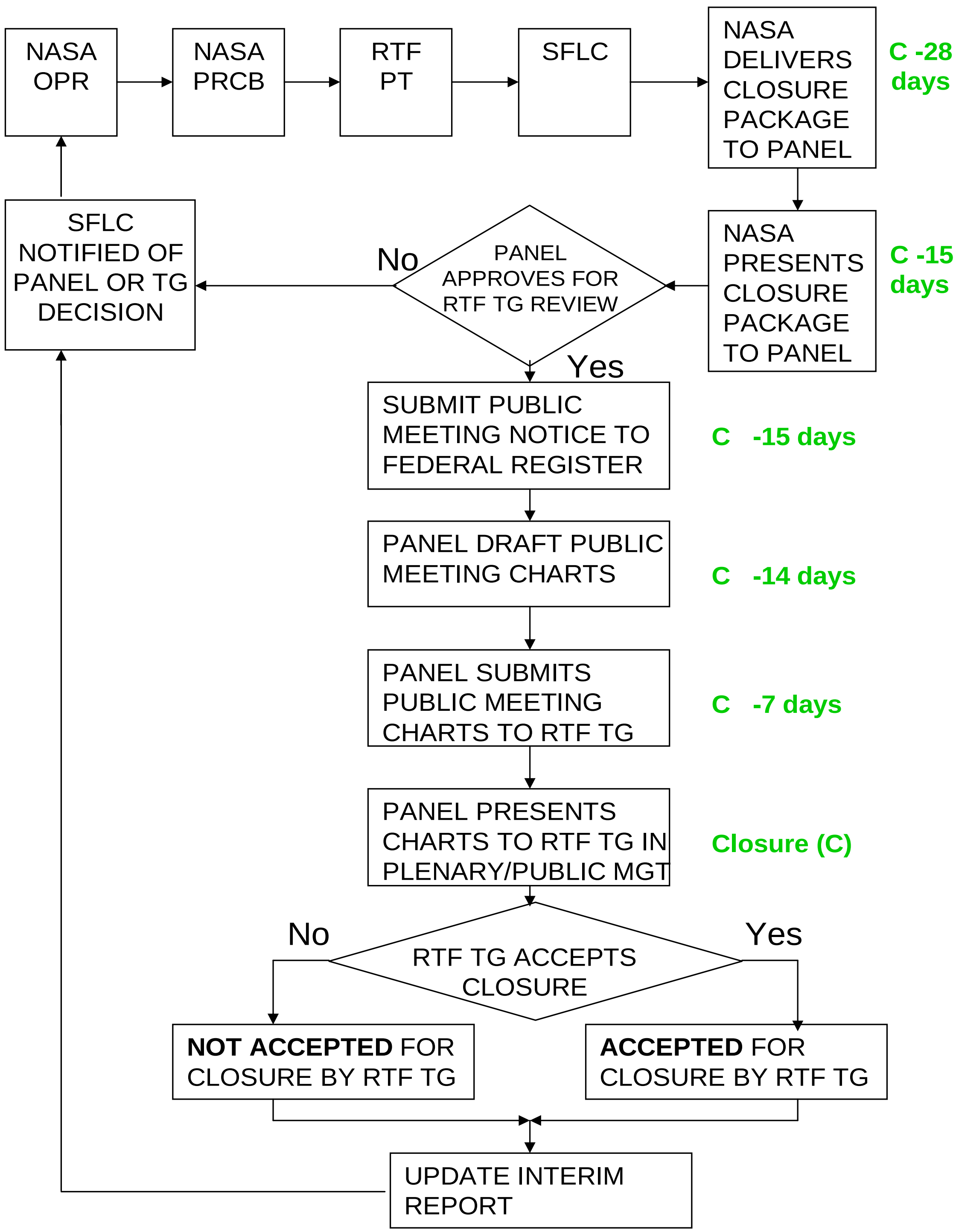
**Appendix F- Process For Review, Signature and Closure**



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# Appendix G - Request for Information Process (RFI) Flow

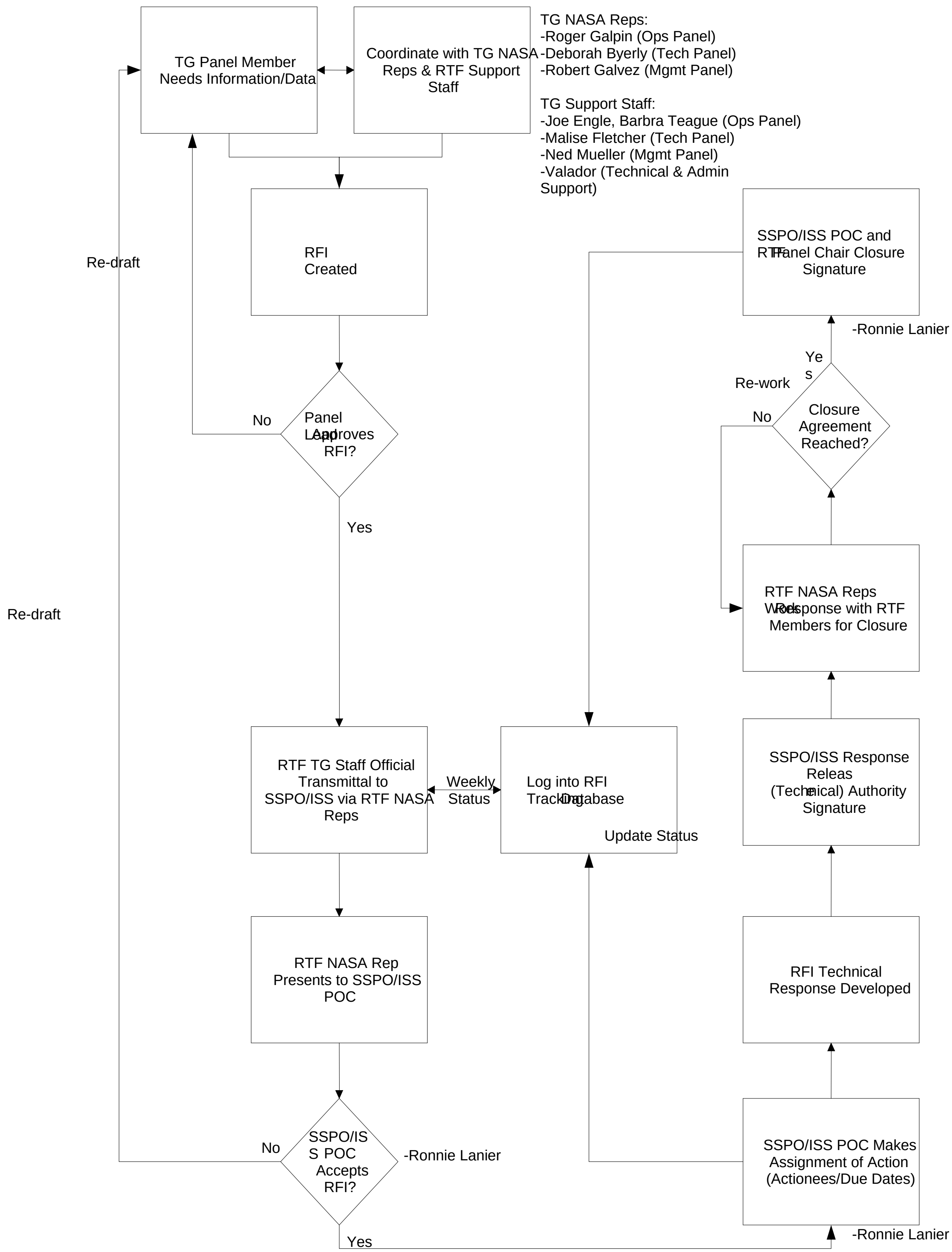
Figure 14 illustrates the process flow for RTF TG members to request information from NASA/contractors. This includes both the SSPO and ISS Office. When a TG member identifies a need for information, the NASA Panel representatives assigned to the RTF TG and the RTF TG Advisory Staff should be consulted about the request. In some cases, an official RFI might not need to be created, i.e., an existing event or meeting. However, once consultation is done and a request is still considered valid, an RFI will be created. Figure 15 illustrates the RFI form. Upon completion of the form, the RFI must be signed by the appropriate TG Panel Lead and NASA Panel representative. At this point, the RFI is considered official and will be released to either the SSPO or ISS Office as appropriate. Concurrent with release to NASA, the RFI is logged into a tracking database maintained by RTF TG staff. The database will be used to keep track of the status of each RFI and maintain a centralized location for close out. RTF TG staff will coordinate with NASA Panel Representative and/or Points-of-Contact (POC) to track due dates, actionees, and status.

A NASA POC has been identified for both the SSPO and ISS Offices. All RFI's submitted by the RTF TG will be coordinated through these NASA POC's. The NASA POC's will have the authority to accept or reject the RFI before passing onto the appropriate office. Rejection of an RFI will result in the NASA Panel Representatives reworking the RFI for acceptability. Once the NASA POC accepts the RFI, due dates and actionees are assigned. This information will be fed back to the RTF TG staff for update of the tracking database.

The appropriate actionee(s) will develop the response to an official RFI. A response will only be considered official when signed by an SSPO/ISS Office Release Response (Technical) Authority. At this point, the NASA Panel Representatives will coordinate the official response with the TG member requesting the information. If the information is deemed acceptable, the NASA POC and the RTF TG Panel Lead will sign the RFI form for official closure. The RFI form and associated response will then be uploaded to PBMA and the tracking database will be updated. RTF TG staff will also maintain a hard copy library of all RFI's and associated NASA responses.

# Appendix G: Request for Information Process (RFI) Flow

## Figure 14 – RFI Flow (RTF TG)



# Appendix G: Request for Information Process (RFI) Form
## Figure 15 – RFI Form (RTF TG)

| | | |
|---|---|---|
| **Date of Request:** ____<br>**RTF Need Date:** ____<br>**Date Received:** ____ | **Return To Flight (RTF)<br>Task Group (TG)<br>Action/Request for Information** | **Action No:** ____<br>**Reference No:** ____ |

**Requestor:** __________ Phone: ________ E-Mail: __________

**Title:** ____________________

**Description:**

| | |
|---|---|
| **Response Format:**<br>☐ CD ☐ 3 ½" Disk ☐ Hard Copy ☐ E-Mail<br>☐ DVD<br>☐ Presented to: ________<br>☐ Other Explain: ________<br>No. of Copies: ______ | **RTF TG Approval of Request:**<br>TG Panel Chair: ________ Date: _____<br>NASA Panel Rep: ________ Date: _____ |
| **SSPO/ISS Acceptance:**<br>Name: ________ Phone: ______<br>E-Mail: __________ | **Action/Data Type:**<br>☐ Action<br>☐ Data Request |

**SSPO/ISS Actionee(s):**

Name: ________ Phone: ______ E-Mail: __________

Name: ________ Phone: ______ E-Mail: __________

Name: ________ Phone: ______ E-Mail: __________

**Actionee Due Date:** ______

**SSPO/ISS Response:**

**SSPO/ISS Response Release (Technical) Authority:**

Approval: ________ Phone: ______ E-Mail: __________

**Closure:**

SSPO/ISS: ________________ Date: ________
*Signature*

Accepted by TG: ________________ Date: ________
*Signature*

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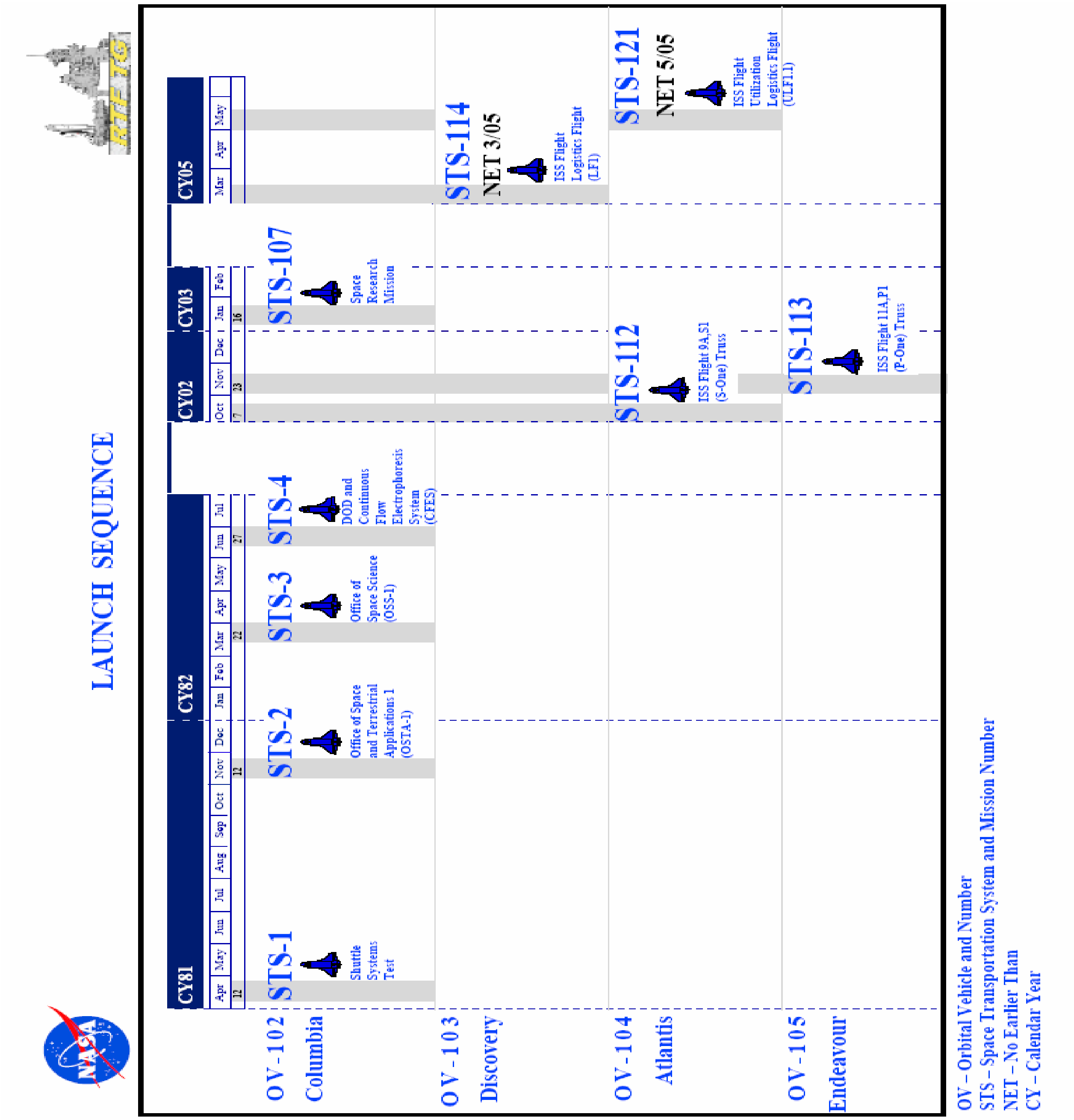
# Appendix H – Shuttle Launch Flow - Historical



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# Appendix I - Acronyms

| | |
|---|---|
| ASAP | Aerospace Safety Advisory Panel |
| BST | Behavioral Science Technology, Inc. |
| CAD | Computer-Aided Design |
| CAIB | Columbia Accident Investigation Board |
| CSCS | Contingency Shuttle Crew Support |
| DCR | Design Certification Review |
| ET | External Tank |
| FACA | Federal Advisory Committee Act |
| FOD | Foreign Object Debris |
| FRCS | Forward Reaction Control System |
| HDTV | High Definition Television |
| ICB | Integration Control Board |
| ISS | International Space Station |
| ITA | Independent Technical Authority |
| IVASP | Integration Vehicle Assessment Sub-Panel |
| KSC | Kennedy Space Center |
| L02/LOX | Liquid Oxygen |
| LH2 | Liquid Hydrogen |
| LON | Launch-on-Need |
| MAF | Michoud Assembly Facility |
| MLGD | Main Landing Gear Door |
| MMT | Mission Management Team |
| MPP | Material Processing Plan |
| MR | Material Review |
| MRB | Material Review Board |
| NESC | NASA Engineering and Safety Center |
| NDI | Non-Destructive Inspection |
| NSI | NASA Standard Initiator |
| OBSS | Orbiter Boom Sensor System |
| OIP | Operations Integration Plan |
| PAL | Protuberance Air Load |
| PR | Problem Report |
| PRCB | Program Requirements Control Board |
| RCC | Reinforced Carbon-Carbon |
| RFI | Request for Information |
| RTF TG | Return to Flight Task Group |
| SEIO | Systems Engineering and Integration Office |
| SFLC | Space Flight Leadership Council |
| SIMS | Still Image Management System |
| SMA | Office of Safety and Mission Assurance |
| SRB | Solid Rocket Booster |
| SRMS | Shuttle Remote Manipulator System |
| SSPO | Space Shuttle Program Office |

| | |
|---|---|
| TPS | Thermal Protection System |
| USA | United Space Alliance |
| WAVE | WB-57 Ascent Video Equipment |
| WLE | Wing Leading Edge |

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