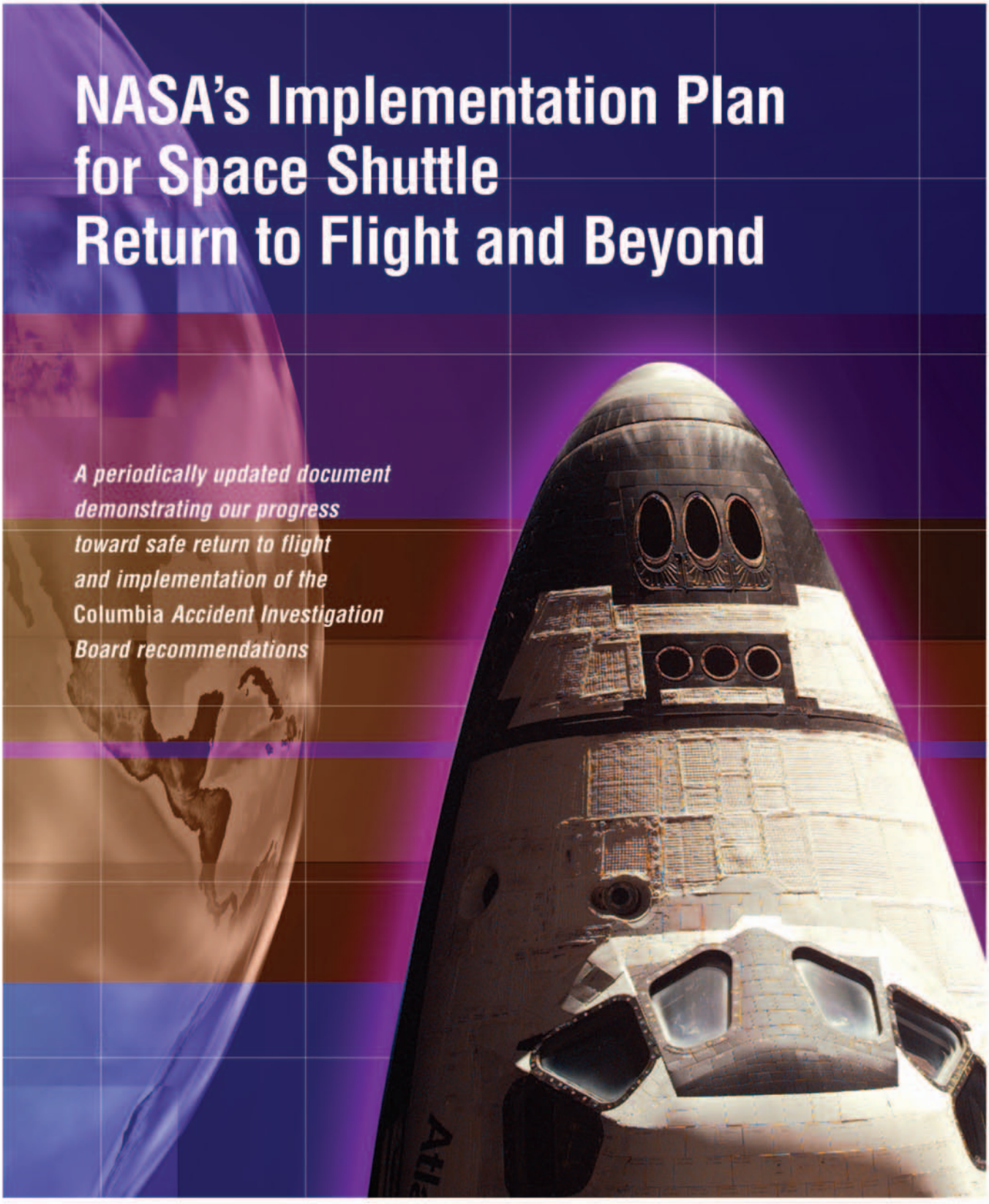
National Aeronautics and Space Administration

July 7, 2005
Tenth Edition
Addendum

NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond

A periodically updated document demonstrating our progress toward safe return to flight and implementation of the Columbia *Accident Investigation Board recommendations*



Message From NASA Administrator Michael Griffin

With this, an addendum to the 10th revision of *NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond*, our Shuttle program team presents the culmination of 29 months of intensive effort to make the Space Shuttle system, and NASA as a whole, stronger, and safer.

Following our rigorous Flight Readiness Review, the launching of the Space Shuttle *Discovery* and its seven person crew on the STS-114 mission is now within sight. This flight will test and validate hardware and procedures developed since the tragic loss of *Columbia* and its valiant crew. The *Discovery* mission represents an important step in our nation's unfolding journey of exploration that will take astronaut pioneers back to the Moon, to Mars, and beyond.

Return to Flight has been a massive effort, focusing the energies of every technical discipline across all the NASA Centers and Space Shuttle contractors on a very specific objective. I am proud of this Agency for its hard work, diligence, and professionalism in working toward the goal of flying the Shuttle safer than ever before. I also appreciate the work of the *Columbia* Accident Investigation Board and the Stafford-Covey Return to Flight Task Group. The members of both bodies have provided valuable recommendations and analysis to our Shuttle program.

We know from hard experience that human space exploration is not and will never be without risk. Nothing great worth doing ever is. But I am firmly convinced that this nation and this agency can execute as safely as humanly possible the bold and noble exploration agenda set forth by President George W. Bush, beginning with the STS-114 mission.

Michael D. Griffin

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Summary

At a plenary meeting held on June 8, 2005, the Stafford Covey Return to Flight Task Group closed five Return to Flight (RTF) recommendations and the Space Shuttle Program (SSP) raising the bar action SSP-3, Contingency Shuttle Crew Support (CSCS). The Task Group held its final plenary meeting on June 27, 2005. At that meeting, the Task Group discussed NASA's efforts to address the remaining three *Columbia* Accident Investigation Board (CAIB) RTF actions: 3.2-1, External Tank Thermal Protection System Modifications; 3.3-2, Orbiter Hardening and Thermal Protection System Impact Tolerance; and 6.4-1, Thermal Protection System On-Orbit Inspection and Repair. In each instance, the Task Group felt that NASA had completed significant work but had not fully complied with all elements of the Task Group's interpretation of the CAIB's intent. The Task Group said, "The remaining three recommendations were so challenging that NASA could not completely comply with the intent of the CAIB, but conducted extensive study, analyses, hardware modifications, design certifications and made substantive progress. However, the inability to fully comply with all of the CAIB recommendations should not imply that the Space Shuttle is unsafe."

CAIB Recommendation 3.2-1 called for NASA to initiate an aggressive program to eliminate all debris shedding from the External Tank at its source. NASA did initiate an aggressive program to eliminate debris. Early in this process we recognized that eliminating all debris is impossible given the existing Space Shuttle configuration. The Task Group chose to interpret this Recommendation in a more restrictive fashion and held NASA to a standard of eliminating all sources of critical debris from the External Tank. For several months NASA strove to identify the debris that would be shed from the External Tank and the ability of the Space Shuttle to withstand damage. This complicated, iterative process still showed that all critical debris could not be eliminated. NASA's debris transport and impact tolerance testing and analysis also showed that it was not necessary in order to significantly reduce the likelihood of damage. However, NASA's program has resulted in a significant reduction in both foam and ice debris that will be shed during launch and ascent. NASA revamped the manual foam application and inspection process; redesigned critical areas of the External Tank and Solid Rocket Boosters; and verified our new processes to ensure that we would not release foam debris over the critical threshold. We have also fully eliminated the proximate cause of the *Columbia* Accident by redesigning the bipod foam area. NASA also took steps to reduce the possibility of critical ice debris by installing a heater on the External Tank feed line bellows and developing more restrictive criteria for our pre-launch ice inspections. Because of these improvements, we do not expect to see any critical foam debris, and the risk of critical ice debris has been reduced to an acceptable level.

The Task Group lauded NASA's work to understand the impact and damage tolerance of the Space Shuttle's thermal protection system and to harden the thermal protection system tiles against damage as called for in CAIB Recommendation 3.3-2. However, the Task Group did not close Recommendation 3.3-2 because NASA cancelled its long-term program to harden the existing Reinforced Carbon-Carbon material. NASA cancelled the development program after the planned service life of the Shuttle was shortened to 2010, consistent with the Vision for Space Exploration.

This decision was based on NASA's assessment of the relative value of investing in along-term capability that might not be available prior to the Shuttle's retirement against the other critical investments needed to ensure the continued safe operations of the Space Shuttle.

Finally, the Task Group acknowledged the significant accomplishments NASA made in implementing CAIB Recommendation 6.4-1, Thermal Protection System Inspection and Repair, but felt that NASA had not met the intent of the CAIB relative to thermal protection system repair. The Task Group felt that NASA's efforts relative to inspection did meet the CAIB's intent. At return to flight, NASA will be fielding an unprecedented capability to detect and inspect the Orbiter's thermal protection system on-orbit. We will also have a limited capability to repair damage to the Orbiter; on our first two flights, the new tools and techniques associated with this capability will be tested in the combined environments of space by manifesting a number of the techniques on the STS-114 and STS-121 missions. The Space Shuttle's thermal protection system was not designed to be repaired on-orbit. As a result, developing repair techniques has been extremely challenging; however, we have put forth our best efforts to develop these capabilities. We acknowledge that our repair capabilities will be limited; we accept the risk associated with those limitations, and we continue work to develop these capabilities. When we return to flight, a combination of Shuttle and International Space Station assets will allow us to detect damage at the critical threshold and inspect any suspect areas with greater detail. NASA had pursued a repair capability at various points over the life of the Shuttle Program. Until now, thermal protection system repair was a technical challenge that eluded us. On the first two flights, STS-114 and STS-121, we will test an array of repair tools and techniques for both thermal protection system tile and the reinforced carbon-carbon panels that make up the wing leading edge. We expect these repair techniques to allow us to fix a range of tile damage, including lost tiles and cracks and holes in the wing leading edge up to 4 inches in diameter. Because of the significant work done to improve the Space Shuttle system and reduce the risk that critical debris will be liberated during ascent, we do not expect to see damage that requires repair; however, it is prudent to field the capabilities we have at return to flight so that we can respond in the unlikely event that critical damage occurs.

Since the loss of the Space Shuttle *Columbia* and her crew, NASA has developed and implemented many safety improvements to the Space Shuttle system to eliminate, reduce, or control the known risks. However, human space flight is inherently risky; at RTF, there will be some residual risk which NASA must accept. To the greatest extent that it is practical and possible on the ground, NASA has thoroughly reviewed and tested the new capabilities developed to detect, inspect, and repair damage to the Orbiter. However, many of these capabilities can only be verified by actual flight operations in the environment of space. The first two RTF Space Shuttle missions will be the test flights that validate our new designs and procedures.

At the Flight Readiness Review for STS-114, NASA formally reviewed the actions taken to prepare the Space Shuttle for return to flight and accepted the level of risk remaining in the Space Shuttle system. NASA is now ready to return the Space Shuttle safely to flight. The Space Shuttle *Discovery* and her crew, commanded by Col. Eileen Collins, is planned for launch July 13, 2005.

Implementation Plan Updates

Update the following in the June 3, 2005, 10th Edition of NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond.

a) Add the following closure statement to the RTF CAIB Recommendations listed below:

"Note: The Stafford-Covey Return to Flight Task Group held a plenary session on June 8, 2005, and NASA's progress toward answering this recommendation was reviewed. The Task Group agreed the actions taken were sufficient to fully close this recommendation."

p. 1-79, R 6.2-1 – Scheduling
p. 1-85, R 6.3-1 – Mission Management Team Improvements
p. 1-89, R 9.1-1 (7.5-1, 7.5-2, 7.5-3) – Detailed Plan for Organizational Change
p. 1-45, R 3.4-1 – Ground-Based Imagery
p. 1-53, R 3.4-3 – On-Vehicle Ascent Imagery
p. 2-5, SSP-3 – Contingency Shuttle Crew Support

b) Add the following statements to the RTF CAIB Recommendations listed below:

"Note: NASA has closed this recommendation through the formal Program Requirements Control Board process. The following summary details NASA's response to the recommendation and any additional work NASA intends to perform beyond the *Columbia* Accident Investigation Board recommendation."

p. 1-1, R 3.2-1 – External Tank Thermal Protection System Modifications
p. 1-15, R 3.3-2 – Orbiter Hardening and Thermal Protection System Impact Tolerance
p. 1-25, R 6.4-1 – Thermal Protection System On-Orbit Inspect and Repair

c) Add the following closure statement to the non-RTF CAIB Recommendations listed below:

"Note: NASA has closed this recommendation through the formal Program Requirements Control Board process. The following summary details NASA's response to the recommendation and any additional work NASA intends to perform beyond the *Columbia* Accident Investigation Board recommendation."

p. 1-41 R 3.8-2 – Reinforced Carbon-Carbon Spares
p. 1-73 R 4.2-4 – Micro-Meteoroid and Orbital Debris Risk

d) Add the following closure statement to the non-RTF CAIB Observations listed below:

"Note: NASA has closed this observation through the formal Program Requirements Control Board process. The following summary details NASA's response to the observation and any additional work NASA intends to perform beyond the *Columbia* Accident Investigation Board observation."

p. 2-35, O 10.1-1 – Public Risk Policy
p. 2-57, O 10.5-2 – Orbiter Processing Improvements
p. 2-79, O 10.8-2 – Galvanic Coupling
p. 2-93, O 10.11-1 – Shuttle Maintenance Through 2020

e) Add the following closure statement to the Space Shuttle Program Actions listed below:

"Note: NASA has closed this Space Shuttle Program (SSP) action through the formal Program Requirements Control Board process. The following summary details NASA's response to the SSP Action and any additional work NASA intends to perform beyond the SSP Action."

p. 2-13, SSP-6 – Waivers, Deviations, and Exceptions
p. 2-21, SSP-10 – Contingency Action Plans
p. 2-29, SSP-14 – Critical Debris Size