



**JUN - 8 2004**

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**TO:** MSFC/MP31/Manager, External Tank Project Office

**FROM:** W/Assistant Inspector General for Auditing

**SUBJECT:** Status of NASA OIG Review of External Tank Thermal Protection  
System Debris Shedding  
Assignment Number A-04-005-00  
Report Number IG-04-020

The Office of Inspector General has been reviewing NASA's progress in responding to Columbia Accident Investigation Board (CAIB) recommendations concerning the thermal protection system (TPS) for the External Tank. (Details regarding the review objectives, scope, and methodology are in Enclosure 1). Determining the cause of the debris shedding from the External Tank is of critical importance for the return to flight of the Space Shuttle. With respect to the External Tank's TPS, the CAIB recommended that NASA initiate an aggressive program to eliminate all External Tank debris shedding at the source with particular emphasis on the region where the bipod struts attach to the External Tank (Recommendation 3.2-1) and require that at least two people attend all final closeouts and observe all intertank area hand-spraying (Recommendation 4.2-3).

While implementation of corrective actions is incomplete, in our opinion NASA is taking appropriate steps to fully address the two CAIB recommendations concerning the TPS for the External Tank. As a result, we plan to suspend activities on this assignment. However, we will continue to monitor NASA's progress in implementing corrective actions for External Tank TPS and reactivate our review as necessary and report the results.

Although the CAIB recommended that the Agency initiate a program that would eliminate all External Tank TPS debris shedding, the CAIB Chairman stated publicly that eliminating all debris from the External Tank would not be feasible. NASA has also stated that it cannot eliminate all debris. The Agency is pursuing methods designed to significantly reduce debris shedding to an acceptable safe level prior to return to flight of the Space Shuttle. In determining what debris shedding is acceptable, NASA has employed a variety of analytical tools from resources both within and external to the Shuttle community. The tools include viable risk management processes for

identifying, assessing, and mitigating risks from the sources of External Tank debris and analytical tools such as (1) failure mode and effects analysis, (2) fault trees, (3) root cause analysis, (4) critical defect analysis, (5) thermal analysis, and (6) transport analysis.

While some shedding of TPS debris is expected on future flights, NASA plans to eliminate debris that could seriously damage critical areas of the Shuttle (this debris is referred to as critical debris) prior to return to flight. NASA is defining critical debris from various points on the External Tank by determining the maximum debris mass allowable and debris flow path based on transport and energy analysis. The Agency plans more testing to finalize the definition of critical debris. Once debris is defined as critical, NASA plans to remove the threat of critical debris shedding at its source prior to return to flight.

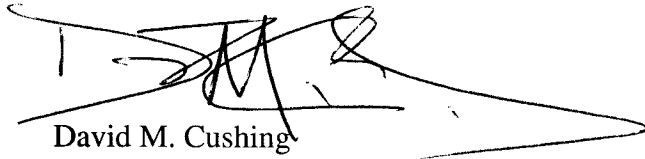
While NASA has stated that it cannot eliminate all TPS debris shedding from the External Tank, we determined that the Space Shuttle Program is taking action to eliminate External Tank TPS critical debris by:

- defining critical debris through identification of TPS debris sources, debris size, impact areas, and impact results;
- determining root causes for TPS debris loss so appropriate corrective measures to eliminate critical debris can be identified;
- mitigating the risk of critical debris shedding by redesigning hardware, using improved materials, and enhancing TPS application processes; and
- developing the means and plans to test and certify or validate materials and processes.

NASA plans to make the External Tanks safer through ongoing efforts that are designed to eliminate critical TPS debris shedding. Specifically, the Space Shuttle Program has a three-phased approach (Enclosure 2) that appears to meet the intent of CAIB Recommendation 3.2-1 by eliminating any critical debris that could endanger the Shuttle. Phase one of the approach includes enhancing or redesigning areas of known critical debris sources and developing a TPS non-destructive evaluation capability. Phase two includes additional post return-to-flight enhancements to the External Tank to further reduce TPS debris, including automating manual TPS spray processes. Phase three is a long-term plan that will offer the best solution for risk reduction through extensive External Tank redesign over the next 5 years. (Phase three could be impacted by NASA's recent announcement of plans to retire the Space Shuttle fleet in 2010).

NASA has also identified corrective actions (Enclosure 3) that will require at least two employees to attend all TPS final closeouts and observe all intertank hand-spraying. Implementation of this plan should meet the intent of Recommendation 4.2-3.

We appreciate the courtesies and cooperation provided to the staff during this review. If you have questions, or would like to discuss this matter further, please contact Mr. Kevin J. Carson, Director, Office of Audits, Safety and Security, at (202) 358-2562, or me at (202) 358-2572.



David M. Cushing

3 Enclosures

cc:

A/Administrator

AD/Deputy Administrator

ADT/Associate Deputy Administrator for Technical Programs

G/General Counsel

M/Associate Administrator for Space Flight

O/Assistant Administrator for Institutional and Corporate Management

OJD/Director, Management Systems Division

Q/Associate Administrator for Safety and Mission Assurance

JSC/AA/Director, Lyndon B. Johnson Space Center

JSC/MA/Manager, Space Shuttle Program

KSC/AA/Director, John F. Kennedy Space Center

MSFC/DA01/Director, Marshall Space Flight Center

MSFC/QS01/Manager, Safety and Mission Assurance

MSFC/RS40/Audit Liaison Representative

SSC/AA00/Director, John C. Stennis Space Center

# **Objectives, Scope, and Methodology**

## **Objectives**

The overall objective was to assist NASA in returning to flight by reviewing activities planned to address recommendations made by the Columbia Accident Investigation Board (CAIB) for the Space Shuttle External Tank Thermal Protection System (TPS). Specific objectives of the review included determining whether NASA has (1) adequate plans to eliminate all External Tank TPS debris shedding at the source, (2) designed a comprehensive testing, certification, and verification program for the External Tank TPS, and (3) established procedures and controls that require at least two employees attend all final closeouts and intertank area hand-spraying.

## **Scope and Methodology**

To review the Agency's plans regarding the External Tank, we conducted interviews and discussions with key NASA and contractor personnel involved in implementing the recommendations of the CAIB and preparing the External Tank for return to flight. We also reviewed applicable documents and records that related to identification and proposed mitigation of External Tank debris shedding, and we physically observed ongoing efforts at the Michoud Assembly Facility to reduce debris to an acceptable level based on transport and energy analysis. In addition, we attended meetings and project status briefings such as the (1) Space Shuttle Program Manager Status Briefings, (2) Space Flight Leadership Council Meetings, (3) Return-to-Flight Task Group Technical Panel Briefings, (4) Critical Design Review Board, (5) Debris Summits, and (6) Government Mandatory Inspection Point Independent Assessment Team Meetings.

## **Management Controls Reviewed**

An assessment of management controls was not part of the review objectives; however, we observed that all levels of management are involved in NASA's efforts to satisfy return-to-flight concerns regarding the External Tank.

## **Review Field Work**

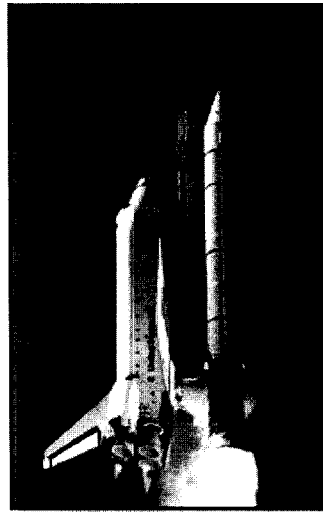
We performed field work for this review at the Kennedy Space Center, Michoud Assembly Facility, Marshall Space Flight Center, and Johnson Space Center from October 2003 to April 2004 in accordance with generally accepted government auditing standards.



**External Tank Project  
Return to Flight**

**Presentation to the  
Stafford - Covey Technical Panel**

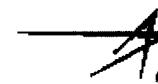
**December 2, 2003**



**CAIB Recommendation for  
External Tank Thermal Protection System**



***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.***






## **Three Phase Approach to Minimal Debris ET**



- **Minimal debris ET concept baselined after Lockheed Martin Ascent Debris Minimization Independent Review Team (ADMIRT) Final Report**
  - Three Phases of Minimal Debris External Tank project plan
    - Phase 1: Develop, design, certify and implement the required modifications to the ET that will allow for a safe return to flight
    - Phase 2: Implement additional enhancements to reduce debris risk
    - Phase 3: Develop, design, certify and implement modifications to the ET that will minimize debris sources in the critical debris zone
  - Progress reviewed by ADMIRT on August 22nd
  
- **Phases 1 and 2 have been actively worked since March 3 and May 5, respectively, with NASA and LMMSS integrated teams**
  
- **Phase 3 has been worked since June through LM funded IR&D (Independent Research & Development)**
  - Offers best solution for debris risk reduction

REVISION 1.0 (MAY 1997) - 10/1997

  
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## External Tank Response to CAIB Recommendation 4.2-3

Space Flight Leadership Council

November 21, 2003

Steve Brettel, NASA/MP31  
Hal Simoneaux, LM/ET



## CAIB Recommendation 4.2-3



- **Finding**

- F.2-13 *Two close-out processes at the Michoud Assembly Facility are currently able to be performed by a single person.*

- **Recommendation**

- R4.2-3 *Require that at least two employees attend all final closeouts and intertank area hand-spraying procedures*

- **Discussion in CAIB report**

- During the Columbia Accident Investigation, a board member observed that a technician could perform a hand-spray TPS application without the presence of another individual to witness the work or to verify that the work had been performed per the process plan

*It is difficult for anyone to access critical Shuttle hardware alone or unobserved by a responsible NASA or contractor employee. With the exception of two processes when foam is applied to the External Tank at the Michoud Assembly Facility, there are no final closeouts of any Shuttle component that can be completed with fewer than two people.*

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Steve Brettel, NASA/MP31

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Enclosure 3



## CAIB Recommendation 4.2-3



- **Corrective Action**

- Manufacturing Process Plans (MPP) will be revised to require (at a minimum):
  - ET critical hardware process i.e. (manual TPS applications) be performed in the presence of two (2) certified Production Operations employees. MPP's will also include a step for technicians to stamp the build paper to verify their presence and validate the work was performed according to plan
  - Additionally, Lockheed Martin Quality Control personnel will witness and accept each hand-spray TPS application
  - Government oversight/surveillance/GMIP of TPS applications will be determined upon completion of the RTF designs and the identification of the critical process parameters

- **Implementation Plan**

- LM Quality currently developing and approving Test Plans for ET RTF design and witnessing development, verification and validation sprays used for testing
- Implementation for flight hardware (including part specific training and certification) will be implemented prior to the first RTF redesign hand-spray application

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Hal Simoneaux, LM&T

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