For Immediate Release
CAIB PA 21-03

Date: *April 17, 2003*
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Columbia Accident Investigation Board Issues Preliminary Recommendations to Improve Inspection and Testing of RCC Components, Shuttle Imaging on Orbit

Houston, Texas -- The Columbia Accident Investigation Board today issued two preliminary recommendations to NASA. Additionally, the Board issued several facts regarding the shuttle program.

Recommendation One: Prior to return to flight, NASA should develop and implement a comprehensive inspection plan to determine the structural integrity of all Reinforce Carbon-Carbon (RCC) system components. This inspection plan should take advantage of advanced non-destructive inspection technology.

This recommendation was issued because of the board's finding that current inspection techniques are not adequate to assess structural integrity of RCC, supporting structure, and attaching hardware.

Recommendation Two: Prior to return to flight, NASA should modify its Memorandum of Agreement with National Imagery and Mapping Agency (NIMA) to make on-orbit imaging for each Shuttle flight a standard requirement.

This recommendation was issued because of the board's finding that the full capabilities of the United States Government to image the Shuttle on orbit were not utilized.

Facts Regarding RCC Components -- The board will include the following facts in its final report:

- The Reinforced Carbon-Carbon (RCC) system (including all RCC, supporting structure and attaching hardware) is an essential component of the Space Shuttle Orbiter Thermal Protection System (TPS) and has a Criticality Rating of 1 (loss of crew - loss of vehicle).

- The RCC composite consists of a reinforced carbon-carbon substrate that carries the structural loads, a tetraethyl orthosilicate impregnation that reduces inherent substrate porosity, a silicon carbide treatment that protects the substrate from oxidation, and a sealant coating that provides additional oxidation protection. These composite structures are attached to the shuttle by a metal support system.

- During initial manufacturing acceptance, the integrity of production composites used in the RCC system is checked at various points in production by physical tap, ultrasonic, radiographic, eddy current, weight gain, and visual tests. In addition, a flat plate control panel made in parallel with the production piece is destructively tested at various points in the production process.

- A projected design mission life has been established for each RCC component. These projections are based on analysis correlated to simulated flight load testing, and assume the presence of sound composite material and metal support structure.

- Visual external inspections and tactile checks are the only specified post flight inspections of RCC composite components. The planned interval for removing RCC composite components for more thorough inspection is typically many flights, unless their removal is dictated by an observed

visual surface condition or necessitated by the requirement to provide access for other operations.

- Non-destructive testing of some post-flight RCC components has shown indications of RCC material defects not previously identified by visual inspection methods currently employed.

Facts Regarding Shuttle Imaging -- The board will include the following facts in its final report:

- The U.S. Government has the capability to image the Shuttle on orbit.
- A Memorandum of Agreement exists between NASA and NIMA regarding on-orbit imaging of the Shuttle.
- During the flight of STS-107, there were no on-orbit images taken of sufficient resolution to assess the Orbiter's condition.

The CAIB issued these recommendations and findings in advance of their appearance in the final report. The board's final report will be issued later this summer. It will include the probable cause of the accident, contributing factors, findings and additional recommendations.

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Date: *June 27, 2003*

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Columbia Accident Investigation Board
Issues Preliminary Recommendation Three:
On-Orbit/On-Station TPS Inspection and Repair Capability

ARLINGTON, VA – The Columbia Accident Investigation Board today issued its third preliminary recommendation to the National Aeronautics and Space Administration, in advance of its appearance in the final report.

Recommendation Three:

- Before return to flight, for missions to the International Space Station (ISS,) develop a practicable capability to inspect and effect emergency repairs to the widest possible range of damage to the Thermal Protection System (TPS,) including both tile and Reinforced Carbon Carbon (RCC,) taking advantage of the additional capabilities available while in proximity to and docked at the ISS.

- Before return to flight, for non-station missions, develop a comprehensive autonomous (independent of station) inspection and repair capability to cover the widest practicable range of damage scenarios.

- An on-orbit TPS inspection should be accomplished early on all missions, using appropriate assets and capabilities.

- The ultimate objective should be a fully autonomous capability for all missions, to address the possibility that an ISS mission does not achieve the necessary orbit, fails to dock successfully, or suffers damage during or after undocking.

Facts:

- At present there is no certified on-orbit or on-station capability to inspect the orbiter TPS for damage, or to effect repairs.

- Past efforts, some predating STS-1, have not resulted in an operational capacity.

- Changes in imaging and inspection capabilities, materials technology, and the access provided by the ISS have greatly improved the prospects for deploying this capability.

Finding:
An inspection of the TPS, accomplished as soon as possible after achieving orbit/rendezvous, coupled with repair capability, would result in improved safety.

Background:
The Board is convinced of the necessity of taking all practicable steps to “de-couple” foam insulation shedding from loss of crew and vehicle, including: 1) design improvements to prevent foam shedding; 2) toughening the TPS; 3) improved TPS inspection and repair capability.

An inspection and repair capability is fundamental to improving the ability of the orbiter to experience TPS damage without catastrophic consequences.

This effort does not reduce the urgency or importance of aggressively reducing all sources of potential damage to the orbiter. Only by reducing the likelihood of damage to the orbiter, as well as developing the ability to detect and repair damage, can the maximum safety improvement be realized.

During the STS-107 flight and investigation, the lack of repair capability was cited repeatedly, and may have been a factor in decisions made during the STS-107 mission, including the decision not to seek images which might have assisted in the assessment of damage resulting from the foam strike on ascent.

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Date: *July 1, 2003*

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Columbia Accident Investigation Board Issues Preliminary Recommendation Four: Launch and Ascent Imaging

ARLINGTON, VA – The Columbia Accident Investigation Board today issued its fourth preliminary finding and recommendation to the National Aeronautics and Space Administration, in advance of its appearance in the final report.

Recommendation Four:

- 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 readiness of these assets should be included in the Launch Commit Criteria for future launches.

- Consideration should be given to using mobile assets (ships or aircraft) to provide additional views of the vehicle during ascent.

Facts:

- Imaging the Space Shuttle vehicle during launch and ascent provides necessary engineering data including the ability to examine the entire Space Shuttle system for any unexpected debris or other anomalies during ascent.

- A variety of assets are already in place at the Kennedy Space Center (KSC) and on the Air Force Eastern Range (ER) to accomplish this task.

- Ascent data from the optical assets at KSC and the ER are reported to the Mission Management Team in the days following the launch. A “quick look” report is available the day after launch, and a more detailed analysis is available within a few days. For the most part, engineering quality ground-based data is not available in real time.

- During the STS-107 ascent, two ground-based long-range camera sites provided data that was usable for evaluating the foam strike against the vehicle. A third camera that would have provided a better view was unusable.

Findings:

- The current long-range camera assets on the Kennedy Space Center and Eastern Range are inadequate to provide best possible engineering data during Space Shuttle ascents.

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

Background:

- The Space Shuttle is still a developmental vehicle, and engineering data from each launch is essential to further understand the vehicle.

- Although numerous ground-base imaging assets are available, they are often inadequate to provide meaningful data to the program.

- The ability to validate models on the effect of the TPS debris strikes has been hampered by the lack of high quality ascent image data.

- The existing camera sites suffer from a variety of readiness, obsolescence, and urban encroachment (i.e., civilian buildings around the asset) problems.

- The imaging systems have not been upgraded to reflect changes in launch patterns, primary azimuths associated with International Space Station support missions.

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Columbia Accident Investigation Board Issues Preliminary Recommendation Five: On-Board Ascent Imaging

ARLINGTON, VA – The Columbia Accident Investigation Board today issued its fifth preliminary finding and recommendation to the National Aeronautics and Space Administration, in advance of its appearance in the final report.

Recommendation Five:

- Provide a capability to obtain and downlink high-resolution images of the External Tank (ET) after ET separation. Modifying one of the two umbilical cameras to meet this requirement is acceptable.

- Provide a capability to obtain and downlink high-resolution images of the underside of the orbiter leading edge system and forward section of both wings' Thermal Protection System (TPS).

Facts:

- Imaging the Space Shuttle System during launch and ascent provides necessary engineering data including the ability to examine the Space Shuttle System for any unexpected debris or other anomalies during ascent.

- The Shuttle has two on-board cameras that image the ET after separation, but the images from these cameras are available only post-flight.

- Very little engineering quality, on-board imaging of the ET was available for STS-107.

Findings:

- There is a requirement to obtain and downlink on-board engineering quality imaging from the vehicle during launch and ascent.

Background:

- The Space Shuttle is still a developmental vehicle, and engineering data from each launch is essential to further understand the vehicle.

- An ability to provide engineering quality imaging data of the ET after separation is important to determine if any debris from the ET was shed during ascent.

- Since the total elimination of all sources of debris has not yet been achieved, a much better understanding of all the potential sources of debris is required.

- Since the total elimination of all sources of debris has not yet been achieved, early detection of debris strikes against the forward underwing TPS of both wings will increase safety margins.

- The CAIB is aware of the excellent preliminary work already in progress at NASA in this area.