Loss of Signal
Aeromedical Lessons Learned from the STS-107 Columbia Space Shuttle Mishap

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Loss of Signal, a NASA publication to be available in May 2014, presents the aeromedical lessons learned from the Columbia accident that will enhance crew safety and survival on human spaceflight missions. These lessons were presented to limited audiences at three separate Aerospace Medical Association (AMA) conferences in 2004 in Anchorage, Alaska, on the causes of the accident; in 2005 in Kansas City, Missouri, on the response, recovery, and identification aspects of the investigation; and in 2011, again in Anchorage, Alaska, on future implications for human spaceflight. As we embark on the development of new spacefaring vehicles through both government and commercial efforts, the NASA Johnson Space Center Human Health and Performance Directorate is continuing to make this information available to a wider audience engaged in the development and design of future space vehicles.

The Investigation

The Crew Survival Working Group - Ninety minutes after loss of signal, Admiral Harold W. Gehman, Jr., was named Chair of the Columbia Accident Investigation Board (CAIB) by the NASA Administrator. One of his first acts was to appoint an independent group of experts to advise the CAIB on issues related to the investigation. This group included an aeronautics expert, an accident investigation specialist, and an atmospheric scientist who were appointed to help the CAIB understand the conditions that led to the loss of Columbia. The CAIB was established by Admiral Gehman in January 2003 to investigate the causes of the accident and to recommend changes to improve the safety of future space missions.

The Analysis

Columbia’s reentry on February 1, 2003, was a direct result of the Columbia's mechanical injury during the CE and the CMCE. The crew module depressurized rapidly. The crew module catastrophic event (CMCE) involved the complete breakup of the crew module. The forensic medical findings of injuries incurred during and after the CE and the CMCE can be categorized as follows:

1. Mechanical injuries incurred during the CE
2. Depressurization injuries incurred after the CE
3. Mechanical injuries incurred after the CE and before the CMCE
4. Thermal injuries incurred during the CMCE and exposure to the atmospheric environment
5. Common injuries incurred during the CMCE and ground impact

Analysis of legal issues encountered during the recovery and investigation also resulted in valuable lessons learned for future spacecraft aircraft investigations.

The Mission, Crew and Mishap

When STS-107’s flight was announced, the Space Shuttle Program was focused on assembling the International Space Station. However, NASA decided to have this one last research-dedicated Space Shuttle mission using the SMEX/HAB laboratory. STS-107 research focused on the consequences of microgravity on physical and living systems. The underlying goals were to enhance the well-being of people on earth using microgravity for basic scientific understanding with the expectation that this knowledge might enable scientists to build better spacecraft and to understand the human system. Once the science was selected, NASA mission managers and the STS-107 crew worked with the investigators to ensure the highest quality of research.

Columbia launched the morning of January 16, 2003 for the 16-day mission. During ascent, foam debris from the external tank shed during the extreme conditions of launch and struck the left wing of Columbia exactly 81.9 seconds into the flight. It was recognized that Columbia had suffered a debris strike, analysis and engineering experts worked to identify the significance of this event for vehicle integrity. Because operational experience with previous foam debris strike events had shown that such strikes had never caused significant structural damage, this event was not considered mission critical and the flight continued uninterrupted.

On the morning of February 1, Columbia began her return to Earth. At 08:59:32 CST, no further telemetry was received from Columbia. This moment would come to be known as the Loss of Signal. The initial search area for crewmembers was 200 miles long and 50 miles wide. As recovery patterns emerged, the search area was redefined as a more manageable 60 mile x 5 mile corridor. The final area was 25 miles x 1 mile. The first crewmember remains were transported from Lufkin, TX, to Barkdale AFB on February 2, 2003. Twelve days after the accident, all crewmembers had been identified. The official search for remains was terminated on February 13th.

The Response

Within hours of the mishap, the Columbia Mishap Investigation Team (MIT) was activated, and by 3:30 PM CST members of the Johnson Space Center and Kennedy Space Center teams were enroute to Barkdale Air Force Base (AFB), LA, the strategic command center for recovery operations. The primary objective of the MIT medical team was to receive, analyze, identify and transport human remains to the Armed Forces Institute of Pathology (AFIP) at Dover AFB, DE. Additionally, a team from the Office of the Armed Forces Medical Examiner deployed to Barkdale AFB to begin preliminary examination of recovered remains.

A disaster field office was established in Lufkin, Texas, to manage the crewmember recovery effort carried out by 2000 personnel. Search methods for the crew included the search dogs and heat sensors. As remains were discovered, they were photographed and catalogued by Federal Bureau of Investigation (FBI) Forensic Response Teams (ERT). Human remains were transported from the recovery point to Lufkin, TX, then to Barkdale AFB and subsequently flown to Dover AFB.

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The Future

One of the lessons learned from the loss of the Space Shuttle Columbia was that root-cause investigations do not dig deep enough to trace the initial crewmember experiences to determine the successes and failures of protective measures. Pathology investigations focused on determining the root cause of the mishap and preventing recurrence. However, if the crewmembers were not identified in the causal chain of events, their experiences were not analyzed and lessons were lost.

The crew survival in-depth investigation process supplements the root-cause investigation. The crew survival investigation focus is different from that of the usual mishap investigation. Specifically, the crew survival investigation team investigates the performance of the crew, crew protective equipment, crew-vehicle interfaces, emergency and crew survival systems, training, and procedures that are intended to protect the crew. A crew survival specialist, with extensive mishap investigation and human factors training, leads the team. Typical team members are a medical doctor, a pathologist, a legal representative, and specialists in structures, environmental control and life support systems, flight performance, and crew equipment (crew survival and emergency equipment and crew suits).

The outcomes of the crew survival investigation are the awareness of factors and effects that affected crew survivability and recommendations for improving crew survival for future human space flight.