



Engineering Ethics: The Columbia Space Shuttle Disaster

An Online Continuing Education Course for Engineers

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Engineering Ethics: The Columbia Space Shuttle Disaster

Edward P. Brunet, Jr., P.E.

In 1981, Columbia became the first shuttle to reach space successfully. Its first flight took place in April 1981, and it successfully completed 27 missions, spending a total of 300 days, 17 hours, 40 minutes, and 22 seconds in space, before the disaster that occurred on February 1, 2003.

Columbia, on mission STS-107, left Earth for the last time on January 16, 2003. At the time, the shuttle program was focused on building the International Space Station. However, STS-107 stood apart as it emphasized pure research. From 1981 to 2003, Columbia carried dozens of astronauts on missions; its final flight, STS-107, a 16-day research mission, focused on scientific experiments. The crew was a diverse group and included the first Israeli astronaut, Ilan Ramon, and the first Indian-born woman in space, Kalpana Chawla.

During the crew's 16 days in space, however, NASA investigated a foam strike that had taken place during launch. About 82 seconds after Columbia left the ground, a piece of foam fell from a "bipod ramp" that was part of a structure that attached the external tank to the shuttle. Video from the launch appeared to show the foam striking Columbia's left wing. (Howell, 2019) Although similar incidents had occurred on three prior shuttle launches without causing critical damage, some engineers at the space agency believed that damage to a wing could cause a catastrophic failure. (History.com)



Figure 1 - The left bipod foam ramp which damaged the wing

On the second day of the mission, the chair of the Intercenter Photo Working Group contacted the Shuttle Program Manager for Launch Integration at Kennedy Space Center (KSC) to request imagery of Columbia's left wing on-orbit. The program manager agreed to explore the possibility—this was the first imagery request of the mission. (Space Safety Magazine, 2014)

A Debris Assessment Team (DAT) was formed with NASA and contractor engineers. DAT contractor engineers prompted a NASA shuttle manager to make a second imagery request. The Department of Defense (DoD) Manned Space Flight Support Office began implementing the request with the understanding that this was merely information gathering, not a formal request for action. The first formal DAT meeting was held on January 21, 2003, five days into the mission.

Without additional on-orbit pictures, the DAT was restricted to using a mathematical modeling tool called Crater, which predicts the depth to which debris will penetrate a Thermal Protection System (TPS) tile. Crater was suitable for small debris impacts, on the order of 49cm³ – versus 19,665cm³, the estimated size of the bipod ramp foam. Crater was classified as a “conservative” tool based on its projections of ice projectile damage to reinforced carbon-carbon panels (RCC) turning out to be more severe than that achieved experimentally. Because foam is less dense than ice, the DAT used a qualitative extrapolation of the test data and engineering judgment that a foam impact angle of up to 21° would not penetrate the RCC. (Space Safety Magazine, 2014)

The assumptions and uncertainty incorporated in this analysis were never fully presented to the Mission Management Team (MMT). The DAT assigned the NASA co-chair to pursue a request for imagery of the vehicle on-orbit—constituting the third request for imagery—by going through the engineering department rather than through shuttle program managers. The imaging request was viewed by shuttle program managers as a non-critical engineering desire rather than a critical operational need. (Space Safety Magazine, 2014)

Seven days into the mission, a NASA Headquarters Safety and Mission Assurance (S&MA) manager called a Johnson Space Center (JSC) S&MA manager for the Shuttle Safety Program and the Associate Administrator (AA) for S&MA, to discuss a potential DoD imaging request. The JSC manager for Shuttle Safety program said he was told this was an

“in-family” event—meaning it was normal and nothing to worry about. The AA for S&MA stated that he would defer to Shuttle management in handling such a request. Despite two safety officials being contacted, safety personnel took no actions to obtain imagery. (Space Safety Magazine, 2014)

This lack of action would later render NASA incapable of bringing the shuttle safely home and sparing the lives of the crew.

After discussion with other MMT members, the Shuttle Program Manager cancelled the DoD imagery request. The MMT had concluded this was not a safety-of-flight issue, apparently confusing the notion of foam posing an “acceptable risk” with foam not being a “safety-of-flight” issue. MMT members were making critical decisions about TPS damage tolerance based on little or no knowledge. (Space Safety Magazine, 2014)

Several people, including engineers, within NASA pushed to get pictures of the breached wing in orbit. The Department of Defense was reportedly prepared to use its orbital spy cameras to get a closer look. However, NASA officials in charge declined the offer, according to the Columbia Accident Investigation Board (CAIB) and “Comm Check,” a 2008 book by space journalists Michael Cabbage and William Harwood, about the disaster. (Howell, 2019)

On February 1, 2003, the shuttle made its usual landing approach to the Kennedy Space Center. Just before 9 a.m. EST, however, abnormal readings showed up at Mission Control. Temperature readings from sensors located on the left wing were lost. Then, tire pressure readings from the left side of the shuttle also vanished. (Howell, 2019)

Although the shuttle broke up during re-entry, its fate had been all but sealed during ascent, when a 1.67-pound piece of insulating foam broke away from an external fuel tank and struck the leading edge of the craft’s left wing. The foam punched a hole that would later allow superheated gases to cut through the wing’s interior like a blowtorch. (Schwartz, 2008)

The Capcom, or spacecraft communicator, called up to Columbia to discuss the tire pressure readings. At 8:59:32 a.m., shuttle commander Rick Husband called back from Columbia: “Roger,” followed by a word that was cut off in mid-sentence. At that point, Columbia was near Dallas, travelling 18 times the speed of sound and still 200,700 feet (61,170 meters) above the ground. Mission Control made several attempts to get in touch

with the astronauts, with no success. It was later found that a hole on the left wing allowed atmospheric gases to bleed into the shuttle as it went through its fiery re-entry, leading to the loss of the sensors and eventually, Columbia itself. (Howell, 2019)

Residents in the area heard a loud boom and saw streaks of smoke in the sky. Debris and the remains of the crew were found in more than 2,000 locations across East Texas, Arkansas and Louisiana. Making the tragedy even worse, two pilots aboard a search helicopter were killed in a crash while looking for debris. (History.com)

At the Kennedy Space Center, the families of the astronauts waited to welcome them home, but contact was never made again. Two minutes after KSC lost contact with the shuttle, video footage emerged of Columbia re-entered the atmosphere. All



Figure 2 – The Columbia astronauts who died in Mission STS-107