Madison Saunders

AVIA 3143

Columbia

The *Columbia* disaster was led by a shifting need of the shuttle program and a series of assumptions. This led to a misunderstanding of the true nature of the incident while it was happening. The significance of *Columbia* is how the shuttle program changed with the protocol that the orbiter would roll over to have the International Space Station (ISS) check the heat shield and that safety programs had not been put in place after *Challenger*.

History of the Shuttle Program

The shuttle program was the next and an ambitious step after the end of the Apollo era in 1970. The original goals where to be able to have a fully reusable two stage rocket with consistent flights that could service a space station and put up both commercial and governmental satellites with a future Martian goal (Board, 2003). At the time, the space race was winding down and this was after the Apollo-Soyuz mission. With a decreasing governmental and public interest, the National Aeronautical and Space Administration (NASA) had to find a solution to get the program funded. The solution was to make the Shuttle into a revolutionary spacecraft with being reusable, wings, reusable thermal protection, high-pressure engines, and to transition from orbital to glide for reentry (Board, 2003).

NASA after the space race was made to cut down on the budget and slowly lost purchasing power. The space race had high public and political interest. In May 1971, NASA was told to only expect a max amount of $5 billion for five years for a new program which made the goals had to be pulled back and promises that wouldn't be able to kept up with (Board, 2003). These promises have that each shuttle would be able to have 100 launches, $7.7 million dollars for each flight, for a cost of $5.15 billion and it was known to be optimistic, but was approved on January 5, 1972 by Nixon (Board, 2003). Apart of this was the justification of all mission types would need 50 launches per year that would include a relationship between

Department of Defense and commercial along with scientific mission (Board, 2003). As the years went on, the shuttle program was cut back from the original vision.

STS-1 was launched using *Columbia* for a first flight and without prior flight testing. This was a deviation from historical NASA programs as there was on-ground testing and unmanned flight testing. Mercery had Ham before any astronaut was launched (National Aeronautical Space Administration, 1961). Apollo lost three astronauts during an on-ground test that was later renamed as Apollo 1 in honor of the American astronauts who first would loose their lives in the name of space exploration (National Aeronautical and Space Administration, 2015). The shuttle program however only had on ground and the STS-1 launch as tests, with STS-1 being a manned flight (Board, 2003). This was the first time after the Apollo-Soyuz that Americans had been in space as it took time with politics and development to occur. It was declared operational early for NASA wanting a quick approval for a manned space program of a space station and had commercial competition in the form of European Space Agency for commercial satellite launching (Board, 2003). Before *Challenger*, there was an average of 67 days between ready status for the Shuttle and a goal of 24 launches with a record of 9 launches during one year (Board, 2003). These factors lead to a management system that allowed a more relaxed safety system and the system was never fully understood. It would come to a head on January 28, 1986 as the *Challenger* accident occurred. As the 25th launch occurred, the 73rd second was when the O-ring failure occurred that caused the Solid Rocket Booster to fail and allow the explosion to occur (Board, 2003).

After *Challenger*

After *Challenger*, the Rogers Commission found that the night before the launch that there were discussions being made about the cold temperatures (Board, 2003). The

recommendations were to have an independent safety review board that reported to the Administrator along with other structural changes (Board, 2003). Risks are something that cannot be ignored otherwise disaster will follow not long after, as evidence of *Challenger* occurring in the first place. Safety is a living and breathing consideration that must be at a forefront in planning, especially in a scenario that would easily cause a loss of life event. After *Challenger* it took 32 months, an estimated $12 billion cost for the country, a new Orbiter named *Endeavour* (Board, 2003).

History of the *Columbia* Orbiter

The *Columbia* orbiter was the oldest built and functional orbiter. This means that the orbiter was not designed to the higher standards of the others in the fleet and was unable to dock to the ISS unlike the other Orbiters that were able to dock directly with ISS. The resemblance to the original build included more than 44 precent of tiles and 41 titles of leading-edge tiles (Board, 2003). Most of the science biased missions were selected to be on Columbia due to the fact that the missions would prepare scientists for the future ISS transition (Board, 2003). The early standards and non-standard construction would impact what options where available to managers when it came to any rescues attempts that would be available. There were plans after STS-107 to modify the Orbiter to be able to dock with the ISS safely and to be prepared for ISS mission (Board, 2003).

Mission ID	Date	Launch Pad
STS-1	4/12/1981	A
STS-2	11/12/1981	A
STS-3	3/22/1982	A
STS-4	6/27/1982	A

Mission ID	Date	Launch Pad
STS-5	11/11/1982	A
STS-9	11/28/1983	A
61-C	1/12/1986	A
STS-28	8/8/1989	B
STS-35	12/2/1990	B
STS-50	6/25/1992	A
STS-52	10/22/1992	B
STS-55	4/26/1993	A
STS-58	10/18/1993	B
STS-62	3/4/1994	B
STS-65	7/8/1994	A
STS-75	3/9/1996	B
STS-78	6/20/1996	B
STS-80	11/19/1996	B
STS-83	4/4/1997	A
STS-94	7/1/1997	A
STS-87	11/19/1997	B
STS-90	4/17/1998	B
STS-93	7/23/1999	B
STS-109	3/1/2002	A
STS-107	1/16/2003	A

(Frommert, n.d.)

STS-107

Prior to Launch

Scheduling of the Shuttle did not always correlate with naming of the missions, nor did the missions always keep the same naming rules. This also means that the STS-107 was the 113 launch and the 28th flight of *Columbia* (Board, 2003). The first Israeli astronaut was brought over as an international experiment called the Mediterranean-Israeli Dust Experiment (MEIDEX). Additional security had to be put in place due to this international cooperation due to national security concerns (Board, 2003). (CNN Editorial Research, 2023)

In many cases within aviation, the concern of national security occurs and international cooperation must be coordinated for this reason. There were 13 delays over two years due to other missions being considered more important (Board, 2003). This would be due to competing Human Space Flight objectives and interests. Maintenance took longer due to wiring having problems, a four-month grounding due to flowline cracks discovered on *Atlantis* which did allow for some repairs and items being fixed (Board, 2003). The crew and Mission Operations had no problems with training and the delays would allow a more in-depth training (Board, 2003). There were 3.9 million steps to complete in the preparation of the Orbiter that had to be completed (Board, 2003). The final Flight Readiness Review was held a week after the standard two-week

review that included various departments within NASA (Board, 2003). The Go for launch was given 48 hours prior to the launch and even with a longer launch sequence scheduled 24 hours (Board, 2003). The launch went without much delay considering some missions have been scrubbed completely for days or even longer due to weather.

In Orbit

While there was a lot of little elements, the foam breaking off of the External Tank was the major issue that the Orbiter would have to face. At T+81.7 seconds three foam pieces struck the wings at T+81.9 seconds (Board, 2003). While foam debris occurred with enough frequency to not halt the Shuttle program, five out of the past seven launches that had the left bipod foam location that occurred in the past (Board, 2003).

The on-orbit activities went mostly as scheduled throughout the flight. The most significant was some water under the SPACEHAB module and heat increase that impacted flight days four, five, and six (Board, 2003). On day eight was the first time there was any communication about the fact there had been foam that impacted from Mission Control and that was due to a press conference that day so the astronauts would not be surprised if there was mention of the event (Board, 2003). Days 15 and 16 had computer landing system simulations to ensure that Rick Husband, William C. McCool, and Kalpana Chawla where prepared for the re-entry (Board, 2003).

On the ground, multiple meetings had taken place to determine how the mission was proceeding. Despite multiple requests for formal imagery and opportunities, all were ignored due to bureaucracy and a lack of understanding the significance. There had been no data to support how a severely damage tile on the leading edge could impact the Orbiter being able to survive re-entry along with the program Crater that could figure out penetration of a Thermal Protection

System title, it often was considered conservative and would not have been able to accurately predict the level of damage that *Columbia* had received (Board, 2003). There were requirements across the board that were never met and there was a general disregard for the seriousness of the foam impacting the leading edge. The NASA culture had developed into an overly-optimistic and that nothing could go wrong which led to a bad understanding of the harsh realities of under-estimating the need for an effective safety protocol. There was little that anyone could have done once upper management had decided that the foam striking the fins where not a concern and should not interrupt the around-the-clock science schedule.

Re-entry

270 seconds after *Columbia* started re-entry protocol, the strain on the left leading edge was higher than previous re-entries (Board, 2003).This started a chain reaction of higher then expected temperature readings, reaching all the way up to a recorded 3,000 degrees Fahrenheit after 651 seconds after re-entry, the finals moments had begun (Board, 2003). From the Orbiter starting to become a bright spark across the sky, the final words of the crew were "Roger" from Husband and within the moment was shown to be breaking apart (Houston, 2013). From there, there was debris scattered across Texas and Louisiana and a shocked nation to contend with the loss of the seven crew members. The doors were locked in Mission Control as the last debris fell to the Earth.

Theories

Fins

In rocketry, the fins are a delicate item to adapt and have damaged. There are some areas that are better able to tolerate damage compared to others. *Columbia*'s left delta wing was struck on the leading edge that connected to the root edge. This would allow the wing to suffer a vast

amount of damage quickly. The root edge connects to the main body of a rocket and cannot suffer much damage before the rocket will have a catastrophic failure. This can be seen in model rocketry as a severe wobble trajectory during launch or a spin resulting in the inability to gain much altitude. While in launch is a critical point in model rocketry for a fin to fail, in the shuttle program there was no place for a fin to fail.

In the *Columbia* reentry, the leading edge takes a significant amount of heat. This makes the leading edge a valuable element of protection for the fin. However, the compromised left fin would not be able to provide much if any valuable protection. The ripple effect would be that the fin would allow more damage to occur on the root edge then is considered within a margin of error.

In theory, had the fin been damaged on the tip and possible trailing edge, there would been a more likely chance of survival. The tip of the wing would be a piloting challenge but one that could have allowed life. This is the outermost point and as far away from the root cord as one can get. If the fin is not hollow and allowing hot gases to spread within a hole at the top or missing the tip, then the chances would be higher.

The trailing edge, the edge towards the engine in the orbiter, would have been a possible problem but biased on model rocketry should have allowed a chance. This would once more be a piloting challenge but one would allow an opportunity for the astronauts to go home safe and alive. Like many things in life, a risky job comes with no guarantees to go home, but the chances would have been higher of returning home that day.

A more extreme break down the middle of the fin, a common model rocketry fin break, might have been also another lethal outcome. This would have been an extreme breaking of a half of a wing vertical and would be unlikely to happen to the orbiter biased on the construction

of the orbiter. This scenario may have allowed a livable outcome as it would have been clearer to NASA that the orbiter was unable to come home safely. However, the orbiter was never designed for an ISS connection point. This may have led to a similar downfall due to the managerial perspective of the non-seriousness of the foam striking the fin, however if the fin was completely and noticeably broken appropriate action might have taken place.

The Board's Findings

The Columbia Accident Investigation Board (Board) presented two theories in the report made. One was a rescue while the other was a repair plan that could have been taken on by NASA.

Atlantis

Had imagery been taken, deciding by day seven that the crew of *Columbia* needed rescue, the timeline would have been up to 30 days since the arrival in space before consumables would be exhausted (Board, 2003). *Atlantis* could have been made ready by February 10th and be prepared to take on the crew of *Columbia* before February 15th (History.com, 2018). This would have required a space walk and astronauts who where trained to be in *Atlantis*.

This would have been the main rescue attempt due to the fact *Columbia* could not dock with the ISS. The option of docking would have been likely more appealing with either rescue pods or a Shuttle being able to be sent up to rescue the astronauts.

Repairing

The Board believes this would have been another option that NASA could have considered. It was filled with high risks and uncertainties that it might not have been undertaken (Board, 2003). It would have involved a space walk and having a bag of water freeze into ice to allow for a possible re-entry but not guaranteed (Board, 2003).

Aftermath

38 precent was found of the Orbiter's dry weight was found throughout the United States and taken to be reassembled, found in a large part due to the help of volunteers (Houston, 2013). The Board was formed to start investigating NASA and to organize the retrial of debris (Board, 2003). This included reconstruction and interviewing people along with multiple studies. The Columbia Crew Survival Investigation Report was formed and released to the public in 2008 about the likelihood that the crew could have survived and how to improve future missions (Houston, 2013). The crew was likely killed due to lack of oxygen or blunt force trauma, further compounded by crewmembers not all wearing the proper uniform for reentry even if the accident would have still been lethal (Borenstein, 2008).

Astronaut Diaries: Remembering the Columbia Shuttle Crew filmed by David M. Brown before *Columbia* re-entered orbit was aired in May 2005 (Houston, 2013). Not all the science done was lost, with around 30 precent being able to recover with three of the Freestar having complete success from the work accomplished which would lead to an impact on the future of science (Houston, 2013). There were multiple design changes to ensure that there was a reduction of a similar event occurring again as well was restructuring of management.

What changes to management

There were multiple people who were involved in *Columbia* who resigned due to pressure (Venugopal, n.d.). There was also the ultimate decision to retire the fleet once the ISS was completed, something that had been planned and contributed to the rushed schedule of the program. The culture would have to change to ensure that safety was kept up within NASA. There was at least a slight culture shift to allow for better safety and an understanding of needing people who understood what was going on (Clash, 2020).

One of the Board recommendations was to be able to repair and inspect tiles. This was to ensure that imagery and foam strikes that did occur were understood and where able to be taken care of. Due to all the other Orbiters being able to dock with the ISS, there was less of a risk of being unable to get to some form of safety should a rescue need to occur. This procedure was often accomplished by rolling over the Orbiter. There was also the recommendation to allow shuttle tiles being able to be repaired during the mission (Board, 2003).

Shuttle Era Ends

Discovered in the aftermath, the need for the ISS to check the heat panels was needed. Congress had been effectively attempting to shut down the program, a long-standing culture of "faster, better, cheaper" due to budget cuts, and an aggressive schedule made managers complacent and accepting fate (Board, 2003). In 2011, the final landing of the Shuttle program occurred to retire the program.

Throughout space flight, the loss of human life has been considered a possibility. A lack of a safety culture combined with a bit of bad luck led to *Columbia* ending in the breakup over the United States. Afterwards, policy changes allowed an improved safety culture and protocols to prevent *Columbia* from happening once again.

Works Cited

Board, C. A. (2003). *Columbia Accident Investagion Board.*

Borenstein, S. (2008, December 30). *NASA reports graphic details of Columbia deaths*. Retrieved from https://abcnews.go.com/Technology/story?id=6549678&page=1

Clash, J. (2020, April 22). *Challenger, Columbia Accidents Easily Avoided, Says Shuttle Astronaut*. Retrieved from Forbes: https://www.forbes.com/sites/jimclash/2020/04/22/challenger-columbia-accidents-easily-avoided-says-shuttle-astronaut/?sh=4790e32973f7

CNN Editorial Research. (2023, January 17). *Space Shuttle Columbia Fast Facts*. Retrieved from CNN: https://www.cnn.com/2013/09/30/us/space-shuttle-columbia-fast-facts/index.html

Frommert, H. (n.d.). *List of all Space Shuttle Flights*. Retrieved from https://spider.seds.org/shuttle/past.html

History.com. (2018, August 21). *Space Shuttle Columbia*. Retrieved from https://www.history.com/topics/space-exploration/columbia-disaster

Houston, R. (2013). *Wheels Stop.* Board of Regents of the University of Nebraska.

National Aeronautical and Space Administration. (2015, September 10). *Apollo 1*. Retrieved from Apollo 1: https://history.nasa.gov/Apollo204/

National Aeronautical Space Administration. (1961, January 31). *Chimpanzee Ham with Trainers*. Retrieved from NASA: https://www.nasa.gov/image-feature/chimpanzee-ham-with-trainers

Venugopal, R. (n.d.). *The Space Shuttle Columbia Disaster*. Retrieved from http://www.spacesafetymagazine.com/space-disasters/columbia-disaster/

Addendum: Essay was edited on 8/29/2025 by Madison Saunders for OKLIS Screen Reader Testing presentation. Essay was originally written by Madison Saunders for class and edited with the table, the photo, and the sources. It was inspired from using the essay for CIDT student worker within the Accessibility Team for training.