

# *Columbia Space Shuttle Disaster*

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## Abstract

This case study dives into the events surrounding the catastrophic series of events that unfolded on February 1st, 2002. NASA's space shuttle Columbia had tragically broken apart into pieces while in the re-entry phase of their returning flight. Sadly, all seven astronauts on board had lost their lives in the incident. It occurred over north-central Texas and the shuttle was at an altitude of about 40 miles. Below we begin to examine the ethical considerations, engineering failures, and critical issues of risk management associated with operating complex spaceflight systems.

## Introduction

The disaster involving NASA's Columbia space shuttle, paired with the disaster involving a separate space shuttle known as The Challenger in January of 1986, totaled out to claim the lives of fourteen astronauts at the hands of NASA. The Challenger incident occurred during their launch flight. They hit T:0.0 and ignited their engines and soared past the tower, however a failure within one of Challenger's rocket boosters sealing mechanisms had a catastrophic failure. This failure occurred with an O-ring and resulted in blow-by of propulsion gases, which led to the explosion and destruction of the shuttle as a whole, this one alone killed seven astronauts. The incident focused on throughout this report, is that of Columbia. Another tragic disaster happening at the hands of NASA and their executives. This incident occurred at an altitude of roughly forty miles above northern central Texas, at

which the space shuttle Columbia began to practically disintegrate.[1] Seen in *Figure 1*, as Columbia re-entered Earth's atmosphere, there is a factor of drag. Much like friction this drag factor produces a resulting heat and as this heat grew and grew, Columbia began to dismantle. Pieces of the shuttle scattering off as it cruised



*Figure 1.* The image above from *Space Safety Magazine*, shows what could be seen as Columbia was breaking on its re-entry face to land.[4]

through the air like as a fireball.[1] Citizens looking up to the sky obviously could see this immense fireball traveling across the sky and began funneling calls to '911', as these citizens did not really understand what exactly it was that they were viewing at the time.[5] Ultimately the shuttle came to

disintegrate into pieces, killing all seven astronauts on board the craft. To reinstate, following the incidents of The Challenger and The Columbia Space Shuttles, NASA now had two major incidents on their hands within less than twenty years of each other, ultimately resulting in fourteen lives lost of NASA team members/astronauts.[5]

### **Columbia's Final Flight**

NASA's space shuttle Columbia launched into space, taking flight for its 28<sup>th</sup> mission, on January 16<sup>th</sup>, 2003.[1] The Columbia shuttle housed seven NASA astronauts, one of them being Ilan Ramon, the first ever Israeli astronaut.[1] As mentioned, Columbia practically disintegrated as a whole, as it re-entered Earth's atmosphere. The destruction done to Columbia on its re-entry phase, much like Challenger were caused from the launch.[1] A complication suffered on the outer hull of the shuttle, compromised the shuttle as a whole and made it vulnerable to immense heat faced due to air resistance/drag when re-entering the atmosphere.[1] Screenshots of live recordings of the Columbia launch, show evidence of an insulation foam block broke loose from the external propellant tank and struck the left wing about eighty seconds after launch.[1] In past, it was known by NASA engineers that foam insulation blocks were prone to falling off and breaking, yet they have not had an issue large enough for them to have any concern around it as they did not believe the foam was able to carry enough momentum in order to cause significant damage to the shuttle structure.[1] This strike caused significant damage to the wing of the shuttle, making it vulnerable.

As the crew enters the re-entry phase of the mission, hot gases begin to penetrate the damaged tile section and melted major structural elements on the wing of the space craft.[1] The wing then eventually collapsed, with data from the shuttle showing rising temperatures in sections of the left wing around 8:52 A.M, however the crew only knew of the situation at hand, minutes before complete shuttle breakup.[1] Now in orbit, The Columbia crew continued to carry out their mission and after seventeen days in space, they prepare for re-entry.[5] Columbia's wing eventually succumbs and collapses, causing the

shuttles to then scatter into thousands of pieces across the sky leaving behind a massive debris field. NASA's team retrieved as much as they could have of The Columbia debris that was scattered about over thousands of square miles and reoriented it to use as evidence to evaluate and understand what exactly had happened.[5]

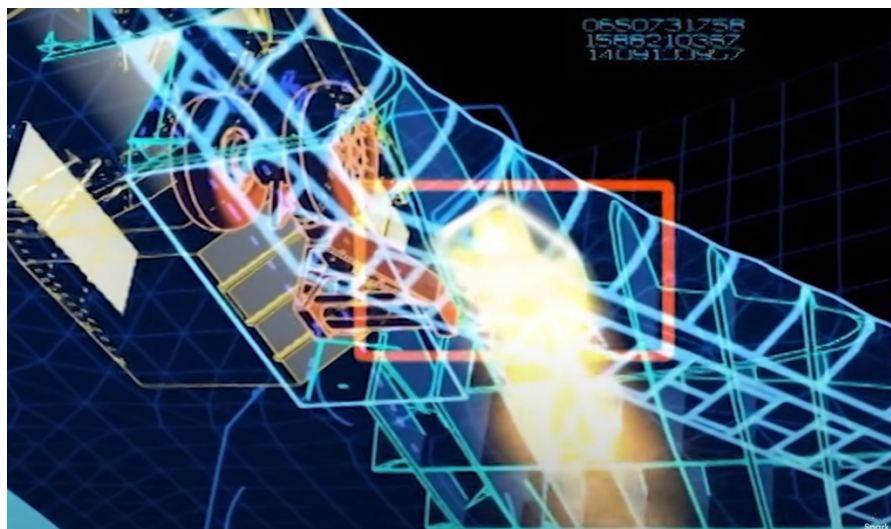


Figure 2. Above shows a simulation of a potential hole within the wing of the shuttle. The red box indicates the trail of immensely hot gases entering through on re-entry. As this occurs, the entire wing structure begins to weaken and eventually collapse.[5]

## Engineering Analysis

When engineers were tasked with designing the space shuttle, they were tasked with developing this space shuttle for a variety of missions.[5] An engineer from the Spark documentary on the disaster mentions in the opening, how that when an engineer is tasked with developing something along these lines, the machine developed never does one extremely well. Hinting that basically the shuttle then being developed would perform mediocrally on a lot of missions. If you go back to *figure 2*, we start to get an understanding of how this all occurred. On takeoff that 3 pound block of insulation, about the size of an average briefcase, falls off striking the wing on launch day.[5] The wing of a shuttle is made up of hundreds of aluminum cross members and has thousands of thermal sensors stored within it.[5] This is how these recordings came through showing the increasing heat temperature within the left wing during re-entry. Those aluminum cross-members carry majority of the load for the wing and now once you have a hole within this wing you have immense heat rushing through melting the entire structure of the wing as a whole.

Once it was understood that this was occurring in the wing, there was no way to reverse it, the shuttle was stuck in descent. The other insulating tiles begin to fall off as more and more damage accrues on the shuttle, furthering the damaging effects of the heat on the plane as their shield is practically disappearing. On descent, the shuttle began tilting to the right, presumably from damage to the left wing

and it is known that rocket boosters were fired on the shuttle to correct this tilt.[5] Sadly, this means that unlike in Challenger, the crew was aware of what was happening around them and did suffer some type before the eventual total break up of Columbia.[5] At this point the ground made the call that Columbia was lost.[5].

## How Could This Happen?

NASA as well as the independent Columbia Accident Investigation Board found numerous managerial flaws along with immediate technical issues with the shuttle itself to be the cause of Columbias fate.[1] For example, the same documentary referenced earlier mentions how a breach

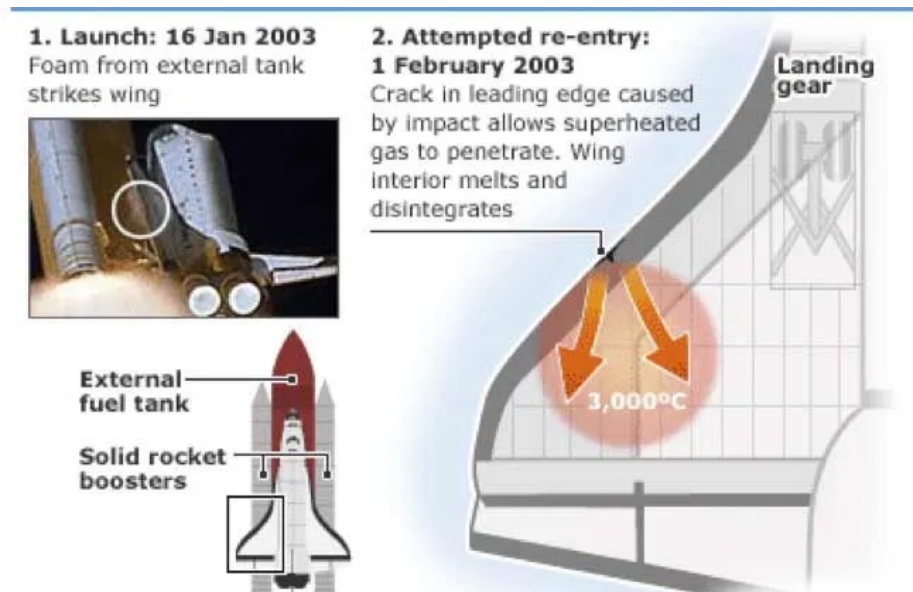


Figure 3. The above image shows how the hot air would have pushed through into the wing leading to its destruction.[4]

within the heat shield on the underside of the shuttle was of major concern for a very long time.[5] Even with this being a known cause for concern, let alone a major cause for concern as re-entry into atmosphere requires many variables to align exactly right for everything to go smoothly, very little was done to address it, a common pattern within NASA's management team.[5]

As mentioned previously NASA engineers believed the foam insulation to not be capable of carrying enough momentum in order to do any real damage to exterior of the shuttle. This however was proven not to be the case as this was the root cause of the Columbia space shuttle incident. Testing after Columbia had already gone down showed that these insulation blocks were very capable of causing serious damage to the shuttle.[1] In fact tests showed the foam was capable of punching massive holes in the reinforced carbon-carbon insulation tiles that were meant to shield the shuttle from the immense heat it would encounter.[1] The engineers did have a point though as a piece of them have never seen a chunk of this size come off the hull but this should have been heavily considered as it was Challenger's 28<sup>th</sup> mission.[5] Overtime the shuttle undergoes more and more damage, making it weaker and weaker, therefore this should have been a serious cause for concern. People at NASA were made aware of issues within this realm of the shuttle upon multiple occasions.

### **NSPE Ethical Analysis**

The National Society of Professional Engineers, or the NSPE, is an organization created in 1934 with one crucial goal. The overall goal of the NSPE taken directly from their website is to, "create an inclusive, nontechnical organization dedicated to the interests of licensed professional engineers, regardless of practice area, that would protect engineers (and the public) from unqualified practitioners, build public recognition for the profession, and stand against unethical practices and inadequate compensation." [3] With that being said, the NSPE has come together to set up a list of rules/guidelines to uphold the morals and ethics within the engineering world.

The board in charge of investigating Columbia stated in the report, that NASA management has missed eight opportunities to address concerns pertaining to the falling foam on space shuttles.[1] This being the main cause of the Columbia incident, shows pure negligence across the board within NASA headquarters. This has been shown not once but now twice as this would be the second incident to claim the lives of everybody on board. NASA disregarded majority of the NSPE fundamental canons, especially when looking at the canons involving the holding safety paramount. Not only was NASA management warned in both instances, but they were also warned **multiple** times by engineers, who were holding safety paramount. Multiple NASA engineers pleaded in both cases for change to be made before launch and both times their advice was ignored. Had they have listened to these tips; we may still have those fourteen astronauts walking on Earth however sadly that is not the case.

### **Recommendations**

There are two main recommendations I would have for the engineering aspect of the shuttle. One would be the idea of ejection seat, as they were installed in the shuttle up until its fifth mission.[5] Taking out these ejection seats, leaves the astronauts with no means of escape if any part of the launch goes south, more, or less just strapping them down to a rocket and hoping for the best. This is not ethical, nor safe when dealing with that amount of propulsion gases. Had these astronauts been riding on a shuttle equipped with such ejection seats, they would have potentially been able to escape the

shuttle safely on re-entry. This is not a guarantee, however a better option than having the astronauts disintegrate along with the shuttle. The second recommendation goes for both management and engineering aspects. Why were proper maintenance precautions not put into place for these shuttles. If they are so expensive to develop and manufacture, they should be maintained to perfection, refurbished after every flight. As anyone could guess, the forces faced when reaching space are not benign. How these warnings from multiple engineers were ignored upon numerous occasions is a showing of pure neglect and simply cannot happen. Had these tiles been repaired or replaced Columbia very well would have made a successful round-trip mission that morning.

### **Conclusion**

In the end Columbias crash led to the grounding of all space shuttles for quite some time with the next launch not taking place until 2005. NASA took those two years to work on and develop many safety improvements revolving around the shuttle. Ultimately, the shuttle program within NASA was shut down entirely and disbanded, mainly because of the cost but the consistent disasters were known to be a factor in pulling the plug as well. I believe this to be quite sad as enjoy space exploration and find many theories in the realm of space to be quite interesting once researched upon. Hopefully these engineering interests resurface sometime in the near future as the world continues its exploration into space.

### References

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