Assignment Description

This ethics case study focuses on the [Space Shuttle Challenger Disaster].

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Q1. Describe the Space Shuttle Disaster, what happened, why, and who was involved.

Team member: Luke DeVries

https://en.wikipedia.org/wiki/File:Challenger_explosion.jpg

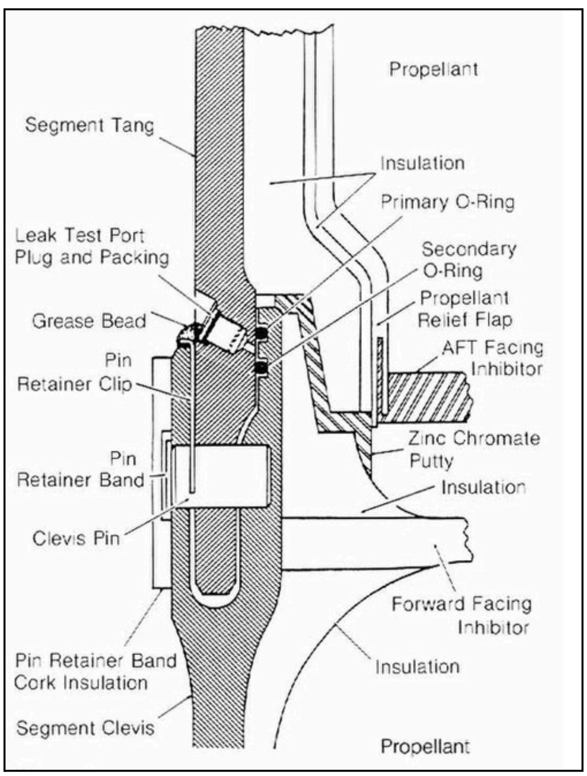
January 28, 1986. The Challenger space shuttle was set to depart on its 10th flight mission (SLS-51L), but 73 seconds after launch disaster struck as an explosion led to the death of all 7 crew members. The image on the right shows the explosion as seen live by thousands of people in person and on television.

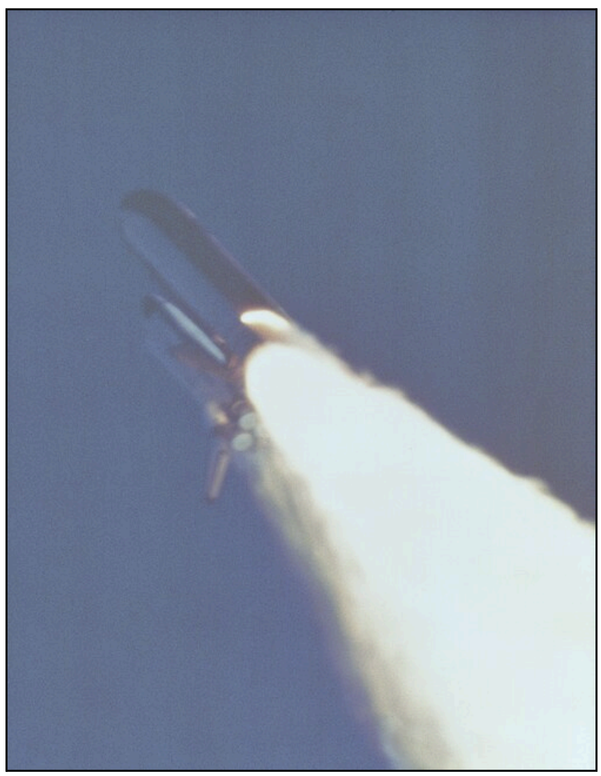
https://en.wikipedia.org/wiki/File:Challenger_flight_51-l_crew.jpg

There were seven in flight crew members for this mission:

- Francis R. Scobee, Commander
- Michael J. Smith, Pilot
- Judith A. Resnik, Mission Specialist
- Ellison S. Onizuka, Mission Specialist
- Ronald E. McNair, Mission Specialist
- S. Christa McAuliffe, Teacher in Space
- Gregory B. Jarvis, Payload Specialist

It is known that at least some of the crew survived the initial explosion as they quickly activated Personal Egress Air Packs, but as the shuttle plummeted back towards the ocean, the impact of 200 G's exceeded any level for survival. The crew was not fitted into pressurized suits for the launch, and so the severe pressure drop after the explosion more than likely caused them to be unconscious for the remaining duration of the shuttle's descent towards the earth and unable to perform any emergency procedures after the explosion.The official cause of death was not able to be determined, even after recovery of the wreckage. This tragic disaster has been well reviewed with the most notable documentation being the Rogers Commission Report, which concluded that the cause of failure was O-ring erosion on one of the Solid Rocket Boosters (SRB) from colder than expected conditions preceding the morning of the launch.





https://en.wikipedia.org/wiki/File:RogersCommission-v1p57_cropped.jpg
https://en.wikipedia.org/wiki/File:Booster_Rocket_Breach_-_GPN-2000-001425.jpg

The record low temperatures compromised the seal of the O-rings which allowed a liquid hydrogen leak that was ignited just seconds after launch. The image to the top right shows the visible plume on the right SRB due to the leak. This introduced lateral acceleration which subjected the shuttle to aerodynamic forces that it was not designed to handle. The shuttle was broken apart by the force as the SRBs continued to propel themselves until they were terminated. The shuttle lacked any launch escape systems as NASA believed that expected reliability was enough to justify not needing one.

Engineers had expressed much concern over the O-rings and other temperature related issues that could have been reason for post-poning the launch, and while these concerns were heard by upper engineering management, the information was withheld from NASA Mission Management and left to be monitored and recorded for engineering data only. Specifically, Allan McDonald and Roger Boisjoly were strong voices in the company Morton Thiokol. Despite their advocacy, it was other leaders in the company that considered the concerns to be inconclusive, leading to the advancement of launch operations and leaving the concerns to be reviewed internally rather than bringing the information to NASA Mission Management Leadership. Had this information been brought to more attention, it is possible that the O-rings issues could have been dealt with through redesigns of the field joints and more thermal protection to the O-rings.

Mission Control quickly lost contact with the shuttle after the explosion, but after video of the explosion came through they shifted to focusing on recovery forces and went into lock-down to collect data from the computers.

Edward Tufte, information designer, has argued that better communication by the engineers could have led to a better understanding of the potential dangers in the launch, but others have contested this stating that things were not as simple as Tufte claimed. This disaster influenced a major shift of importance onto engineering ethics and concerns over engineering safety, proper communication, and group decision making. NASA and others have made lots of revisions in an attempt to further reduce the possibility of disasters like this from happening. Unfortunately, more disasters have occurred including the space shuttle Columbia’s disaster in 2003 which continue to bring weight to the importance of ethics in engineering and management.

Cited Sources:

- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster#
- https://people.rit.edu/wlrgsh/FINRobison.pdf
- https://www.nasa.gov/history/rogersrep/genindex.htm
- https://www.nasa.gov/history/35-years-ago-remembering-challenger-and-her-crew/
- https://www.youtube.com/watch?v=kZmpYh5Wxto

Q2. Who were the stakeholders (i.e. major entities or people involved)? What do you believe is the motivation of each of these stakeholders?

Team member: Kenny Lee

The Space Shuttle Challenger disaster involved several major stakeholders. Each of them had different motivations that ultimately contributed to the accident. The leadership at NASA were the primary decision makers and were motivated to maintain the shuttles program, on time schedule, public reputation, and continued on with government support. The Rogers Commission found that the decision to launch the Challenger was not right because it was later found that the decision made led to these priorities outweighing safety and safety procedures. Engineers at Morton Thiokol and NASA engineers were mostly motivated by safety and technical integrity as they raised concerns about the O-ring performance in low temperatures prior to launch. Morton Thiokol management acted as a contractor stakeholder and they were motivated by trying to maintain its relationship with NASA which led them to approve the launch. Another stakeholder is the US government. They functioned by supporting and overseeing the shuttle program with political and national interest tied to the success of the launch.

Cited Sources:

- https://www.nasa.gov/history/rogersrep/genindex.htm
- https://prologue.blogs.archives.gov/2021/01/27/roger-go-at-throttle-up-the-35th-anniversary-of-the-space-shuttle-challenger-disaster/
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster

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Q3. Were there ethical issues involved in the engineering design that led to the disaster?

Team member: Kenny Lee

The Space Shuttle Challenger disaster has many serious ethical issues related to engineering design, risk assessment, and professional responsibility. One of the main problems was the known flaw in the solid rocket booster O-ring seals. Engineers at Morton Thiokol previously identified this risk and recommended against launching under the cold conditions that they saw happening the day of the launch but despite the warnings, management overruled the engineers concerns.

Cited Sources:

- https://www.nasa.gov/history/rogersrep/genindex.htm
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- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster

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Q4. Were there ethical issues involved in management or the response of engineers to management (in general or specific to this particular impropriety) that led to the disaster?

Team member: Kenny Lee

Before the launch of the shuttle as described in the previous question, the engineers did bring up that there were many flaws with the launch but management instead prioritized schedule, and pressure from collaborators and outside media. These actions violate one of the fundamental engineering ethics which is to “hold paramount the safety, health, and welfare of the public,” as emphasized from the National Society of Professional Engineers. There was also a lack of communication between NASA leadership and the concerns raised by the engineers. Overall, the disaster shows the ethical failures by decision making processes, which then led to the catastrophic consequence of the shuttle.

Cited Sources:

- https://www.nasa.gov/history/rogersrep/genindex.htm
- https://prologue.blogs.archives.gov/2021/01/27/roger-go-at-throttle-up-the-35th-anniversary-of-the-space-shuttle-challenger-disaster/
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster
- https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/NSPECodeofEthicsforEngineers.pdf

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Q5. As a result of any ethical or professional shortcomings that you have described and the subsequent outcome that resulted, what was the environmental impact?

Team member: Trevor Hale

The Challenger disaster seems to be remembered for the 7 human lives lost “73 seconds” into the launch. I am going to talk more about the events leading up to that tragedy, more specifically what caused the explosion of the space craft. On the morning of the launch there were record “low temperatures” which caused the O-rings to stiffen up. “Shortly after liftoff the seals were breached, and hot pressurized gas from within the SRB leaked through the joint and burned through the aft attachment strut connecting it the the external propellant tank, then into the tank” (Challenger disaster). The explosion as a result of the O-ring failure caused significant environmental impacts like pollution, chemical contamination, and large hazardous debris in the Atlantic Ocean. The space shuttle exploded at an altitude of 46,000 feet with roughly 500,000 gallons of “liquid hydrogen and liquid oxygen on board” (Challenger disaster). The explosion left a large cloud of ammonium perchlorate composite propellant, aluminum, and toxic hydrogen chloride gas into the atmosphere and the waters below.

Propellant: The job of the O-ring seals was to “prevent gases from leaking through the joint during the propellant burn of the rocket motor” (NASA). As a result this caused the explosion and lead to the dispersal of propellant among other chemicals and debris from the Space Craft.

Debris Field/Recovery Operation: “Immediately after the disaster, the NASA Launch Recovery Director launched the two SRB recovery ships,” They had also “requested the support of the US military aircrafts and ships” (Challenger Disaster). They “prioritized the recovery of SRB, followed by the crew compartment, and then the remaining payload” (Challenger Disaster). The debris “covered 486 square nautical miles” (Challenger Disaster). “The failed joint on the right SRB was eventually found on March 1” (Challenger Disaster). The recovery consisted of divers via submarine, US Air Force Divers, and the TDRS satellite.

Cited Sources:

- https://www.nasa.gov/history/rogersrep/v1ch4.htm#:~:text=All%20three%20main%20engines%20from,overloads%20due%20to%20water%20impact.
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster#Recovery_of_debris_and_crew

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Q6. As a result of any ethical or professional shortcomings that you have described and the subsequent outcome that resulted, what was the economic impact?

Team member: Trevor Hale

The ethical and professional shortcomings that led to the Challenger disaster was a direct result of the financial choices made by NASA. The decision to launch the Space Shuttle paired with the loss of the TDRS-B communications satellite "cost the Nation $3.2 Billion" (latimes). The disaster caused a 32 month grounding of all the space shuttles in their fleet. In order to complete their fleet of four orbiters, Congress authorized the construction of a replacement space shuttle "costing $1.7 billion" (Space Shuttle Endeavour) This new ship "Endeavour" allowed the 32 month grounding that was put in place to be lifted.
Cited Sources:

- https://www.latimes.com/archives/la-xpm-1986-03-11-mn-3099-story.html
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster#Decision_to_launch
- https://en.wikipedia.org/wiki/Space_Shuttle_Endeavour#:~:text=Endeavour%20cost%20$1.7%20billion%20to,also%20named%20for%20Cook's%20ship.

Q7. What global impact did the outcome have (were there any policies that may have resulted, for example)?

Team member: Trevor Hale

The Challenger disaster caused a ripple effect that would change international space policies for the foreseeable future. Before the disaster had occurred The US had a policy that mandated almost all commercial and government "payloads be launched via Space Shuttle" (Congress.gov). As a result of the disaster President Ronald Reagan issued a national space following the recommendations of the Rogers Commission "policy of rationing access to the shuttle" (resources.org). It basically said that NASA would not be able to launch privately, or launch commercial satellites. This forced the Global Market to pivot in a different direction towards "Expendable Launch Vehicles." After all the policy changes we saw a huge shift in the global markets and countries like France capitalized on it. NASA also set a gold standard by establishing the "independent office of safety, reliability, and quality assurance.

Cited Sources:

- https://www.congress.gov/crs-product/R45416#:~:text=Until%20the%201980s%2C%20there%20was,5
- https://www.resources.org/archives/space-transportation-policy-a-year-of-upheaval/#:~:text=The%20higher%20spaceplane%20estimate%20is,by%20sending%20business%20its%20way.

Q8. As a result of any ethical or professional shortcomings that you have described and the subsequent outcome that resulted, what was the societal impact?

Team member: Trevor Hale

The Social Impact of the Challenger disaster was traumatic, this was partly because of NASA's managers and how they "did not wish to show vulnerability" (ethics unwrapped). Thereby losing the support of the "public and political support" (ethics unwrapped). And with the loss of a beloved "public school teacher Christa Mc Auliffe" (ethics unwrapped), who was there purely to bring positive PR to NASA, which in turn upset more Americans. Media coverage was provided and "Nationally televised by CNN" (Challenger Disaster). This was to promote the "Teacher Space program with McAuliffe as a crewmember" (Challenger Disaster). This allowed students from all over the US to watch the launch live from their school. Other networks eventually, like "CBS, soon cut into their affiliate feeds to broadcast continuous coverage of the disaster and its aftermath" (Challenger Disaster). All of this led to the Public's distrust in NASA due to their lack of ethics, risk management among other things.

Cited Sources:

- https://ethicsunwrapped.utexas.edu/ethical-lessons-learned-from-the-challenger-disaster
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster#Decision_to_launch

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Q9. Which of the fundamental canons, rules of practice, or professional obligations as specified by the NSPE Code of Ethics would have been relevant in dictating the behavior of the engineers (serving as engineers or in engineering management)? Discuss why those sections of the NSPE Code of Ethics are relevant for this case.

Team member: Luke DeVries

I. Fundamental Canons, Number 1: "Hold paramount the safety, health, and welfare of the public."
II. Rules of Practice, Number 1: "Engineers shall hold paramount the safety, health, and welfare of the public."

The NSPE Code of Ethics clearly states that the highest level of importance should be given to the safety, health, and welfare of the public. The Challenger disaster resulted in the loss of seven talented individuals as well as impacting families, schools, employees, workers, and administrators. It is not true to claim that the engineers and engineering management involved in the launch did not follow the ideology of this first fundamental canon. However, when it comes to rules of practice, it becomes clear that both the engineers and engineering management had the responsibility of making sure their concerns were heard and followed through to the highest chain of command. This is where it could be argued that their responsibilities were compromised as they failed to bring their concerns high enough for the launch to be postponed or for major reviews to be performed on the O-rings. There are also criticisms of the Morton Thiokol leadership for withholding some of the information from NASA and pressuring engineers to sign off on launch approval decisions. This goes directly against the Rules of Practice as outlined by the NSPE Code as it states, “If engineers’ judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate” and “Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.” While the events and reports following the disaster show effort to follow this, it is clear that more could have been done to relay information to the necessary authorities in a way that could have prevented the disaster.

II. Rules of Practice, Number 5: “Engineers shall avoid deceptive acts.”
III. Professional Obligations, Number 1: “Engineers shall be guided in all their relations by the highest standards of honesty and integrity.”
III. Professional Obligations, Number 2: “Engineers shall at all times strive to serve the public interest.”

It could be argued that the decision by Morton Thiokol leadership was an act of deception on the part of engineering management as they withheld information about the O-ring concerns from NASA leadership. The NSPE clearly states, “Engineers shall acknowledge their errors and shall not distort or alter the facts.” This can also be applied to management in which all information must be acknowledged and expressed upon concerns of error or possible error. This is similar to what the NSPE says, “Engineers shall advise their clients or employers when they believe a project will not be successful.” While we have discussed some of the notable engineers that led the discussion of concerns with management in Morton Thiokol, their leadership should also have been held to the responsibility of taking these concerns seriously even if they believed the evidence to be inconclusive. The highest standard of honesty and integrity would have been to make sure that the concerns be made evident and if they truly were inconclusive, more testing should have been done in response to the engineers’ concerns.

Cited Sources:

- https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/NSPECodeofEthicsforEngineers.pdf
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster#

Q10. Based on the NSPE canons and the environmental, economic, global, and societal issues at stake, what were the professional responsibilities of the engineers involved in the Space Shuttle Disaster? What engineering decisions should have been made?

Team member: Luke DeVries

Based on the NSPE canons and the issues at stake, it is evident that the engineers involved should have brought more attention to design concerns and possible failures due to the weather conditions leading up to the launch. Furthermore, the engineering management teams should have echoed these concerns to the proper authorities in an effort to uphold the professional responsibilities of honesty and integrity as well as keeping the public health and safety as a priority for the mission. In light of the issues spotted by engineers around the O-ring erosion and weather influence at the time of launch, the engineering decisions that should have been made include postponing the launch, revisions to the O-rings and field joints, and more extensive pre-launch testing/review of the components. Despite the previous nine successful missions, the engineering decisions should have been treated as seriously as they would have been for a first launch. It is likely that many of the engineers knew the risks, and reports support that many did try to make these risks known but ultimately the engineering decisions that resulted did not align with the concerns.

Had the decision been made to postpone launch, revise the O-rings and field joints, and be more extensive in testing the components, it is possible that the shuttle could have been repaired and/or launched in more favorable weather conditions. This could have resulted in another successful launch as well as future safety of missions had the concerns been corrected. Had the launch been successful, the mission's goals like the teacher in space project could have inspired many students to pursue technology and science and important data could have been collected while studying Halley's Comet. It is also very likely that the costs from delay and revisions to the shuttle would have been much less expensive than the resulting costs of the disaster.

It is possible to believe that the postponing of launch and/or revision of components would not have been enough to prevent the disaster or that a successful launch would have simply delayed disaster to a future mission. These claims should not be disregarded and do hold some clear perspectives of possible outcomes for the proposed engineering decisions. However, the proposed decisions would have optimized the efforts to prioritize safety and could have led to implementation of emergency procedures and/or resolutions to problems that had not occurred yet. It would not have been futile for the concerns to be reviewed and fixed even if it meant a major delay in the mission. In the case of an organization like NASA, prioritizing safety even in the little details can mean protection of future missions, future crews, and inspiration to future generations. It would hardly be reasonable to claim that the proposed engineering decisions would have resulted in an even less favorable outcome, although disasters are clearly still possible even within more modern standards of ethics and decision-making. That being said, it is important to thoroughly review disasters and failures in an effort to learn from them and prevent future events from having the same results.

Cited Sources:

- https://www.nspe.org/sites/default/files/resources/pdfs/Ethics/CodeofEthics/NSPECodeofEthicsforEngineers.pdf
- https://en.wikipedia.org/wiki/Space_Shuttle_Challenger_disaster#

Private Video Link:

Only accessible by team members, professor, and TA’s

https://drive.google.com/file/d/1qna_ZQRRPNzZwYH-neM5biWrhyN3gzKF/view?usp=drive_link