An Analysis of the Space Shuttle Challenger Disaster of 1986

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By

Isaac Morrison

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: ________Isaac Morrison_________________________

Approved: _______________________________________ Date ________________________
Benjamin J. Laugelli, Assistant Professor, Department of Engineering and Society

Introduction

Even though the Space Shuttle Challenger disaster happened nearly forty years ago, it still affects the spacecraft and engineering world today. Robert Cabana, a former NASA astronaut and director of the Kennedy Space Center, said that NASA engineers and scientists made over 100 changes to the space shuttle to make it safer and more reliable (Crane & Urbany, 2016). The real mystery is why did such a large organization like NASA not make these changes sooner and instead allow a multi-billion dollar spacecraft project to fail even when the causing flaw was known years prior to launch?

There are multiple paths of reasoning behind the cause of the disaster ranging from miscommunication between multiple levels of authority to the arrogance of management to a flawed culture at NASA. Many of these tracks are outdated and do not use all of the resources that are available today. The goal of this paper is to figure out if there was any particular person or group at fault for the explosion. I will do this by using the Actor-Network Theory framework as well as the ethical framework of Responsibility. The combination of these will allow me to look at not only each potential cause to the disaster, but also at the connections between each of them to possibly show if there is a specific person to blame for the explosion or if this was a "fault of many hands" situation. The "fault of many hands" means that no one person can be fully to blame for the outcome but rather there was a combination of factors that created a situation where nobody could take all of the fault.

Background

On January 28, 1986 at 11:38 EST and temperatures hovering around 36°F, the Space Shuttle Challenger was launched from the Kennedy Space Center. The plan was to deploy a large communications satellite, deploy and retrieve an astronomy payload to study Halley's Comet, and to conduct lessons for school children while in orbit (Uri, 2021). This mission was abruptly stopped because after approximately 73 seconds after liftoff, the entire shuttle broke apart, killing all seven members of the crew on board.

This explosion was due to the failure of two O-ring seals used in the joint of the solid rocket booster (SRB) (Presidential Commission, 1986, p. 58). The aforementioned failure led to the burning gas from inside the SRB to escape, reach the external fuel tank, and cause the fuel tank to explode. However, there were many other factors leading up to this moment that could have stopped this disaster from ever happening.

There were tests from 1977 that showed there was a problem with the SRB O-rings' design but they were never pushed as a major issue by Thiokol engineers. There was also a teleconference the night before launch where other Thiokol engineers suggested not to move forward with the launch due to the cold temperatures but were shut down by management (Berkes, 2012). Yet another possible reason for failure was that there was ice on the exterior of the SRB (Presidential Commission, 1986). All of these definitely are a part of the Space Shuttle Challenger disaster but who is to blame for it all? The final reasoning behind all of this will be further investigated in the sections to come.

Literature Review

Many scholars have looked into the reasoning behind the explosion of the Challenger and who is to blame for it. The disaster cost the United States of America over $3 billion (Rossiter, 1986) and caused a major shift in the space exploration world that can still be seen to this day. The following studies try many different approaches to find an explanation to how such a large organization like NASA can still make mistakes for such a large project of theirs. Some have concluded that it was doomed to fail from the beginning while others believe that it was a combination of bad decisions made by different groups of people that led to the explosion. I will now go over some of the current approaches to the cause of the disaster.

The path that NASA took to make their decisions is one that was used for every previous space shuttle launch to the Challenger. There were levels of authority ranging from the highest in Level I all the way down to Level IV (Hirokawa et al., 1988, p. 413), as shown in Figure 1 below.

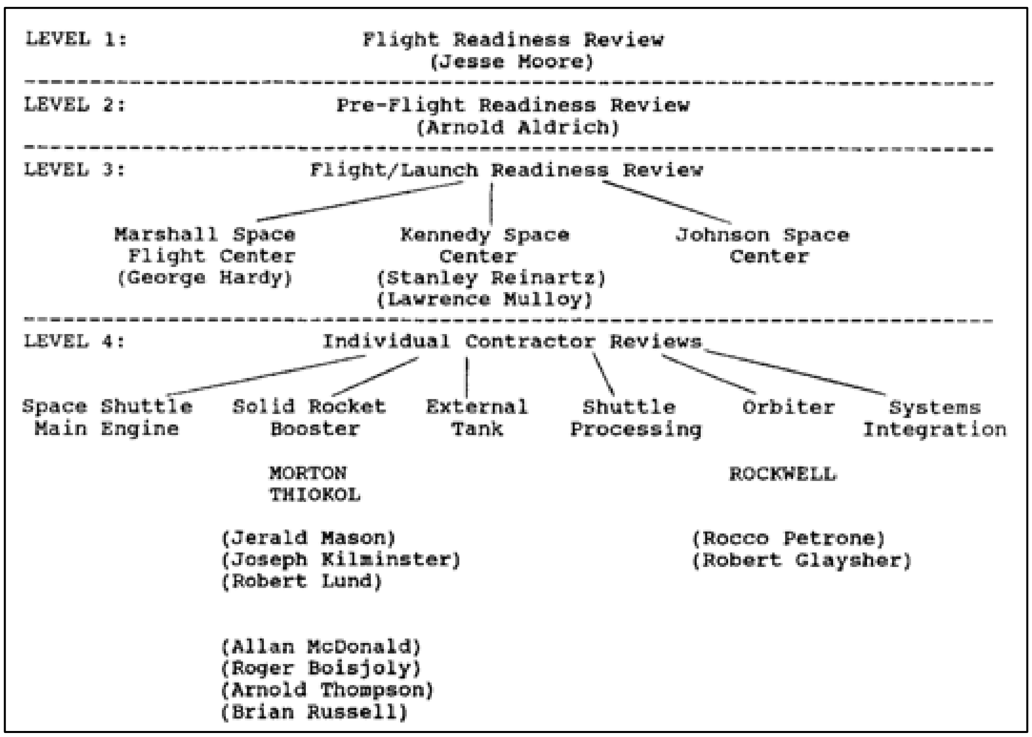

Figure 1. Hierarchy Chart of Challenger Mission

The Report to the President by the Presidential Commission (also known as the Rogers Commission) states that the disaster was an “accident rooted in history” due to the fact that there were faulty designs of the SRB, NASA managers at Level III were aware of the possibility of an

O-ring failure as early as 1977, and that both NASA and contractor management failed to fix the problem pre-launch (Presidential Commission, 1986, chap. V). This was originally the most common path for blame for this mission until others began to do more research.

Randy Y. Hirokawa from the University of Iowa and Dennis S. Gouran and Amy E. Martz from the Pennsylvania State University have come up with a different conclusion. They decided to look more into how “the interaction and joint influence of various cognitive, psychological, and social factors” altered the decision-making process along the way. Many members of the launch team agreed that the redundancy of the second O-ring would be more than competent even under worst case conditions (Presidential Commission, 1986, chap, III). Lawrence Mulloy and other NASA managers put immense pressure on the engineers for the go ahead to launch even through the engineers’ hesitation. Also, the decision-making process previously discussed (as shown in Figure 1) was thrown out. Instead of being conservative and needing just a single instance of doubt to cancel the launch, NASA managers looked for definitive proof that the launch would fail. Brian Russell, an engineer for Thiokol even stated that he had a “distinct feeling that we were in the position of having to prove that it [the launch] was unsafe instead of the other way around, which was a totally new experience (Presidential Commission, 1986, chap. VI).” Hirokawa and his colleagues concluded that the disaster was “not the result of simple, singular causes, but rather the result of a complex interplay among a number of interrelated cognitive, psychological, and social influences constituting the decision environment (Hirokawa et al., 1988, pg. 430).”

Howard S. Schwartz from Oakland University states that many of the problems for the Challenger disaster were self-imposed by NASA. He goes on to say that NASA set their own overly ambitious launch schedule and therefore set themselves up for failure from the beginning.

Also, he found in the Rogers Commission report instances where they mentioned issues with not only the SRB, but also the brakes, steering, turbine blades, fuel valves so "if the SRB joints had not been the cause of disaster, inevitably something else would have been." These problems can be attributed to the culture at NASA where there was a "can't fail mentality" and that the show must keep moving forward (Schwartz, 1987).

Due to all of the factors listed, Schwartz puts the blame on NASA as a whole for creating a world where NASA was the center of it and others could join in to become part of the center of the world (Schwartz, 1987). This caused the Thiokol managers to feel the need to overrule the engineers and proceed with the launch.

So initially, the Rogers Commission placed blame on the whole system. This was later disagreed upon by Hirokawa and his colleagues which said that it was more just a few errors, but rather a complex interplay of many factors throughout the process of the launch. Schwartz also went a different way by stating that NASA created an unsafe, fantasy-like world that caused everyone involved to overlook key problems and push forward with the mission. These studies/reports are outdated and do not use today's resources to determine the final outcome of the explosion. In this report, I will use the science, technology, and society (STS) framework of Actor-Network Theory (ANT) to analyze each key player (or actor) in the Challenger disaster in order to attempt to provide a more in-depth analysis of the explosion as well as the ethical framework of Responsibility to determine who is to blame for the aforementioned explosion.

Conceptual Framework

Actor-Network Theory (ANT) is a science, technology, and society (STS) framework that will allow me to look at the Challenger disaster and help me to figure out who is at fault. It attempts to consider human and non-human elements equally as actors within a heterogeneous network (Cressman, 2009). This raises connections between all of the elements in a network to helps researchers draw convincing conclusions. However, don't be fooled into thinking this is just finding connections between actors. It is also mapping how actors "define and distribute roles, and mobilize or invent others to play these roles" (Law & Callon, 1988, p. 285).

The method of ANT is believed to be originated in the 1990s and laid out by Michel Callon, Bruno Latour and John Law. It set itself apart from other frameworks by wanting to help better understand "science and technology in the making" as opposed to "ready-made science and technology" (Latour, 1987). It tries to trace the complex connections between anything and everything from individual people to technologies and products to entire organizations and governments (Cressman, 2009, p. 3).

According to Cressman, there are a few unique concepts dealing with ANT. I will look into Black Boxes as well as Heterogenous Engineering to help explain more about ANT. Both of these are essential to the framework to be complete. Black boxes can be any technological artifact that "appears self-evident and obvious to the observer" (Cressman, 2009, p. 6). Essentially networks need to be simplified at some point so everything can be observed by someone not an expert in that certain field. Two examples of this are a seat belt and a nuclear bomb. The actual workings of both are complicated to different groups of people but as long as the reader/researcher can understand their connection to other actors in the network, their actual technologies can be put into black boxes.

Heterogenous engineering can be seen as the "actors who initiate scientific and technical innovation and exert influence over its direction and trajectory" (Hughes, 1979). These actors are the ones who are constantly designing and redesigning parts of society to further the limits of humankind. This works very well with ANT since it is constantly looking for the changing science and technology.

According to the Responsibility framework, responsibility takes two forms: passive and active. Active responsibility refers to the responsibility one feels before something has happened while passive responsibility is the feeling one has after something, usually desirable, has happened (Van de Poel & Royakkers, 2011, p. 10). For a person (or collection of people) to be held passively responsible for blame, they must meet the following four conditions: wrong-doing, causal contribution, foreseeability, and freedom of action.

Wrong-doing means that the person "has violated a norm or did something wrong." Causal contribution refers to the person doing (or not doing) something that directly caused the problem to occur. The fact that the person could have "known the consequences of his or her actions" refers to the foreseeability aspect (Van de Poel & Royakkers, 2011, p. 12-13). The last part is freedom of action and that means that the person needed to able to act without feeling compelled by someone/something else. If and only if all four of these conditions are met, then the person can be held responsible under the Responsibility framework.

With respect to this report, I will utilize Actor-Network Theory to analyze each actor surrounding the Challenger disaster. I will also figure out who (if anyone) is to blame for the explosion through the use of the responsibility ethical framework.

Analysis

For me to employ the use of Actor-Network Theory, I must first identify both the network itself as well as all of the actors that are part of said network. The network can be seen to be the entirety of the Space Shuttle Challenger mission team with a focus on the Space Rocket

Booster (SRB) team. As far as the people involved for this, this includes but is not limited to the following: NASA management (George Hardy, Lawrence Mulloy), Thiokol management, Thiokol engineers (Roger Boisjoly, Robert "Bob" Ebeling), as well as the general public. Each of these individuals/groups of people played a role in the Space Shuttle Challenger's launch. However, this network has not only human actors, but also non-human ones. This includes the weather on the day of launch, the ice formed on the exterior of the SRB, the communication systems used, and the O-ring seals inside of the SRB that failed. Each of these actors played a specific role in the disaster of the Space Shuttle Challenger. I will now go through each of them to identify their part in the story and also use the four conditions from the Responsibility framework to find the actor to blame.

The first group I will look into is all of the non-human actors. These are important because they helped the people involved to make the decisions that they did. The weather and ice on the shuttle are the environmental/natural actors. The low temperatures on the day of launch were the main concern for the Thiokol engineers when reviewing the readiness to launch. This was due to the lack of tests done at such low temperatures. Without the cold weather, the O-rings would have more than likely not failed and the explosion would not have happened. It is self-evident that blame cannot be placed on the weather because it's a natural occurrence and could not make any decisions.

The mechanical actors are just as significant because they embody years of work from different groups and are what the people involved have to work with. The communication system and the O-ring seals used in the Solid Rocket Booster are the mechanical actors in this situation. The night before launch, there was a teleconference between Thiokol and NASA managers. During this call, Thiokol pushed NASA to delay the launch due to the lack of testing at low temperatures to no avail. The O-rings inside of the SRB were the actual mechanical failure that caused the Space Shuttle Challenger to fail (Presidential Commission, 1986, chap. IV). However, these both are in a similar boat as the environmental actors because they had no control about what happens because they are inanimate objects. The users/creators of the objects would be to blame, not the equipment used.

The human actors are the most significant actors as far as assisting in the search for someone to blame. I will start with the Thiokol engineers and in particular, Roger Boisjoly and Bob Ebeling. These were the engineers that designed and did the tests for the O-rings in the SRB. They knew that there was limited test data for the O-rings at low temperatures and believed that the safe thing to do was to wait for a warmer day. However, after they got told to take off their "engineering hat" and put on their "management hat" by their managers (Presidential Commission, 1986, chap. V), they decided to move forward. Looking at the four conditions of the Responsibility framework, these engineers meet the first three, but not the fourth. They knew that there was a problem with the design, were the ones who designed the O-rings, and knew that moving forward had a high likelihood of failure. However, the engineers (specifically Roger Boisjoly) were pressured by not only their own management at Thiokol but also from management at NASA. This led them to make their decision of grudgingly moving forward with the launch and therefore I do not place the blame on them.

The next group of people I will look into is the Thiokol management. These are the people connecting the Thiokol engineering team to NASA. They were made aware of the O-ring problem so that leads to the foreseeability condition to be met. They went against the norm of the space mission process set forth by NASA in which they were looking for definitive proof that the launch would fail rather than sure-fire proof that the launch would pass. This leads to the wrong-doing condition to be met. The causal contribution condition can easily be seen as met due to the fact that the management team decided to move forward with the launch. This leads to the fourth and final condition which is not met. While they were not under the same pressure as the Thiokol engineers, they felt even more pressured by the NASA management team. Their job is to please NASA and due to the immense pressure put upon them, they decided to go against their colleagues' advice and proceed with the launch. I do not place the blame on the Thiokol management team because they do not meet the last condition of the Responsibility framework.

The final group that I will analyze is the NASA management team, and in particular Lawrence Mulloy, the project manager for the Space Shuttle Solid Rocket Booster Program. He is a member of the Level III hierarchy (previously discussed and shown in Figure 1) which helped lead the flight/launch readiness review for the Space Shuttle Challenger. This level worked directly above Thiokol and received the problems with the SRB from them. Mulloy was made aware of the O-ring problems over a year in advance of the launch and while he did request more data to be shown at the time, he waived the launch constraint between July 1985 and January 1986 and allowed six other flights to occur under his management (Presidential Commission, 1986, chap, VI). This meets the foreseeability condition.

Mulloy and the other NASA managers also had the same responsibility of stopping the launch if they deemed necessary and looking for something to be absolutely wrong instead of everything being absolutely right, so this meets both the causal contribution and wrong-doing conditions. While there is the argument to be made that NASA had the pressure of the public to appease, the expertise and experience from the members of NASA should be at such a professional level that they would have to disappoint the people watching the launch in order to maintain safe launch conditions. This leads me to say that the blame for the Challenger launch can be placed on Lawrence Mulloy and his fellow NASA management team.

As I have just said, according to the Responsibility framework I am leaving Mulloy and NASA management as the responsible party for the Space Shuttle Challenger disaster. I understand that this is not the only viewpoint for this situation, as is the case with Hirokawa and his colleagues. Their conclusion was that the explosion was due to a “complex interplay of many factors throughout the process of the launch”, which could also be referred to as a “problem of many hands” where no one particular person is to blame. However, Mulloy stated that he himself had the “ultimate responsibility for the launch readiness of the Solid Rocket Boosters” (Presidential Commission, 1986, chap. VI) and therefore meets the fourth and final condition set by the Responsibility framework. Based on this and the rest of the evidence I have stated above, I have to say that Mulloy and his NASA colleagues are to blame.

Conclusion

Through the use of both STS framework Actor-Network Theory and the ethics framework of Responsibility, I was able to conclude who was to blame for the Space Shuttle Challenger disaster of 1986. I found that the NASA management, and specifically Lawrence Mulloy, the NASA project manager for the SRB, was to blame for the explosion. This was shown by identifying each of the actors in the network and then checking whether or not the conditions for the Responsibility framework were met.

While most engineers in the world will never be at such a high level throughout their careers as Mulloy, it is still vital that the correct precautions and steps are taken for any project, no matter how big or small it is. As can be shown with the Challenger explosion, severe, even fatal, consequences can occur if they are not followed.

Word count: 3,291

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