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# Remembering The Challenger Mission 5l -L

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# Challenger Mission 51-L

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> "The decision to launch the Challenger was flawed. Those who made that decision were unaware of the recent history of problems concerning the O-rings and the joint and were unaware of the initial written recommendation of the contractor advising against the launch at temperatures below 53 degrees Fahrenheit and the continuing opposition of the engineers at Thiokol after the management reversed its position. They did not have a clear understanding of Rockwell's concern that it was not safe to launch because of ice on the pad. If the decision makers had known all of the facts, it is highly unlikely that they would have decided to launch 51-L on January 28, 1986." (1)

The above passagge is a statement made by the Presidential Commission who did investigative work on the space shuttle *Challenger*. I think many of us remember that day, January 28, 1986 watching the launching on television. I know I do, I was around eight years old at the time.

Many different corporations played key roles in the *Challenger* launching and aftermath. NASA wasn't the only company affected. Morton Thiokol, the company who made the solid rocket boosters, was a major player, who was affected financially as well as also threatened by their business performance. To further understand the whole process, we need to identify the issues and their providers. The roles of many people were important in dealing with the crash, such as the executives, astronauts and their families, along with the public opinions. This accident did have a slight impact on our economy, this issue also had to be dealt with.

To understand these complex issues requires stepping back to late 1985, when NASA, National Aeronautics and Space Administration was preparing for yet another mission. This mission would include the use of the space shuttle *Challenger* 51-L, scheduled for a December 1985 launch. The *Challenger* very much resembled a jet airliner. Its wide body was one hundred and twenty-two feet long with seventy-five feet wingspan. Most of the vehicle could be recycled, lowering costs. The entire shuttle could be reused so costs of fueling, launching, and routine maintenance would be reduced. (2)

The purpose of the space shuttle was to provide the United States with cheaper access to space then using expandable rockets. Morton Thiokol Inc., located in Utah, received the contract to make the rockets for NASA.

Beginning in 1973, starting the shuttle program was difficult for NASA. Funds for research, development and operation were cut early in the program. A few times the shuttle program was going to be canceled. Although many parts of the shuttle were able to be reusable, conflicts arose, such as a system in one section wouldn't work well with another so costly rework would have to be done. Cutting corners in the shuttle program is a good example of how in the end, much higher costs were required. If the good funding could have been given in the beginning, a more dependable, reusable space shuttle would have been built.

The 1985 *Challenger* flight was the first mission with two civilians on board. The first civilian, Greg Janis, helped with building the satellite and the second was the winner of the Teacher in Space Program Christa McAuliffe, a teacher from Concord New Hampshire.

The mission of this trip included the launching of a satellite and observe Halley's comet pass through our galaxy. The satellite to be launched on the first day of the mission was called the TDRS-2 or Tracking Data and Relay Satellite. TDRS-2 would allow NASA to track and communicate with other in-flight shuttles and orbiting spacecrafts. The TDRS-1 was already in orbit and the two satellites would work together to communicate better in space. TDRS-2 satellite would go into orbit by rocket powered engines and allow it to travel along with earth's rotation. Although the satellite would be orbiting, it would appear to be stationary hovering over Hawaii. (3)

On the third day of the mission the crew was to take pictures of Halley's comet on its seventy-five year orbit. The Spartan Halley Observatory, a photographic telescope, would take the pictures. The crew would focus on the pictures of the ultraviolet light from Halley's comet. On the fifth day of the mission the observatory would be retrieved from orbit by using a fifty-foot mechanical arm.

The Teacher in Space Program winner was Sharon Christa McAuliffe, also known as Christa McAuliffe, who was one of the seven crewmembers chosen to join the NASA mission *The Challenger* 51-L in 1985. For Christa McAuliffe, the process started in the fall of 1984 when President Reagan decided to give a tribute to the teaching profession by sending a teacher into space.

In November of 1984, NASA distributed an 'Announcement of Opportunity' across the states and into the US territories. This was an opportunity to send the first civilian into space. According to the announcement, only one teacher would be chosen to go on the mission. (4) Over 10,000 applications were returned to NASA and from there NASA narrowed it down to two per state and territory for a total of one hundred and fourteen people. These candidates ranged from former astronauts to pro basketball players to college presidents and administrators. All one hundred and fourteen candidates, including Christa McAuliffe, were interviewed by nineteen different staff members. Along with the interviews, medical exams, and physical and psychological fitness tests were administered. The candidates had to be briefed about space flight by going through chamber simulated conditions. Finally, after all the testing the nominees had to return to Washington D.C. for a final interview. On July 19, 1985 the committee chose Christa McAuliffe to go on the shuttle *Challenger* mission in December of 1985.

(5) When she received the award, and was granted to join the mission of the *Challenger,* in the White House she stated, "It is not often that a teacher is at a loss for words, I know my students wouldn't think so. I've made nine wonderful friends over the last two weeks. When that shuttle goes, there might be one body, but there's going to be ten souls I'm taking with me." (6)

McAuliffe was a high school teacher, specializing in American history and social studies, believed that students learn about historic or current events best when challenged to experience life for themselves. She took one year off of teaching to focus on the training of the mission but planned to return to her school after the mission. During training, McAuliffe tried hard not to be a burden for the other crewmembers because of her lack of experience. "Throughout her training, Christa McAuliffe remained a teacher first. She called herself a space flight participant, not an astronaut." (7) With constant interviewing by the media, Christa used her role as NASA's link to the public very responsibly by sharing experiences and observations in ways that would benefit the space program.

Along with McAuliffe, six other members of the *Challenger* crew both male and female began preparing for the great journey ahead. The Mission commander of the *Challenger* was Francis R. (Dick) Scobee, who was responsible for seeing all mission assignments carried out according to plan. Scobee would also maintain constant communication with mission control in Houston Texas. The pilot of the *Challenger* was Mike Smith. His job was to guide the *Challenger* out of orbit with the Earth and land the shuttle in Edwards Airforce Base in the Southern California Desert. One of the first black men in space was to be Ron McNair, who was going to observe Halley's comet and

interpret the photographs taken by the observatory. Along with one of the first black men in space, the first Japanese-American Ellison Onizuka from Hawaii was going to go in the shuttle *Challenger* and be in charge of deploying the satellite. Lastly, one of the first civilians to go into space on a NASA mission was Greg Janis, who was the manager in charge of designing the satellite that would be deployed to keep contact with other space missions. (8) Judith Resnik joined Christa McAuliffe as the second woman aboard the *Challenger*. Her job was to operate the remote manipulator arm to release and retrieve the Spartan Halley Observatory. Resnik helped to perfect the design and operation of the arm. (9)

On Monday January 27th, the mission was ready to begin. The seven crewmembers were ready to launch, they got into the shuttle and were strapped in their seats when a faulty bolt in the door was discovered. The countdown was stopped and the crewmembers waited for four hours for the bolt to be fixed, but by then the winds were too bad to take flight. The launch was postponed for the next day on January 28th.

According to *Challenger: A Major Malfunction*, this led to problems with launching the shuttle. NASA personel had only a slight window for launching, if they miss the days, they cannot launch for there are other missions to pursue. NASA was launching about six missions a year. Especially during the winter months, the weather plays a key role in the decision to launch. The shuttle will not work properly of the weather is too cold. The worst launch ever recorded in NASA history was at 50 degrees Fahrenheit in the solid rocket boosters. The O-rings are pressure seals between the middle and lower sections of the solid rocket booster, if they get too cold, they will erode and not form an airtight seal. (10)

Mission consultants at the Morton Thiokol Plant in Utah heard of cold weather moving into the Kennedy Space Center and unanimously recommended the launch not be attempted for the next day. Being pushed for time, the Marshall Representatives at Kennedy Space Center couldn't believe Morton Thiokol executives wanted to cancel the launch, especially the director William Lucas. They wouldn't accept the fact that the low temperature might cause the O-rings to fail. "Marshal Representatives at NASA knew that some initial erosion would occur, after this erosion, the O-rings would ultimately seal intact. If the primary O-ring failed to seal the joint, Marshall executives researched that the secondary O-ring would act as a back-up." (11) Marshall Representatives wanted Morton Thiokol manager Allen MacDonald to reconsider thoughts on the launch and give proof of how the crew- members would be harmed if the mission were carried out. Even after proof of the back-up O-ring, Morton Thiokol still wouldn't approve of the launch, NASA began to threaten future involvement with Morton Thiokol. As this meeting went on all night, the crew of the *Challenger* had no idea of the arising conflicts. (12)

The launching disagreement created a conflict between companies. In 1973, NASA decided to build a Space Shuttle both reusable and cost effective. Morton Thiokol had the best bid, $800 million including the cost plus reward fees. The Morton Thiokol Plant created the solid rocket booster project, and they had to work closely with NASA, but if they didn't have equipment that could hold up to certain standards, NASA would need to find a new company that would. It was debated for a length of time whether or not to use solid or liquid rocket boosters, since it has always been liquid in the past. "Liquids are preferable to solids because they can be restarted and are easier to control. Once the liquid is ignited, it will burn until it is empty, in case of a problem, it cannot be

turned off. Solids have always been considered too dangerous because of capacity on the spacecraft. For solid rocket boosters, they had only been used in escape and retro-rocket situations." (13) An article written by Kurt Hoover and Wallace T. Fowler suggests that, "after much internal debate within NASA, a cost and politics driven decision was made to use solid rockets despite their inherent dangers." (14) "The statistics of the solids are one in fifty failed uses." (15)

By analyzing many readings, the solid rocket boosters are constructed in sections and stacked on top of each other to form the completed booster rocket. Four fuel sections are stacked on top of the nozzle and topped by the nose cap. Before the *Challenger,* each intersection was connected by a field joint held with 77 steel pins, and sealed by an O-ring joint made of synthetic rubber to protect it from the internal combustion products and high temperatures. The boosters had an internal layer of putty which helped in the sealing of the O-ring joints. (16)

Even in 1973, the solid rocket boosters had several problems, but "costs to correct did not negate the Morton Thiokol cost advantage." (17) Meaning that the price Morton Thiokol charges is so low that it is easier to deal with the problems and try to fix them then to get a new company. Both Morton Thiokol and NASA documented problems with O-ring design, "despite consistent evidence of the hazardous nature halted to correct the anomalies...with the fourth test flight NASA declared space shuttle operational!" (18) Beginning with the tenth mission of the shuttle in January 1984 and concluding with the twenty-fifth, Challenger flight more than half the missions experienced O-ring problems. By 1985, the O-ring erosion problem had been well documented at Marshall and Morton-Thiokol, yet the management of both organizations ignored concerns and labeled the

problem an "acceptable risk" rather than suspending shuttle missions until the problem was fixed. NASA administrators reported that they did not consider the problem hazardous to mission safety. (19) NASA and Morton Thiokol kept having successful missions with no explosions so they kept launching and taking risks.

In the middle of the night on January 28,1985 a meeting was held between Morton Thiokol, Marshal Representatives, and NASA officials. The meeting was about the O-rings, and whether or not the launch should take place. Morton Thiokol's Vice President Jerold Mason stepped in and was concerned with the future business with the Marshall Representatives at the space center. Roger Boisjoly, Morton Thiokol's engineer in charge of the O-ring Seal Task Force who protested the launch said that he had never had a safety person ask him about the workings of the solid rocket booster joint. No one from Safety, Reliability, and Quality Assurance program attended the meeting which could have been crucial in the decision making process of whether or not to launch. They identify in-flight and post-flight problems. After a meeting the Vice President of Morton Thiokol decided to overrule the recommendation given by manager MacDonald and notified the space center of the approval to launch. MacDonald still refused to sign the permission document, so the others went on without his signature.

The next morning, on Tuesday, January 28th the ice conditions were really bad. The launch was moved from 9:38 a.m. to 11:00 a.m. Every hour or so the ice committee would check the launch pad to see if melting had begun, by 8:30 a.m. all the ice was gone. A meeting was held by the National Space Transportation System Director Arnold Aldrich. During this meeting, Robert Glaysher, the Vice President of Orbiter Relations at Rockwell thought the launch was unsafe. His primary concern was icicles hanging on the

launchpad would fall and damage the heat tiles on the *Challenger*.

At 10:30 a.m. another inspection of ice was done and no ice was present. The left solid rocket booster was at thirty degrees Fahrenheit and the right solid rocket booster was at nineteen degrees Fahrenheit. At this point, the Mission Management team decided to launch. At temperatures too cold, the shuttle at risk, and companies future with NASA 'on the line,' they decided to launch the *Challenger*.

At 10:35 a.m. on January 28th, the crew of the *Challenger* came ready to launch into space. "One of the launch technicians handed Christa McAuliffe an apple. Smiling, she handed it back to him and said, "save it until I get back." (20) Family members were located in the VIP viewing grandstands, crews immediate family members viewed from the roof of the launch control building. Even fifteen third graders from Concord, New Hampshire were flown to Florida to be present for the viewing of their teacher flying into space.

At 11:00 a.m. the *Challenger* began the launch. As soon as the rockets ignited, so did the troubles. The first indication of a problem occurred as the shuttle was rising, a large puff of gray smoke came from the right solid rocket booster. As the shuttle rose and accelerated its vertical climb, more smoke came out of the same, but it turned darker and darker. NASA's computer graphics analysis showed that the grease and O-rings were being burned and eroded by the hot propellant gases. (21) At this time, powerful winds swept through and put a large amount of force on the shuttle. Meanwhile the crewmembers experiencing the intense acceleration of the flight didn't realize all this was going on. They flew upward into the sky just as a flame appeared on the right solid rocket booster in area of the field joints. This lowered the pressure of the right solid

rocket booster, which meant that a leak was growing in the field joints. The flame now was growing larger and began mixing with the leaking hydrogen.

It was at this point that the *Challenger* began to struggle. The right solid rocket booster was breaking away from the external tank and being rotated around the upper attachment crashing into the oxygen tank. "This was the beginning of the structural failure of hydrogen tank that culminated in the entire aft dome dropping away. This released massive amounts of liquid hydrogen from the tank and created a sudden forward thrust of about 2.8 million pounds, pushing the hydrogen tank upward into the intertank structure." (22)

For the C*hallenger* a massive explosion occurred with burning of hydrogen and oxygen engulfing the shuttle into an explosive burn. "The *Challenger's* reaction control system ruptured and a hyperbolic burn of its propellants occurred as it excited the oxygen-hydrogen flames. The orbiter, under severe aerodynamic loads, broke into several large sections which emerged from the fireball." (23)

The sequence of events did not immediately kill the crew, as autopsies later revealed. No one died from the explosion. The crew compartment was found over a month later, the bodies of the crew were still seat-belted in their chairs. "Pathologists worked for weeks to establish the cause of death, findings were inconclusive. It is known that the forces of the breakup were not violent enough to cause death or even unconsciousness." (24) Three of the four personal egress air packs had been recovered and activated with two-thirds of the air exhausted. "This evidence would suggest that the crew survived the momentary high G-force load of the explosion and were aware of their fate. But the impact of the crew compartment with the water imposed forces excess two-

hundred G's, far beyond the level of survivability." (25)

Recovery crews found several tons of debris on the first day. With this material NASA has tried to reassemble the collected remains into a skeletal model of the *Challenger.* Some parts of the shuttle were unharmed, whereas some were badly burned. Jim Devlin, who was in charge of the Liberty crew, the ship collecting the debris, reports that "the crew of the Liberty worked with grim professionalism, not allowing their emotions free reign until they found a section of side fuselage bearing the American flag. Then they shed their first tears." (26)

President Reagan immediately addressed the nation to help the people deal with the tragedy. His main focus was to console the children, those who watched the tragedy on television all over the country. Three days later, President Reagan in a national broadcast honored the heroes at the Johnson Space Center in Houston Texas. "After the President spoke, the band played 'God Bless America' and the NASA T-38 jets thundered overhead in the traditional 'missing man' formation that symbolized the loss of a pilot." (27)

Many services followed the one held in Houston, including a memorial in Florida at the Kennedy Space Center. Christa McAuliffe was remembered at three additional services. One was at her elementary school where she taught, another at her college of Framingham State held a memorial service attended by one-thousand people, and a third private service for her family and close friends. (28)

A nationwide flag-raising ceremony was coordinated by the Kentucky Department of Education on February 4th at 11:39, exactly one week later. Education sites in over thirty different states raised 'learning and liberty,' a special flag to

commemorate the importance of public education. (29)

Following the accident, President Reagan created a special Commission to investigate the *Challenger* accident. It sought to discover exactly what went wrong, who was involved, and take steps to further determine the future of NASA space flight. Throughout the investigation the presidential committee found much displeasure with the agency's internal review of what caused the explosion. "Commission members weren't satisfied with NASA tests showing the seals on the rocket boosters on the shuttle weren't affected by temperatures as low as minus-10 degrees Fahrenheit." (30) Commission members also wanted NASA to run more detailed tests and to run simulations of the actual liftoff conditions to be more accurate. "The commission even asked NASA to hire an outside observer to watch-over the tests to make sure they are accurate." (31)

From researching an article in the Administrative Science Quarterly, it is easy to see that the presidential commission found three problem-reporting requirement failures. First, the Safety, Requirements, and Quality Assurance program (SR&QA) did not establish and maintain clear and sufficient requirements for reporting shuttle problems up the NASA hierarchy. "In 1983, the director of SR&QA at Johnson Space Center reduced the requirements for reporting problems, resulting in less documentation and fewer reporting requirements that all safety problems be reported to upper levels." (32) Second, the commission found that SR&QA had failed to create a concise set of requirements for reporting in-flight anomalies (unexpected events or unexplained departures from past mission experience. Often times with this situation, scattered individual documents often contradicted each other. Finally, SR&QA failed to detect violations of problem reporting requirements. NASA's level III project managers were required to inform Level II of

launch constraints. A launch constraint is issued by Level II managers in response to a serious safety issue. Corrective actions need to be taken before the shuttle can even launch. With the extensiveness of O-ring erosion found after the shuttle launch of April in 1985, Level III managers placed a launch constraint against six shuttle flights. (33)

Intense investigation began also with an examination of the shuttle. Many different theories concluded from the investigations mostly dealing with the O-ring failure but some with the smoke and flames from the rockets. An engineer at NASA believed, "a flawed joint seal was not the sole cause of the explosion and thought that pieces of struts holding the bottom of the right booster to the external fuel tank and related hardware broke away from the craft about 55 seconds after liftoff." (34) Those struts, investigated by the presidential commission, were under extraordinary stress. NASA also found unusual smoke at liftoff. "When the two solid-fuel rocket boosters were ignited at liftoff the smoke appeared to last about 1.4 seconds." (35) It emerged several feet from the nearest joint in the rocket booster. Engineers haven't been satisfied with their performance. Documents released by NASA showed that the agency waved a "fail safe" requirement for the joints even though tests indicated failure of a main seal could be catastrophic.

NASA engineers were speculating that the low temperatures may have been caused by a pinhole leak in the shuttles huge external fuel tank; such a leak would have allowed a jet of supercold fuel to spurt onto the booster, perhaps freezing a joint. The joint then could have failed when exposed to the tremendous heat inside the booster during liftoff.

"NASA now attributes the disaster to what many officials had long speculated:

the failure of a seal joining two sections of the *Challenger's* right booster rocket. Such a failure would have allowed superheated gases to burn a hole into, and eventually ignite, the shuttle's massive exterior fuel tank." (36) Tests have ruled out structural defects in the *Challenger's* fuel tanks, damage from flying debris and load stresses.

An article by the Wall Street Journal summarizes a chain of events entitled "Scenario Six" which is a theory created by Marshall Reps. that outlines the accident. "According to this theory, cold temperatures may have stiffened or slightly frozen the putty used in the rocket joint, preventing the seal from pressurizing and therefore closing poorly." (37) The putty is supposed to flex slightly at ignition, forcing the rocket seals or O-rings, to close the joint from the hot temperatures of the burning propellant inside. The putty though, is temperature sensitive. The putty is supposed to hold pressure off the O-rings at lower temperatures and for longer periods of time. The freezing temperatures caused the putty to stiffen, which may have delayed or prevented the O-ring from pressuring the moving into its proper place. In the event of this, the hot gases could have gone through the joint like it wasn't even there. Later tests showed that at a temperature of 30 degrees F the putty appeared to hold the pressure off the O-ring for 10 seconds, which was very significant. (38) But the performance at lower temperatures was unclear. The temperatures on the day of the launch were 24 degrees at dawn and rose to 38 degrees at liftoff. The putty wasn't discussed during a two-hour telephone conference the night before the launch between NASA and Morton Thiokol. Any apprehension about the putty's performance apparently was forgotten in the debate over how cold weather would affect the O-rings. "Quite frankly, we didn't think the putty was an issue." A Thiokol engineer said. "It might have been an oversight on our part." (39)

Space agency officials are finding that the putty's failure could have been exacerbated by the natural expansion of the joint during liftoff, which may have caused the failure of a backup seal. "The putty may help in the investigation of the smoke spewing from the rocket at liftoff, indicating a bad seal, how was the *Challenger* able to fly for 73 seconds before exploding? With a bad seal, the shuttle should have exploded after only 10 to 20 seconds." (40)

Investigators are finding that the putty could have formed a temporary protective seal over the damaged joint, allowing the *Challenger* to fly for slightly more than a minute before the explosion. From all the research the seal failure could have been any number of conditions. Remember the delay in the failure of a backup seal closing off the main seal and stiffening of the putty could be main failures. The presence of ice in the joint that might have forced the seal out of place; or a breach of the main ring due to a number of environmental factors, like cold and humidity. Many believed though that the O-ring would form its function. Rocket seals in the past had held up in the past flights. Some erosion, or chipping, was shown on only six of the 171 main seals used between the rocket segments and none on the backup seals. Sixteen of the 57 main seals used between the bottom of the rocket and the exhaust nozzle showed some erosion, as did one backup seal. (41)

The National Science Foundation has written critical reports about the joints and claim that following the accident no backup joint had been created and the assembly of the bad joint remains being made, even without regard to the consequences of the *Challenger*. They claim that they are still in a developmental program, despite that it has been occurring since 1982 or so, and with new designed joints they won't know until the

full-duration tests are done if they will be successful. The redesign of the joint is less reliable on paper than the original design was. Morton Thiokol and NASA are betting that with successful test programs will verify that the poorly redesigned joint is acceptable for flight certification. Both companies believed this before the *Challenger* accident, and the consequences were horrible. The joint used before and on the *Challenger* had nine test firings and 24 actual flights before the bad design produced a failure, the *Challenger*. Before beginning a developmental design program with the bad joints, NASA and Morton Thiokol need to recognize the consequences and start from the beginning with a whole new idea.

As a result of this unfortunate accident, many important people from all companies took early retirement or simply left the companies. Jesse Moore, who was in charge of the space shuttle program at the time of the *Challenger* accident, resigned from NASA. He was the associate administrator for space flight and gave the "OKAY" for the launching of the *Challenger*. Although a few months after the accident, Moore became the head of Johnson Space Center in Houston, which he left in October of 1984 to become NASA's special assistant to the General Manager. Moore has said that he wasn't informed of the recurring problems with the shuttle's booster rockets, and was also unaware of the engineers at Morton Thiokol who urged a delay in the launch until the weather changed.

With NASA at the Johnson Space Center, JSC, since the reporting system is carried out similar to the game called 'telephone.' NASA modified the number of people needing to be reported to in case of a conflict. In October of 1986 a new JSC Center Director was appointed. The Center Director is the highest position to be reported to,

they carry out the action. In the past, the Flight Crew Operational Director reported to the Director of Space Operations who then reported to the Center Director. As a result of the *Challenger* tragedy, the Director of Flight Crew Operations Division now immediately reports to the Center Director. (42) Marshall Space Flight Center Director Dr. William Lucas retired in the following July. Morton Thiokol Vice-president Gerald Mason, of Wasatch Division plant outside Brigham City, Utah was moved to oversee the facilities two other operations, strategic and tactic missiles. Mason was to focus on the two money-making businesses unaffected by the shuttle disaster. One spokesman said about Mason, "If all management's concerns are on the business in crisis, than those businesses not in crisis will be there because of mismanagement." (43) Responsibility for the space division was given to Edward G. Dorsey Jr., who had retired from the company in 1984 but returned as Vice-president to the general manager. Dorsey was very respected at Thiokol and will head the task force for completing the investigation and new engineering designs and qualification tests for future rockets. Calvin Wiggins, another four year senior executive, decided to clear the launch will become Mr. Dorsey's deputy, Wiggins previously held the post Dorsey will assume. Lawrence Mulloy, the director of solid rocket booster project left the company. Responsibilities weren't changed for Joseph Kilminster and Robert Lund, the two other space division executives who agreed to launch the day before the accident.

As for the families of the lost crewmembers, most of them just slowly moved on with their lives. Many have established scholarships in their names, and learning groups about space shuttle education in their memory. Only two of the seven families sued NASA and Morton Thiokol after all investigations were completed. Since the research

dates back to 1986, the only information that was given on the cases were that the families won their filed lawsuits.

The New York Times wrote an extensive article on the remains of the space shuttle *Challenger* and the burial process. All remains were to be buried in an abandoned missile silo adjacent to Cape Canaveral Florida. Lawyers had to delay the burial because as of December in 1986 many of the claims were not yet completed. Thankfully no news organizations were allowed to view the shuttles badly damaged crew compartment or obtain pictures of it. "The crew cab investigation creates problems because it is where seven people died and raises privacy concerns with the astronauts' families." (44) With this incident, news reporters would find out less information about the shuttle then they would about an airplane crash.

A major turning point for NASA was dealing with the press throughout this whole accident process. Since the launch was broadcasted on television, the nation knew before NASA could plan a public relations strategy. The networks were coming up with their own ideas even before NASA could analyze it. The agency was not very quick with a response to the accident. Everyone was sort of in a trance from the explosion that the agency's form of handling the explosion turned into a major human and technological loss into a public relations fiasco that could have seriously damaged the agency's prestige and credibility. "In the past NASA has had audio broadcasts from space flights since the early 60's, but it has a 60 second delay in the tape so that if any catastrophe were to happen it would never be broadcasted live." (45) *Challenger* launch, by contrast, was live because Teacher in Space winner Christa McAuliffe was to teach live broadcast lessons to gain public support for the space program into thousands of American

classrooms.

NASA has needed the media since it began in 1958. Any friction with the media had a negative effect on NASA. Image-conscious officials manage the flow of information to avoid any risks and try to receive the public and political support. When a shuttle mission, or any mission is successful, that keeps the public interest alive and supports future funding requests. NASA even helps sympathetic politicians with aggressive campaigning. With the *Challenger* disaster, the agency kept a tight lid on engineering and quality control records, which forced dozens of reporters to seek other sources of information. Some people from the agency did leak out information to reporters, however which damaged NASA. The truth is that NASA's communication faults cost it political support. Only successful launches will restore public confidence. "NASA has taken lots of careful steps in protecting the *Challenger* explosion, but with their handling of the crisis, it has done little to repair the damage." (46)

On February 11, 1986 a poll was taken by the Wall Street Journal and NBC to find the response of the public opinion on NASA. Out of 1,597 adults contacted, three-fourths of the public still believes that the space shuttle is a good investment for the U.S. More people in February of 1986 were willing to endorse the program than five years earlier. A substantial margin believed that the U.S. was spending a good amount of money in the space program and 49% said they approved the level of the nation's space expenditures, while 33% stated that too much is being spent and 11% said too little was being spent. Apparently the shuttle accident didn't damp Americans' eagerness to fly into space themselves. Two out of five people said if they were offered the chance to fly into space they would. Through the years, views on NASA though have shifted. Half of

the public now say that the accent should be on scientific goals, while only a quarter believe it should be on national defense. Since the *Challenger* accident some have suggested a greater role for the military in recognition of the risks involved. (47)

Many comments have been made by people either in the field or politicians about the NASA launch. Before Al Gore became Vice-president during the time of the accident he was a senator and said, He, "was disturbed that the shuttle program continued, despite warnings within NASA about the booster rockets' seals. "It seems that some of the memos in NASA files should have raised all kinds of red flags and set off warning bells, and yet they didn't." (48) Roger Boisjoly made an opinion statement in September of 1987 with *The Scientist* who used to be a Morton Thiokol engineer at the time of the *Challenger* disaster and who had forewarned the company of potential O-ring problems. He wrote about how all space flights involve risk, but it's the job of the people on the ground level to assess the risk and minimize it. Boisjoly wrote on that, "The question today is whether NASA and Morton Thiokol... have adequately re-examined their approach to the issue of risk assessment." (49) His response to the situation was no. He believes management must listen to technical data and recommendations objectively and then make a decision based on the degree of risk versus the consequences, first to the product user then to its employees. A quality control manager once told him to also ask yourself the following questions when dealing with tough situations. "Would you allow your wife or children to use this product without any reservations?" (50) If a no was answered to this then it's a sign for others to not use.

Boisjoly's opinion gets stronger when he begins to discuss the management positions and their views. He feels that upper management change their personal

philosophy when the position is reached. Self-protection or position become the overriding concerns of all future decisions. He adds on, "I'm afraid that since the *Challenger* disaster, a business-as-usual attitude appears to prevail among management at both Morton Thiokol and NASA. They have no reason to change management style because there has been no accountability to date for wrongdoing. NASA has yet to invoke the $10 million contract penalty against Morton Thiokol." (51)

The *Challenger* shuttle was a great tragedy on the crew members families, NASA, and the American people. After researching the subject, it is easy to say that the choice of the *Challenger* launch was truly a mistake made on part by money. It was important to get the shuttle up because of a mere time space window, but honestly risking the lives of seven people to make a time window is not a good enough reason. In an article by the *Review of Financial Economics* they define catastrophic events as war or natural disasters that capture widespread public attention, dread and fascination. The accident of the *Challenger* was truly a catastrophic event.

An article in *Review of Financial Economics* explains how catastrophic events and the stock market all relate the *Challenger* accident. Their definition of catastrophic events is that the events place extreme stress on the stock market, analysts can be misled by breaking news items that may be inaccurate, incomplete, or biased. During such periods as this, there is a strong and persuasive perception of uncertainty regarding affected securities. Contagion effects also can prevail after catastrophic events. This occurred with the stock market after the *Challenger* accident. Many securities were transferred to other securities either in the same or a related industry. Often this leads to panic and investors will decide to liquidate their holdings until higher quality information

becomes available. Investors almost believe the news, false or not, and will determine their routes dependent on their sources.

The article in Review of Financial Economics also included information about NASA awarding $6.40 billion dollars in contracts to twenty-three major contractors in 1985. Companies with revenues highly dependent upon NASA were the most affected by a slow down in the space shuttle program or by a redirection of NASA priorities. After the crash six of the seven major contractors had negative excess returns on the explosion and of those six, four had significantly negative excess returns. Although, "day four and five after the crash investors had good days mainly because of the news coverage." (52)

*Fortune* reported in May and June of 1985 Morton Thiokol's shares fell 16% to a price of $42.00, which was fifteen times its estimated earnings of $2.80 for the 1985 fiscal year ending in June. From 1982-1987 Morton Thiokol had a growth of 17% in operating earnings and an 18% return on equity. (53) Although with all the lawsuits Morton Thiokol remained strong because the company does so many other businesses which bring in half of its prophets. Morton Thiokol is the leader in packaging adhesives, powder coatings, and chemicals used in electric circuitry, also the Morton Salt operation continues to be successful with return assets in 1987 being 20%. Amazingly enough though, Morton Thiokol agreed with NASA to return $10 million in profits and to redesign the solid-fuel boosters at cost price. Morton Thiokol's chief executive officer Charles Locke was quoted saying; "This shuttle thing will cost us nearly 10 cents a share." (54) New York Representative James Scheuer returned a comment about Locke by saying his remarks were grossly insensitive and earned Mr. Locke a place in the corporate "hall of infamy." (55) They have also agreed on performing $409 million in

repair work at cost, which critics in Washington attacked that the penalties weren't stiff enough. Representative Robert Toricelli replied with, "The company should be in a position of mitigating its damages rather than just limiting its profits." (56)

The lawsuits for Morton Thiokol were predicted not to exceed $1-2 million a piece that the government and Thiokol's insurers have reportedly paid to five of the crewmember's families. The company was given a fine, suspended its work on current contracts and bids for new ones in 1985 and 1986. For 1987 Morton Thiokol earned a total of $86 million from the shuttle contract, only $7 million less than the company anticipated before the disaster. Their share earnings also rose at least 16% to $3.30 in the new fiscal year in 1986. By mid 1988 their stock price rose to $55.00 per share. (57)

After *Challenger* exploded, an analysis on the budget impact of correcting possible causes of the accident, no cost could be estimated but an outline of corrective steps could be done. A Wall Street Journal article from 1986 reported that top space agency officials estimated the cost of replacing the shuttle *Challenger* at around $2.8 billion. (58) This included a figure of $350 million to complete the agency's investigation of the *Challenger*. "To replace the orbiter and remedy any defects in other shuttle systems, NASA needed an additional $500 million in fiscal year of 1986, $900 million in the fiscal year 1987, $900 million in fiscal year 1988 and $360 million in fiscal year 1989." (59) The military (with their money) was to join in more throughout 1988 having fifteen of the twenty flights military missions.

NASA officials have decided to not renew certain agreements with private customers to launch commercial satellites. The agreements are ones (throughout 1986) that have expired or expire within the year. The move reflects a growing consensus

within the interagency task force that, in the future, commercial satellites should be launched by privately owned unmanned rockets, as well as by NASA space shuttles.

An investigation of primary and secondary sources about the *Challenger* lead to many conclusions. A major finding was that without the *Challenger* being launched many companies would lose money. Yet these companies lost money because of the explosion. By seeing stock values of Morton Thiokol it is easy to see that they worried a great deal and lost nothing compared to the lives lost in the explosion. Morton Thiokol was so concerned about losing NASA before the accident, they kept their contract with NASA even after the accident. Morton Thiokol was what I feel, slightly punished. A fine for me isn't a big deal, especially when the fine was about 1% of what they make a year. It is unfortunate that people lost their jobs, the people that made the wrongful decision should have lost their jobs. Such executives as Gerald Mason, I feel should have been fired because he overruled the request.

Communication plays a big role in this situation, and by making adjustments within departments, there is hope that a situation like this won't happen again. After much research it is good to see that NASA pulled together and took responsibility. Sometimes a "rocking of the boat" opens up situations and people can really see what is happening and make changes to protect those in risk of being hurt. NASA needs to relax with the idea of a slight window for launching missions. Many circumstances appear without prior knowledge. We can't control Mother Nature, if the weather turns bad, then it does and those missions prepared to launch should wait. NASA should create a flexibility window so they have longer time to launch, or they should build another launching site so more missions can be carried out.

There isn't much to be said of the *Challenger*, it was nothing anyone could control, only few people could, and even they might not have known the results. As a nation we can only hope and support the future of NASA in dreams that perhaps better decisions will be made in part of the crew and the past NASA missions.

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