PROFESSIONAL ETHICS

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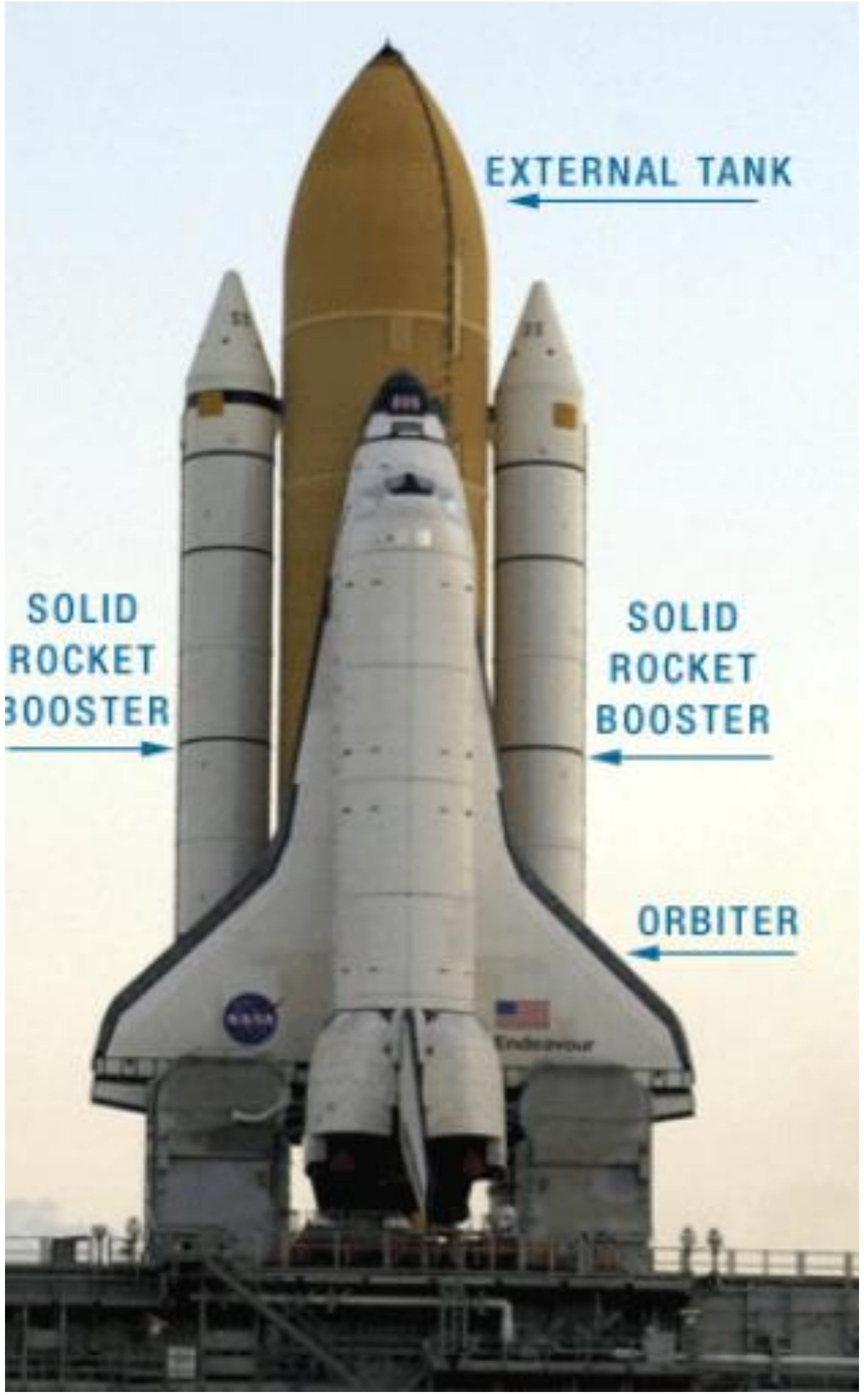
Engineering as Social Experimentation

The Challenger Case Study

Introduction NASA

- The National Aeronautics and Space Administration (NASA) was started on October 1, 1958.
- In 1958 Space Act was signed, establishing NASA as the organization responsible for both aeronautics and astronautics.
- NASA is in charge for the research and development of activities for the exploration of space within and outside Earth's atmosphere.



Introduction Space Shuttle

- There are 3 main parts of a space shuttle.
  - Orbiter
  - Two solid rocket boosters
  - External Fuel Tank.

Introduction Space Shuttle

- Launches like a rocket, maneuvers in Earth orbit like a spacecraft, and lands like an airplane.
- Reusable Spacecraft designed to fly at least 100 missions.
- Three main parts:
  - Orbiter (houses the crew)
  - Large external fuel tank (holds fuel for engines).
  - Two solid rocket boosters (Used in first
  - two minutes)

NASA’S Orbiter Fleet

- Shuttle missions were carried out on one of five reusable orbiters.
- Columbia – The first launched orbiter (1981) which was lost in February of 2003 during re-entry.
- Challenger – Lost during accident.
- Discovery – First launched in 1984, and was responsible for the Hubble space telescope deployment.
- Atlantis – First launched in 1985.
- Endeavour – The newest of NASA’s orbiters; first launched in 1992.

Stages On Flight

- **Launch:** Starts in a vertical position, thrust is provided by the 2 solid rocket boosters.
- End of first minute it has consumed more then 1 ½ million pounds of fuel.
- After 2 minutes booster casing are jettisoned, and gets parachuted into the Atlantic Ocean.

CHALLENGER Crew

- The crew of the Challenger were commanded by Scobie, who had flown on Challenger before as its pilot in April.
- Its pilot this time was Commander Michael Smith. He had been with NASA since 1980 and was on his first mission.
- There were three specialists and all were on their second shuttle flights.
- Dr Judith Resnick was a biomedical engineer involved in research.
- Dr Ronald McNair was heavily involved on work with satellites and Lt. Col.

CHALLENGER Crew

- Ellison Onizuka was an Airforce officer on detached duty with NASA.
- Gregory Jarvis worked for Hughes Aircraft Corporations Space and Communications Group and had beaten 600 other employees of the firm to go on the Astronaut program.
- His role on the flight was to gain information on liquid-fuelled rocket design.
- The final crew member was Christa McAuliffe. A decision had been made by NASA to have a teacher on a mission as a way of boosting the flagging profile of the shuttle missions.

CHALLENGER Crew

Incident Details

- January 28, 1986, seven astronauts were killed while piloting the Challenger space shuttle.
- Challenger exploded 73 seconds after take off due to failure of rocket booster O-rings.
- Failure of O-ring due to several factors, faulty design, lack of testing in low temperatures, and etc.
- Lack of Communication in NASA management

What Went Wrong??

- From 600ms after lift off until 3 and a half seconds, dark smoke came out of the booster.
- At this very spot, some 59 seconds after lift off, one could see hot gases that burned a hole in the booster which then led to the explosion.

What Went Wrong??

- The segments of each booster was joined into three major sections.
- The sections were interlocked by a tang and clevis joint.
- The tang and clevis joint was sealed by two rubber O-rings.
- Through the heat generated by the burning propellant from the boosters, these rubber seals expand to fill the joints of the three sections and prevent the hot exhaust from escaping.

What Went Wrong??

- The O-ring seal in the right solid rocket booster failed to remain sealed.
- It allowed a flare of pressurized hot gas from the solid rocket motor to ignite fuel in the external fuel tank.
- **Failure of an “O-ring” seal in the solid-fuel rocket on the Space Shuttle Challenger's right side.**
- And as a result Flames cut into main liquid fuel tank.

Four Main Causes of O-Ring Failure

- Pre-flight Leak Tests
- O-Ring Erosions
- Joint Rotation
- Low Temperatures
- Combinations of these four problems led to the disaster.
- First, the exhaust gasses were able to penetrate through the zinc chromate putty by way of the blow holes causing erosion.

Four Main Causes of O-Ring Failure

- Joint rotation caused an increasing gap size for the O-ring to cover
- Combination of joint rotation and O-ring resiliency caused the secondary O-ring to not correctly seal.
- Since the second O-ring was not able to properly seal the gap, the exhaust gasses were allowed to enter the entire joint.
- The extreme caused the joint to rupture and the Challenger to explode.
- The exhaust gasses began to eat away at the primary O ring seal.

Partial Ignorance

- "The consensus of the Commission and participating investigative agencies is that the loss of the Space Shuttle Challenger was caused by a failure in the joint between the two lower segments of the right Solid Rocket Motor. The specific failure was the destruction of the seals that are intended to prevent hot gases from leaking through the joint during the propellant burn of the rocket motor. The evidence assembled by the Commission indicates that no other element of the Space Shuttle system contributed to this failure." (Report to the President 1986, vol. 1, p. 40)

ETHICAL ISSUES
Intentional, carelessness or ignorance?

- Who are responsible for this tragedy?
- Manufacturer
- Engineers
- Managers/administrators
- Media/public
- Congress
- Intentional, carelessness or ignorance?

ETHICAL ISSUES
Delays In Mission

- Liftoff Initially Scheduled on Jan. 22, 1986
- The mission was delayed several times before final flight at 11:38 am on Jan. 28,
- due to weather,
- due to launch processing problems,
- due to equipment failure,
- due to hardware interface module problems.
- WHY to take risk of priceless human life?

ETHICAL ISSUES
The Pressure to Flight

- Did NASA knowingly take extra risks because of pressure to maintain Congressional funding?
- NASA managers were undeniably under pressure to launch without further delays; a public-relations success was badly needed.
- Objection:
- The space shuttle had a huge cost, adding this cost to the cost in moral terms of the death of the crew and the cost of suspension of the entire program for many months or even years would give a total cost so large that any rational manager would have judged the risk.

ETHICAL ISSUES
Time Pressure

- Political pressures, economic considerations, and scheduling backlogs.
- Competition between European space agency.
- Repeated delays in previous launches.
- In time for president Reagan’s speech topic on education and the space shuttle.

ETHICAL ISSUES
The Pressure to stay in business

- Did Thiokol knowingly took extra risks because of fear of losing its contract with NASA“.
- Thiokol Management reversed its position and recommended the launch at the urging of Marshall and contrary to the views of its engineers in order to accommodate a major customer.” (Report to the President 1986, vol. 1, p. 105)
- The major customer was NASA.

ETHICAL ISSUES
No Effective Whistle Blowing

- “Complaining to someone inside the company” is not effective whistle blowing.
- Roger Boisjoly’s attempts before the disaster to get Thiokol management to take action on the O-ring problem, though courageous and admirable, do not constitute whistle blowing.
- ‘Whistle blowing’ describes the action taken by an employee who notifies outside authorities that the employer is breaking a law, rule, or regulation or is otherwise posing a direct threat to the safety, health, or welfare of the public.

ETHICAL ISSUES
Negligence towards known Potential Problems

- O-rings were “Critical” feature
- O-ring seal failure on previous missions.
- Very low ambient temperatures recognized as concern by Thiokol.
- O-ring performance at this temperature not understood.
- NASA officials pressured Thiokol to withdraw its concerns.

ETHICAL ISSUES
No escape/ejection system

- No escape/ejection system
- There must be an escape or safe exit system in case of emergency situation
- Designing problem.
- Engineers are responsible.

ETHICAL ISSUES
Level I Flight Readiness Review

- Level I Flight Readiness Review
- The Shuttle Flight Readiness Review is a carefully planned, step-by-step activity, established by NASA program directive
- To certify the readiness of all components of the Space Shuttle assembly.
- Solid Rocket Booster joints were not discussed during the review on January 15.

ETHICAL ISSUES
Pre-flight leak test

- Pre-flight leak test was not performed for components.
- To certify the readiness of all components of the Space Shuttle assembly.
- Managers and engineers both are responsible.

CONCLUSION

- The main cause of Space Shuttle Challenger explosion/failure was failure of the O-Rings/O-ring erosion at low temperature.
- The pressure from the military, Congress and the media were also factors in the disaster.
- The most significant reasons for the Challenger’s untimely destruction was “a lack of communication.”

RECOMMENDATIONS

- Even minor engineering flaws in a design should be dealt seriously because these can cause systemic accidents.
- O-ring problem should have been taken seriously because O-rings were a critical feature.
- If something is not tested for some specifications, human life should not be risked with it.
- In case of an engineering design, management should share 40% and engineering department should share 60% of authority for final test so it can be more fruitful.

RECOMMENDATIONS

- When internal whistle blowing is not effective and some thing as big as loss of human life is possible , external whistle blowing must be done before a loss occurs.
- In ethical issues, you have to often choose between the lesser of two evils.
- In the Challenger disaster, the lesser of two evils choice should have been to delay the launch.

References

- Mike Martin and Ronald Schinzinger, “Ethics in Engineering”, McGraw Hill, New York, 2005
- Miscellaneous Journals and Internet Resources.