The challenger shuttle disaster engineering essay

Abstract

The National Aeronautics and Space Administration (NASA) is a global leader in the field of space flight and space science. NASA as an organization is exclusive in terms of mission, vision, objectives, magnitude, control, risk, and complexity. NASA's space flight program is the most complex and difficult task in their history. It is well known that the accident of Challenger space shuttle on 28th January 1986 was attributed to organizational failure. The breakdown of Columbia space shuttle in February 2003 points out again how even minute details play important roles in complex and high risk organizations. Many major organizational failures are result of poor decision making, adverse conditions, and poor assumptions. This paper focuses on Challenger & Columbia space shuttle disaster, and validation behind calling it as an organizational failure. If NASA is sincerely thinking about reducing failure, they should consider organizational change to reduce probability of occurrence of such mishaps.

Introduction

An organization exists when a group of people work together to achieve goals (Daft, 2007). Organizations are all around us and shape our lives in many ways. Organizations can be classified on the basis of scope, size, clientele, and nature of services. Even though the work culture of every organization is different, the basic principle of operation is same. With rapid globalization, there is added pressure on organizations to outperform each other. The pressure on a firm is the direct pressure on employees to perform. Every individual react to this pressure differently and at times can affect decision making skills in a poor manner. Organizational failure can be described as a single major incident, or chain of incidents, resulting from the action or inaction of individuals associated with the organization (Gillespie and Dietz, 2009). Organizational failures are unavoidable, and it can be consequence of a single cause. The enormity of failure depends upon number of causes. The basic reasons for organizational failures are poor planning, management, and corporate culture.

Organizational characteristics of NASA

The National Aeronautics and Space Administration (NASA), an organization with 18, 000 employees and a budget of US$ 15 billion was set up in 1958. It is exclusive in the terms of size, mission, and motivations. The motivation factor ranged from winning the SOVIET/US space battle during the 1960's, to becoming a leader in all the areas of spaceflight and space science at present. NASA is considered to be a closely " path dependent" organization (Bruggeman, 2002). Path dependence implies to the inclination of an organization to make decisions based on their history. During 1960's space race between United States and Soviet Union for technological superiority, cost concerns were less important. During this period the importance of human spaceflight for a successful space program was realized. There were significant budget cuts for NASA by the end of the cold war era; even then the focus was on human spaceflight. To counter budget cuts, some portions of the shuttle program were contracted out to private suppliers (Hall, 2003).

The key point is that, even today space shuttle is an experimental vehicle. Lessons are still learned from each shuttle returning to earth. The official development stage for the space shuttle was from 1980 to 1982. After that period, it was considered operational, but still shuttle engineers had contradicting opinions. They considered it to be a developmental aircraft because of constantly changing technology and inexplicable problems that cannot be predicted from design. The unexpected problems continued to occur during shuttle missions, but no disasters occurred. Due to budget constraints, management was not keen on finding the root causes of the problem. NASA allowed these technical flaws to pass, as analyses were costly and time consuming. Even at the suppliers end, due to incessant production pressure, problems were often neglected.

The Challenger Tragedy

On 28 January 1986, around seventy-six seconds into the mission, the Space Shuttle Challenger was destroyed, killing all seven crew members (Rogers Commission report, 1986). This happened due to a design flaw in shuttle's solid rocket booster and disintegration of an O-ring on its right solid rocket booster (Lighthall, 1991). The problems mentioned above were significant, but there were many other reasons which contributed to the destruction of Columbia space shuttle.

Components of Shuttle

The Columbia space shuttle, officially called as Space Transportation System (STS), has three major components; the Orbiter, External Tank (ET), and two Solid Rocket Booster (SRB) motors as shown in Figure 1.

Orbiter – It is a winged craft that carries astronauts and payloads (satellites or space station) into space and travel back to land on a runway. However, to get additional thrust, two large Solid Rocket Boosters are provided, each attached to the sides of external tank (shown in Figure 1), as Orbiter alone does not provide enough thrust.

Figure 1: Challenger Space Shuttle (Space Shuttle Challenger Disaster, 2003)

Components of the Space Shuttle

The three components are attached together during shuttle assembly, whereas the field joints between the sections contain two rubber O-rings. The purpose of O-rings is to fill the field joints and prevent hot gases from escaping. The solid rockets are cheaper and less complicated than liquid-fuel rocket engines. The biggest disadvantage of solid rocket is that it cannot be tuned off once ignited.

External Tank

The purpose of external tank is to carry liquid fuel for the three engines located in the aft section of the orbiter. The lower two third of the tank carries liquid hydrogen with the upper one third containing liquid oxygen.

Cold Temperature Concern for O-rings

Before the launch of Columbia shuttle, no experimentation was conducted on space shuttles at temperatures below 51 F (11 C). The air temperature dropped to 18 F (- 8 C) in the night and 36 F (2 C) in the morning before the launch. Even Morton Thiokol, the contractor for construction and maintenance of shuttle SRB’s had insufficient data on performance of boosters at lower temperatures. There were some other notable factors which are discussed as follows:

1. The external tank was filled with -423 F (-253 C) liquid hydrogen and -300 F (-184 C) liquid oxygen. The cold breeze in the night and morning before the shuttle launch changed air in external tank to super-cooled state and moved it down to the ground.

2. It was known that passing of cold breeze results in formation of external tank. This observation was not unusual because it happened during warm temperatures also. The direction of wind was western-northwestern that day, resulting in super cooled air to slide down directly to the lower portion of the right SFB.

3. To measure the thickness of ice layer on the external tank, infrared cameras were used by the ground staff before every launch. On the day of the launch, a temperature of 8 F (-13 C) was recorded at the aft field joint of the right SRB. The ground staff did not pass this vital information to the management.

Figure 2: Challenger Space Shuttle (Space Shuttle Challenger Disaster, 2003)

All these factors contributed to the malfunctioning of primary and secondary O-ring causing hot exhaust gases at the temperature of 6000 F (3315 C) to escape from the rocket chamber and led to catastrophic incident.

Poor Decision Making

Before the launch of the Challenger space shuttle, a teleconference was held between Morton Thiokol, Kennedy Space Center (KSC), and Marshall Space Flight Center (MSFC) to decide whether it should be launched or not. The engineers at Thiokol were not in the favor of the launch because of their apprehensions on the performance of O-rings in cold weather conditions (Hall, 2003). However, before the launch of Challenger there were many cases of O-ring damage (Dalal, Fowlkes, and Hoadley, 1989). Due to immense production pressure, the Thiokol engineers were not able to find the root causes, and justify their arguments with substantial evidence. The graphs presented during the teleconference were vague and confusing. Furthermore in their rush to get ready for the conference call, the engineering team erroneously included slides which were previously used for Flight Readiness Review (FRR) to claim that O-rings would not be a problem (Tufte, 1997). The management was not convinced with the case and decided to launch the shuttle. The report on the challenger space shuttle disaster states, " After the shuttle became operational in 1980, the workforce and functions of several shuttle safety, reliability, and quality assurance offices were reduced. A safety committee, the Space Shuttle Program Crew Safety Panel, ceased to exist at that time" (Leveson, 1995).

Recommendations

Collaboration with Suppliers: NASA needs to change the conventional thinking about sourcing. The Collaborative sourcing approach is different from the traditional approach on sourcing. The traditional sourcing technique is all about squeezing the supplier to make profit. In collaborative sourcing both buyer and supplier craft a joint vision to achieve their objectives. They should emphasize on improving product and line processes by concurrent engineering, combined testing, and root cause engineering for error finding and rectification (Helper, MacDuffie, and Sabel, 2009).

Role of Hierarchy at NASA: A grave problem with NASA was its complicated corporate culture. NASA, which was a research institute, had become a platform, which was used by politicians for their promotion. The management should have understood that minute details play a crucial role in research organization like NASA. Even the decision to launch Challenger was influenced by government officials. As, President, Regan was scheduled to give his State of the Union Address the next night in which he intended to speak about astronaut Christa McAuliffe (Hall, 2003). NASA needs to develop a system for engineers to overcome the bureaucracy and hierarchy. By this way they won't be asked to defend their concerns and intuitions.

Importance to minor problems: Acceptance of deviations from standard was one major reason for the challenger disaster. The nature of work carried out at NASA is very sensitive and therefore the specification of tolerance to abnormalities should be suitably low. The O-ring problem was frequent, but management persisted with it on the grounds that it does not possess flight safety risk. If the engineers had succeeded in convincing the management to replace the damaged O-rings, loss of life and vehicle could have been averted. Following steps are recommended for problem analysis:

1. Find the significance and basis of the problem.

2. Prepare a full proof action plan to rectify the problem.

3. All the parameters should be tested against variables like temperature, wind, humidity etc.

4. Importance to Problem Reporting and Corrective Action (PRACA).

Conclusions

The Challenger shuttle disaster presents various issues that are relevant from engineering management standpoint. One of the key points is change in perspective of engineers who are now placed at managerial positions. It is vital for managers not to overlook their own engineering work experience, or the knowledge of their assistants. A lot of times, even managers with engineering background are not up to date about the latest advancement in the field of engineering. The managers should realize this while taking any decision on technical matters. Another important aspect is the role of ethics in engineering management. The job of engineer is to design, and along with it comes the responsibility that the product or service designed is safe for customers. It is the ethical responsibility of engineers to acknowledge mistakes and present unaltered data to the management. Further, the management decision can have a positive result or negative impact on organization's reputation.