Organizations as Brains: An Information Processing View — An Analysis of the Challenger Disaster

The brain's network of neurons forms a massive parallel information processing system with remarkable capabilities as follows: (1) Its performance tends to degrade gracefully under partial damage. (2) It can learn from experience. (3) Partial recovery from damage is possible if healthy units can learn to take over the functions previously carried out by the damaged areas. (4) It performs massively parallel computations extremely efficiently. (5) It supports the intelligence and self-awareness.

Galbraith's goal of organization design is the ability to deal with uncertainties effectively and efficiently. It is stated that the greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution in order to achieve a given level of performance. Therefore, in order to successfully utilize coordination by goal setting, hierarchy, and rules, two general ways are proposed. First, the organization can act to reduce the amount of information that it is processed by create slack resources or self-contained tasks. Second, it can act to increase its capacity to handle more information by invest in vertical information systems or create lateral relationships. The effect of all these actions is to reduce the number of exceptional cases referred upward into the organization through hierarchical channels.

In general, the brain metaphor of organization is proper and reasonable. When a person is thinking, the brain will collect all the relevant information for further filtering and analysis in order to make decision to the best of one's knowledge. In the process of collecting, filtering and analysis, the massive network of neurons works automatically in parallel to deal with independent and interdependent information. As for an organization, employees, groups or departments perform as neurons in the brain. Under common coordination, each is doing his own assignments and simultaneously shares information with others in order to facilitate everyone's work. From lower level to higher level, information gradually gets integrated and finally goes to the executives to make decision. The Space Shuttle Challenger accident will then be investigated as an information processing system. In this investigation, one can simply describe the organizations as brains.

The Challenger disaster was the worst accident in the history of manned spaceflight. On January 28, 1986, seventy-three seconds after the launch, the space shuttle ended with the propellants igniting in a huge ball of flame that destroyed the external tank and exposed the orbiter to severe aerodynamic loads that caused the complete structural backup. All seven crew members died. The technical cause of the accident was considered to be a failure of a pressure seal in the aft field joint of the right solid rocket motor (SRB). The failure was due to a faulty design unacceptably sensitive to a number of factors. These factors were the effects of temperature, physical dimensions, the character of materials, the effects of reusability, processing, and the reaction of the joint to dynamic loading. However, the Rogers Commission study of the Space Shuttle Challenger Accident concluded that the root of the accident was an accumulation of organizational problems. In the following, some key organizational deficiencies are discussed in view of information processing.

Conflict between engineering data and management perception

It was intended that the O-rings be actuated and sealed by combustion gas pressure displacing the putty in the space between the motor segments. The displacement of the putty would act like a piston and compress the air ahead of the primary O-ring, and force it into the gap between the tang and clevis. This process is known as pressure actuation of the O-ring seal. This pressure actuated sealing is required to occur very early during the Solid Rocket Motor ignition transient, which was also the management's perception. However, the engineering data said that the joint sealing performance is sensitive to a number of factors such as manufacturing tolerances, static O-ring compression, joint temperature, O-ring lubrication etc., either independently or in combination. The conflict or mismatch between engineering data and management perception results in repeating ignorance of engineers' concerns and arbitrary decision making, as revealed by the testimony at the Rogers Commission.

One way to solve the problem is to apply stronger constraints on (1) mechanical manufacturing and assembly so that the joint sealing performance is less sensitive to the mentioned factors, or (2) launch conditions such as temperature. Considering the pressure exerted on NASA by the nation's reliance on the Shuttle to increase the flight rate, the launch schedule may not be flexible enough to have ideal environmental conditions. Therefore, the former approach would be more realistic, which could result in re-design or even upgraded criteria or standardization. In Galbraith's model, this approach is to create slack resources so that fewer exceptions occur. Here, the slack resources are the factors that may affect the joint sealing performance. The stronger the constraints, the larger variations of the factors are allowed, the less need for information processing. Apparently, this approach is a constraint-cost trade off problem. The appropriate balance should be carefully determined.

Lack of problem reporting and tracking

An engineer at Marshall Space Flight Center (one of the NASA field centers) in Huntsville, Alabama, which was assigned responsibility for the SRB, first concluded after tests in 1977 and 1978 that rotation of the SRB field joint under pressure caused the loss of the secondary O-ring as a backup seal. Nevertheless, in 1980, the SRB joint was classified on the NASA Shuttle Critical Items List as Criticality 1R. The use of R, representing redundancy, signifies that NASA believed that the secondary O-ring would pressurize and seal if the primary O-ring failed to do so. Later, the Marshall management finally accepted the conclusion and had the criticality changed to Criticality 1 in December, 1982. However, most of the problem reporting paperwork tracking the O-ring erosion problem still listed the SRB field joint seal as Criticality 1R long after the status had been changed. This misrepresentation of criticality led some managers to believe wrongly that redundancy existed.

The above phenomenon serves as an example of incomplete and sometimes misleading information which lead to the decision to launch the Space Shuttle Challenger. To solve such type of problems, both vertical and lateral information systems need to be improved. On one hand, Marshall needs to increase the frequency of problem reporting and checking through hierarchical communication channels. Providing more information, more often will overload the decision maker. Hence, investment will be required to increase the capacity of the decision maker by employing computers with internal network, assistants-to etc. When an exception occurs, such as the detection of the possible failure of the backup O-ring by an engineer, of the change of criticality of the SRB, the managers can be aware of the problems in a relative short period of time. The significance of the exceptions can then be evaluated to decide whether to make incremental changes or to generate a new design or schedule. On the other hand, specialized liaison roles can be set up to handle the communication between Marshall and Morton Thiokol, who was awarded the contract for the SRBs. Liaison roles at middle level of management can forward the change of criticality from Marshall to Morton Thiokol directly. Or at lower level of management, the engineers at Morton Thiokol will be informed of test result and report the problem upward.

Flaws in the management structure

The lack of an independent role for the safety engineers and their effectively low-level status also contributed to the Challenger disaster. After the declaration of the Shuttle as “operational”, several safety, reliability, and quality assurance organizations were reorganized and reduced in size greatly. Moreover, some safety panels, which were providing safety review, went out of existence or were merged. As a result, there was no effective safety program who took the responsibility with enough authority to guarantee that safety was considered during decision making.

This flaw essentially lies in the defective framework of organization. When the decision making bypass the safety issues, a level in the hierarchy or a node in the neuron network of a brain is skipped. Thus, the safety-related information will never reach the managers who make decisions. The simplest way to solve this problem is to try to complement the framework such that sufficient and necessary information can be obtained.

To sum up, the Challenger disaster results from the poor operation of NASA and Morton Thiokol at least in terms of information processing, even though the direct cause seems to the failure of the O-rings. In fact, the O-ring failure simply triggers the Space Shuttle disaster, but if that event had not happened, another one would have. In order to avoid a similar disaster in the future, a complete hierarchy framework should be established with proper coordination and choice of strategies so as to be able to deal with exceptions and uncertainties.

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