Human Defense-in-depth is Dependent on Culture

Akinori KOMATSUBARA
Department of Industrial & Management Systems Engineering
School of Science and Engineering
WASEDA University
3-4-1 Okubo, Shinjuku, Tokyo 169-8555, Japan
komatsubara.ak@waseda.jp

An objective of an organization is achieved as accumulation of activities of organization members. If an inappropriate act of a certain member is conducted, restoration by human defense-in-depth is wanted to be performed. Based on the idea of KAB model in health care science, it is thought that a good behavior is composed with good knowledge and good attitude. An attitude is strongly influenced by a culture. If an organizational culture lacks in an ethic, human defense-in-depth by organization members is not achieved. An inappropriate act can be expected to be restrained by right knowledge, if the culture does not lack in an ethic, even if the culture gives priority to profit. Based on the above discussions and case studies of two organizational accidents that occurred in Japan, resilience to prevent organizational accidents is discussed in this study.

1 INTRODUCTION

Recently systems become larger and tend to become more complicated. Therefore, organizations which develop and maintain systems also become larger. In such a large organization, it is divided into some parts and is managed by a different party, where plural workers belong to do each job in charge. For example, when a building is built, an orderer, authorized architects, and various on-site workers participate to build a high quality building. A high quality building is not constructed if one of the parties does not play an expected role.

An objective of an organization is achieved by activities of people. This means that it is hoped that each person performs a desirable act which is in line with an objective of the organization. Furthermore, when some people notice an undesirable act performed by some other person, the people should correct the undesirable act so as to prevent organizational failure caused by the undesirable act. In other words, organizations need human defense-in-depth. Human defense-in-depth should be performed even if it is not exhibited by a contract. This is tacit human defense-in-depth. Tacit human defense-in-depth seems one of important approaches for resilience of organizations.

In this study, human defense-in-depth and culture will be discussed through two kinds of organizational accidents which occurred recently in Japan. These accidents seem to be the type of functional resonance, which type is proposed by Hollnagel E. (Hollnagel E., 2004). Based on this, safety of large-scale organizations is studied in this study.

2 CASE STUDY

2.1 JCO criticality accident

A criticality accident happened in a Japanese uranium manufacturing company (JCO Co.) in 1999. In this accident, three workers did batch production of uranium fuel. They knew the production procedure well. From the atomic physics point of view, the procedure was safe. However, its efficiency was so worse, and a production cost was too high with the procedure. Therefore the workers devised a new procedure which was efficient but inappropriate from the viewpoint of atomic physics. After receiving an agreement of a manager, they produced uranium fuel in that procedure. Then, criticality reaction occurred. The workers were seriously injured by radioactive rays, and the two of them died. Furthermore, workers who coped with radioactivity, rescue firefighters and a lot of neighborhood inhabitants were contaminated in radioactive rays. In addition, for 310,000 inhabitants who lived within a radius of 10km, an advice that they should stay inside their houses was made.

It should be pointed out that the company policy of cost cut existed and encouraged the workers to improve the work procedure strongly. Furthermore, it should be pointed out that the workers had little knowledge about atomic physics. Figure 1 shows this accident analyzed with FRAM (Functional Resonance Accident Model) (Hollnagel.E, 2004).

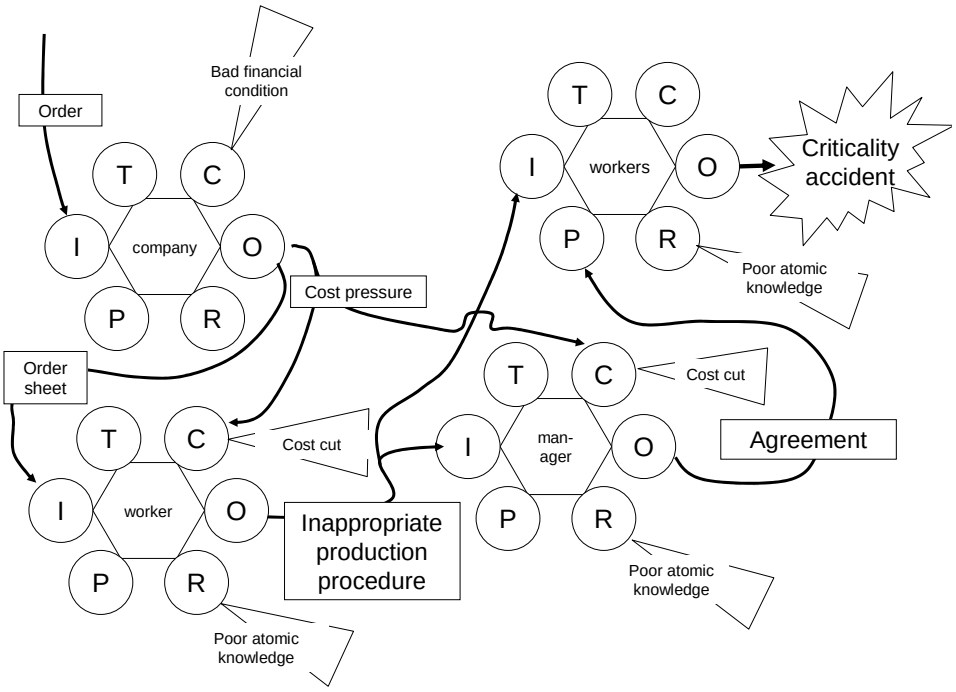

Fig. 1. The JCO Criticality Accident illustrated with FRAM

It is not bad that workers have consciousness of a cost cut and that they improve their work into efficient one. In Japan which became burnt ground by World War II, corporate activities which gave economic priority were made so as to make the country revive. Economic revitalization was made by passing through this time. As a result, the improvement activity for cost cut became a kind of common sense of Japanese industries. But, in case of the JCO accident, improvement which threatened safety was made. Sugimoto N. (2006) points out that use of a machine is admitted when the both sides of benefit and safety are satisfied. Based on his pointing, any jobs should be executed only when the both sides of benefit such as efficiency and safety are satisfied together, as shown in figure 2. If safety is only emphasized without profits, workers will have interests in improvements to obtain benefit. The JCO accident is that case.

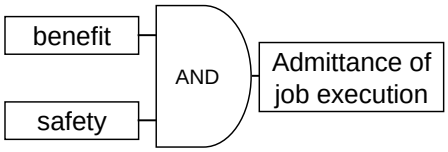

Fig.2. Admittance Model of Job execution with Benefit and Safety

Because the JCO criticality accident was caused by a Japanese sense, accidents of the same scenario threatened to happen in other Japanese companies. Indeed, a Japanese milk company caused a food poisoning accident in 2000. The workers at a factory of this milk company did not know that bacteria poison was not removed only with heating. Therefore the workers did not throw away the bacterial milk, in which bacteria had bred because the milk had been left at warm condition due to a power failure accident. They produced skim milk from the bacterial poisoned milk only with heating. The company sold the processed milk mixed with this skim milk. As a result, more than 6,000 people who drank the processed milk were damaged.

The JCO and the milk accidents occurred since workers acted in quest of efficiency or economic earnings, that was natural consciousness of Japanese worker. Therefore, Komatsubara A. (2000) calls these accidents as cultural caused accidents. When culture encourages attitude commonly, it is almost impossible to prevent the cultural caused accidents from human defense-in-depth with using attitude. However, workers of JCO and the milk company were not always uninterested in safety. In the JCO accident, if the workers or the manager had enough knowledge about atomic physics, a barrier for cost cut consciousness might have been made. In the case of the milk company, if the workers knew right knowledge about bacteria poison, they must throw away the bacteria polluted milk. In other words, knowledge becomes barrier, and in the both case, human defense-in-depth might be achieved.

2.2 A building strength forgery case

A crime case was revealed in Japan in 2005. A first class authorized architect forged a building strength design of several condominiums and hotels. Those buildings were built with very little amount of reinforcement steel rods. The tenants and the hotel owners did not know, however, those buildings had become those which collapsed very easily if an earthquake attacked. The developer which sold the buildings, the authorized architect, the on-site workers, and the agency which had examined the strength design plans played roles in this case. Common consciousness of "build a right building" was desired, of course, naturally.

According to newspapers, the developer imposed a pressure to reduce construction cost on the authorized architect. As a result, the architect did forgery to reduce amount of reinforcement steel rods. According to excuse of the architect, he was very afraid of losing his next jobs unless he obeyed pressure from the developer. The inappropriate strength design plan was examined by an authorized private building inspection agency. However, as for the inspection agency, competition among agencies was very severe. Therefore a very few examiners must process many examination items to reduce examination cost. As a result, the examination became only nominal, and the examiners were not able to find out the forgery. Governmental audit of private inspection agencies was insufficient, either. On the other hand, the on-site workers had noticed that reinforcement steel rods were too few. However, they were those who had taken ordering from the developer. The contract was that they had to build the buildings as they were ordered. As a result, the voice of doubt did not break out formally from them. At last, as buildings were built with very cheap building cost, the developer was able to obtain much profit.

Figure 3 shows this situation with FRAM. This case is the same case as the JCO accident on cost cut. However, the motive was corrupt profit. The architect and the on-site workers had correct and enough knowledge about constructing building. However, their attitudes were those that "All things which I should do are what I was ordered". This means that they ignored objective of the organization of "building a good building". In other words, an ethic (Patankar M.S., 2005) lacked on them. If an ethic lacked, correct knowledge does not work as a barrier, and human defense-in-depth would not be achieved at all.

3 DISCUSSION

3.1 High quality behavior and culture

Even if a business was performed within one company or within the organization where several companies or parties were tied up under some contracts, quality and safety must be given priority. In other words, business must be performed under safety culture. Culture including safety culture affects behavior of the people

who are engaging in the business. On the contrary, it is thought that culture is strengthened by behaviors. In JCO, culture of cost cut encouraged employees. At the same time, the culture of cost cut must be reinforced more by the employees, because the people who do not think about cost must be expelled out of the company. At the building strength case, culture of irresponsible constitution brought behaviors of lack of as ethic. On the other hand, it seems that the irresponsible culture was reinforced by the behavior of lack of as ethic. As an objective of an organization is achieved as accumulation of an individual human act, therefore, there is no way but making act of organization member better, so as to increase safety of organization. Therefore, we must consider what a good act is.

The KAB model is one of the models of health care science (Schooler C., 1995). This model means that the high quality behavior (B) which is good for health needs both enough knowledge (K) of health and good attitude (A) for health. When we take the idea of this model, high quality knowledge and high quality attitude must bring high quality behavior for safety. Unless either knowledge or attitude is good, high quality behavior can not be expected. Knowledge is the knowledge which is necessary for jobs. Knowledge of operation procedures with theoretical meanings and skills which are necessary for job are examples. Moreover, communication skill, general knowledge of manners for business which is for tacit human defense-in-depth is included. High quality attitude are such attitudes as thinking of safety, quality and customer first, and assertion of anxiety feeling of danger. Those attitudes seem to be supported with an ethic or safety culture.

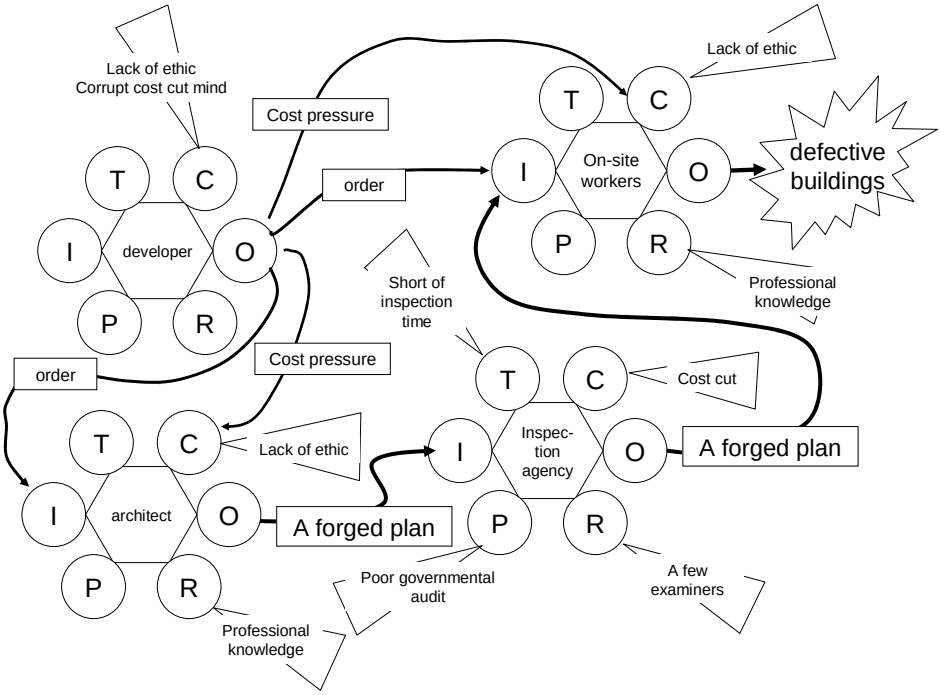

Fig. 3. The Building Strength Forgery Case illustrated with FRAM

High quality behavior would not be achieved if knowledge and attitude are not made best ones. In the case of JCO criticality accident, all employees were in cost cut attitude, and, besides, the workers had little knowledge of atomic physics. Therefore, barrier of knowledge could not be performed. At a building strength forgery case, the architect and the on-site workers had the right knowledge about building strength, however, their attitude was without an ethic, and therefore, the barrier of knowledge did not work. And, in the both cases, the human defense-in-depth would not work at all. It seems that attitude and knowledge, and relations with behaviors in terms of safety become the following.

Case A: The attitude does not lack of an ethic, but it gives priority to profit. Moreover it lacks of correct knowledge. The JCO accident corresponds to this. Human defense-in-depth is expected to be achieved if correct knowledge is given.

Case B: People have correct knowledge, but their attitudes miss an ethic. The building strength forgery case corresponds. They had right knowledge about building strength, but barrier of knowledge did not work because the attitude was without an ethic.

Case C: Another case seems to exist. That is, the case where attitude does not lack of an ethic but it gives priority to profit. So-so knowledge exits. In this case, people will tend to go for an act to take advantage to be seen in ETTO (Efficiency-Thoroughness trade-off) (Hollnagel E., 2004). A situation troubled by dilemma between benefit and safety may occur.

In order to promote a safe act of a worker, knowledge which is required at task, and attitude which is needed for task must be made clear. Moreover, attitude must be supported in an ethic surely. If a worker engages in duties with its being vague, an accident must occur. This is led on the Woods' indication that the high safety is supported by accountability (Woods D.D., 2005). At the building strength forgery case, their attitude was strongly in want of accountability.

3.2 Modified SHEL Model

Komatsubara A. proposed a modified SHEL model (Komatsubara.A.2006). This is the model where L is replaced with H in the SHEL model (Hawkins F.W.1987). Figure 4 shows this modified model. Systems should be designed for operators to be able to treat easily. However, because systems must perform their own functions, they cannot always correspond to the level of operators. In other words, we must give appropriate and balanced Livewares, Software and Environment to systems so as to make systems achieve their functions with safety. The modified SHEL model explains the necessity of the idea of Hardware (system) centered design.

Utilizing of a car is a good example for understanding this model. A car (Hardware) requires a good driver (Liveware) who has a full knowledge of Road Traffic Act and an excellent driving skill, and attitude giving priority to safety. A car must hope to get support with high-level maintenance staffs (Liveware). A car must be driven in good road condition (Environment) with good Road Traffic Act (Software).

If there are some gaps between H and SELL, safety must be threatened. Of course, modifying cars is important, but there are limits. Therefore conforming SELL to H is also important. Like this, we should manage the system in suitable SELL, with considering its scale, degree of complexity, and technical contents of the system. At the JCO accident, uranium fuel production system needs the balanced conditions of an appropriate procedure, environment that atomic control and ergonomic consideration for working was done, and workers who had enough knowledge of atomic physics and good safe attitude. In the building strength forgery case, the buildings must hope to be built by an architect who had enough building knowledge and attitude of customers first, a strict audit agency with accountability, and on-site workers who had attitude of safety and quality first. With using this modified SHEL model, we can obtain the benefit to clarify safety conditions that systems need.

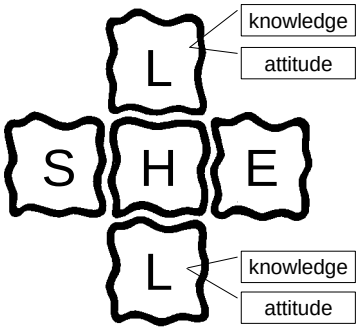

Fig.4. Modified SHEL Model

4 COCLUSION

Recently in Japan, the organizational style in which small organizations and plural people were made to be connected by contracts has increased. The building strength forgery case is an example. However, even if it is such an organization style, each one is desired to perform desirable acts. Therefore we have to define and estimate their desirable acts. The modified SHEL model will help this definition.

Because scale-merit and limit use are demanded recently, systems become larger and more complicated. Therefore energy contained inside systems tends to become larger. As a result, if an inappropriate act including simple human errors is not corrected inside the organization, serious failure may occur. In order to avoid failure, prevention or correction of inappropriate acts is needed. If organization members stand on the culture that does not consider safety as a common ground, inside correction can not be performed. Even if people have right knowledge, if the culture lacks of an ethic, the knowledge does not work as a barrier.

In Japan, the ethic and the justice have existed in the traditional consciousness conventionally. In children, this way of thinking has been brought up by many high

quality picture books. However, recently, leaving of books has been advancing at children. Moreover, moneymaking which does not choose a means even though it is lawful is admired very much in society recently. In other words, ethic culture as a Japanese common ground is collapsing. "The law about promotion of reading activities of a child" was established in 2001. It seems that this law is an outcome of vague uneasiness for collapse of this Japanese culture, and it seems that people are feeling the necessity of rebuilding of ethic culture.

It is required that organization members stand on the culture of an ethic to prevent organizational accident, first. Woods D.D. points the important idea of Accountability (Woods D.D.2005). An ethic leads to accountability. If there is an ethic, high quality knowledge can act as a barrier to an inappropriate act. In organizations, human defense-in-depth is one of the important resilience ways. Enrichment of attitude and knowledge is the key issue to make effective human defense-in-depth to prevent organizational accidents.

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