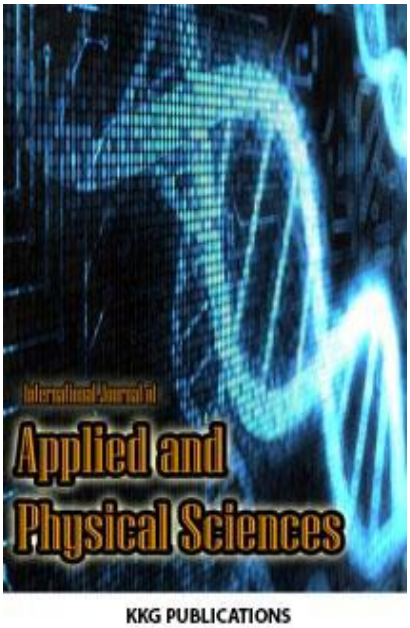

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THE FUKUSHIMA ACCIDENT: THE LIMITS OF ORGANIZATIONAL CONTROL OF RISK TECHNOLOGIES

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Abstract. The failures of organization which run high technologies can be related to the fragile complexity of these organizations. Fragility means here that the selectivity of decisions in organizations implies systematic non-knowledge about a multitude of events inside and outside the organization. It is for this reason that failures appear as surprises. It is not only the control of hazardous technologies which demands particular forms of alertness. It is also the selective preparedness for surprises that make these organizations accident-prone. The Fukushima accident resulted not simply from mismanagement but from selective decisions about necessary and seemingly sufficient safety measures, which, however, did not process enough available knowledge about possible environmental events threatening the operations of the power plants

INTRODUCTION

The Fukushima Daiichi Catastrophe

The power plant accident of Fukushima Daiichi on March 11, 2011 has caused immense damage in terms of lives, health, contamination of soils, radioactive emissions into the air and the ocean. The destruction of the power plant of Fukushima Daiichi has not only required the evacuation of large numbers of people in the vicinity of the power plant, it has also done enormous damage to the regional economy. The question to be asked is: Was the Fuskushima accident an unavoidable natural disaster or was it due to organizational failures of the Tokio Electric Power Company which runs the Daiichi nuclear utilities [1].

The immense material and social consequences of that accident have had groundbreaking consequences for local and regional life contexts. Whether one can speak of a breakdown of society, I would doubt, if breakdown is to be understood in the sense of a total collapse of communicative connections throughout society or of a total loss of future for the region around the damaged power plant. It is certain that the dependency of society on technology , especially the dependency of society on risky technologies does present a threat to society' s sustainability, as accidents and especially catastrophic accidents can interrupt communicative nets temporarily and locally. In that sense I would speak of the fragile complexity of society. In the following sections I will discuss the question of the fragility of social order not primarily on the level of society, but of organizations. The accident of Fukushima is the accident of an organization, of the company Tokio Electric Power Company (TEPCO), which runs power generating plants - a high risk technology. The accident of Fukushima is much more to be attributed to organizational failure than to the natural disaster of the earthquake and the tsunami [1], as the selected organizational complexity was not of a kind that would restrict if not avoid the risks of a hazardous technology like energy production with nuclear combustible.

Organization and Technology

Modern society has not only made itself dependent on technology, and not only on large-scale technology such as the infrastructure systems of transport or of energy supply, not to mention of decentral technologies such as computers, mobile phone or cars. The failure of the basic technologies of water supply and sewage disposal or of energy supply alone would bring great parts of society to a standstill. Society has also made itself dependent on organizations that operate these basic technologies, the so-called infrastructure technologies such as energy supply, but also on organizations that apply a plurality of production and distribution techniques. Organizations as well as technologies (especially high technologies) are risky artefacts in society whose adequate functioning cannot be assumed without reservations. This also applies to such organizations – the so-called high-reliability organizations, which are specialized on anticipating and accommodating a variety of unexpected events.

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In the following paragraph, I will elucidate the character of organizations fraught with risk.

Organizational Complexity

Organizations are modern innovations of society. They start disseminating through society when the recruitment for social functions is no longer dependent on descent or belonging to a social stratum, but on membership based on competencies and performance [2]. Organizations are structured social arrangements to enhance human capacities through division of labor and hierarchy. Think of Adam Smith's famous example of the differences in work output between a craftsman producing needles one after the other and a manufactory coordinating partial processes of the production of needles: the difference is one of organization of human labor (and of vertical ordering of command which Adam Smith failed to mention). In terms of a social theory of communications, organizations consist of a special type of communications: decisions as condensed forms of communications which specify certain demands for action (and exclude many possible alternative actions), relate certain actions to others and open up a window into future consequences. The limits of resources which create expectations about efficient operations and the specificity of goals of organizations demand that the connecting of actions should be limited. This constraint implies selectivity in linking communicative addresses; it is at the same time the source of the complexity of organizations. The complexity of an organization increases with the amount of decisions which are not interconnected with one another [3]. This complexity is fragile, because the action capacity of an organization depends on limiting the possible internal connections. Providing for effectiveness has a price: namely, only those of the many internal and external events can be processed which are represented in the established decision routines. Selectivity of connections creates non-knowledge about events in a turbulent organizational environment. That is why organizations can fail. The consequence of selectivity is non-knowledge about possible consequences of ignored or excluded connections. This non-knowledge is a structural feature of all organizations because of the limits of possible connections among the elements of an organization. Were all possible connections represented in the structure of an organization, such an organization would be incapable of acting. This constitutive limitation of organizations plays an important role in the management of technologies and especially of so-called high-technologies.

Technological Complexity

Let me say a few words about technology. Technology are all artefacts which are characterized by the strict causal coupling of physical, chemical, biological or social elements and which are protected by some sort of containment from an environment of numerous other causal relations which might intervene in the artefact operations [2]. The intended design of technologies consists in the simplification of functional processes, in the control and manageability of their performance parameters. The function of encloing causal coupling operations is the controlled generation of outputs: at generating electrical energy in nuclear power plants, at building cars at assembly-lines, at issuing notifications in legal administrations. In the language of social theory of complexity one might say that the social function of technology lies in the reduction of complexity. This succeeds by when a limited number of technical elements are related to one another so that the artefact can perform recurrently a pre-programmed sequence of operations and yield desired outputs. Reduction of complexity means reduction of the variety of possible states of the elements of a technology. In a nutshell: the purpose of technology rests in its functioning.

The complexity of technology (that is: the selectivity of connecting its elements) can increase for several reasons depending on its safety features, on its interactivity and on its type of coupling. (1) *Safety technology*: The purpose of safety technology is to guard against the anticipated malfunction of parts or all of a technology. Safety technology adds to the complexity of an artefact because it selects some connections between safety features and basis technology and leaves many possible others out. Two other features of technology are more directly related to the complexity of a technical facility as organizational sociologist Charles Perrow has demonstrated: interactivity and coupling (Perrow, Normal Accidents). (2) *Interactivity*: Interactivity refers to the type of linkage internal to technical facilities. Linear linkages relate operations in sequential order: one operational mode follows directly by another. Conveyor belts are examples of linear interactivity. Interactive complexity is the opposite of linearity. Here components serve several functions (common mode operations), i.e. a heater unit heats up a gas tank A and serves at the same time as a heat exchanger for a chemical reactor B. Other causes for interactive complexity are feedback loops or faults in control instruments etc. (3) Coupling: The coupling of elements in a technical facility is another source of hidden complexity. Tight coupling means little slack between two elements or operations (the dream of engineers when constructing technology). Assembly lines are typically tightly coupled: without the action upstream there will be no action downstream. The advantage of tight coupling is direct sequencing of operations, the disadvantage is that if there is only one way to reach a goal unexpected events can severely disturb operations. One fault in the line of operations can bring down the whole facility. Loose coupling allows for sufficient reaction time in case of trouble; it is less prone to total breakdown of a technical artefact, but may carry with it unwanted slack of the operations.

The risk content of technical facilities can be read off of the degrees of interactivity, complexity and safety features. Automobile production is tightly coupled, but quite linear. Universities are loosely coupled (the functions of teaching, research and management are independent from one another and only bound together in the position of professors), but interactively complex (because of the raw material that is being treated in universities: knowledge). A number of technologies and technological networks such as air traffic are interactively complex and tightly coupled. But especially the industry dealing with raw materials such as the chemical, power generation or biotechnical industries are tightly coupled and interactively complex. Because of the toxicity and pathogenicity of the materials which are being processed these technical facilities have a high risk potential. Typically, these production facilities are enclosed in containments which are supposed to prevent the toxic materials from leaking to the outside. One critical implication follows from such precautions: the complications resulting from safety technology. The non-accessibility of the core of the facilities makes operations dependent on measuring and indication instruments whose data can only be checked in remote control centers. Malfunctions in the core may affect or circumvent the measuring devices and project a distorted picture of the operations in the control center.

The more complex a technology has been constructed the less transparent its operations are and the higher the risk of failure to ward off external causalities which can bring down the whole facility.

Control of Technology and Regulation

High technologies run by complex organizations contain chaos and interference problems which threaten the stability of the control and containment of their bundle of causal connections. This applies to the causal relations between the basis technology and safety technology which can push a technology to the limits of possible simplifications. The consequence can be the breakdown of the borders between encased and excluded causalities. In the case of risk technologies this means that when the diverse types of containment are destroyed the dangerous agents will be emitted into the environment.

For organizations running high technologies accidents are always surprises which emerge from the blind angle of the non-connected decisions having been made in the past. Accidents and especially catastrophic accidents are singularities to which an organization might not be able to develop a balanced approach [2]. However, organizations will also fail when the selected decision routines are not being executed (executive failure or organizational failure) [4] or when they fall prey to them during routine operations (see for instance for the first type of failure (negligence during routine operations) the accident at the "Indian Point" nuclear power plant [4] and for the second type of failure (blindness for unexpected events in routine operations) [5].

Regulation

The regulatory culture in Japan did not contribute to accident preparedness in the utility companies. Observers speak of “the organic relationship among TEPCO, regulatory authority and the Japanese government” [1]. The Nuclear Industry Safety Agency (NISA), the highest regulatory body in Japan, lacked institutional independence since it was a sub-division of the Ministry of Economy, Trade and Industry and was guided by economic and political considerations in its supervision practice.

Organizational Failure by Non-Observance: The Case Fukushima Daiichi

a. The accident

The desaster of the Fukushima power plant site started with a magnitude 9.0 earthquake under the pacific sea 130 km east of the city of Sendai. The earthquake triggered a tsunami which hit the Japanese east coast with waves of up 40 meters height. The impact of earthquake and tsunami took about 15 000 people’s lives. Several power plants near the epicenter of the earthquake were damaged by the tsunami; the utility Fukushima Daiichi with its six reactors was hit worst even though three of the six reactors were shut down for repair. In response to the earthquake the active units shut down automatically. The emergency cooling systems had also become inoperative because the earthquake had destroyed the external power lines. The remaining diesel generators started to provide electricity for the continuous cooling of reactor core. All but one diesel generators, however, were flooded by the tsunami waves following the earthquake and all but one unit were cut off from power sources. As a consequence, the radioactive rods of the reactors could no longer be cooled sufficiently. The strong rise in temperature caused an enormous vapor pressure in the reactor tanks which within a few days exploded due to the admixture of hydrogen gas. In two of the three active reactors a meltdown of the radioactive rods occured and radioactive emissions evaded from the reactors into the sea as well as into the air.

Detailed information on the scale of the nuclear meltdown in the three reactors is still not available due to the non-accessibility of the reactors. Environmental and health consequences of the nuclear meltdowns are still unknown [6, 7, 8]. Following calculations of the NISA the released radiation is ca. 200 quadrillion Becquerel which is equal to a tenth of the amount of radiation emitted in Chernobyl. The so-called death zone of about 20km around the Fukushima complex showed a radiation intensity that rules out the area's inhabitability in a medium-term scenario. The IAEA-report concluded that the construction of the nuclear power plants was not adequate to sustain the earthquake and tsunami of 11th March 2011 and that so-called “dry-sites” would have protected the reserve energy supply from flooding. Whether the Fukushima accident will be in comparable to the nuclear power plant accident of Chernobyl will be up to judgement only in some years' time from now.

(We know more about the consequences of the Chernobyl-accident of 26th of April 1986. The Chernobyl-Forum, installed at the initiative of the IAEA, presented a report in 2005 which reflected the consensus of eight UN-organizations, among them the WHO (World Health Organization), UNDP (UN

Development Program), UNEP (UN Environmental Program) and UNSCEAR (UN Scientific Committee on the Effects of Atomic Radiation). It described the Chernobyl-catastrophe as the biggest accident of the nuclear industry to date. The highest, partly lethal contamination was suffered by the 1000 workers who were performing emergency works at the reactor right after the accident. In the progress of events about 600 000 persons were registered as so-called liquidators who had been subject to increased radiation; and more than five million people received relatively low doses of radiation which supposedly do not exceed significantly the dose of natural radiation. The most important death cause in consequence of the accident was laryngeal cancer which was caused by the consumption of contaminated milk and affected mostly children (more than 4000 cases up till 2002). The environmental consequences resulted from the emission of big amounts of radioactive substances in the dimension of 14 Ebq (1 EBq=1018 Bq. Becquerel), of which Caesium due to its extreme longevity will present the biggest problem. More than 200 000 square kilometers – the biggest part belonging to Belorussia, Russia or Ukraine – received Caesium137-radiation of more than 37 kBq per square meter (Chernobyl Forum 2005, S. 22). Since the accident about 330 000 people were relocated with far reaching social consequences such as unemployment and permanently provisional accommodation, as well as big demographic shifts (almost complete emigration of young people from the region).)

Organizational and Regulatory Failures

The organizational response of TEPCO to the accident can be distinguished in three dimensions: vulnerability, defense in depth and resilience.

Assessment of Vulnerability

TEPCO' assessment of the vulnerability of the plant to environmental hazards expected 8.0 magnitude earthquakes; the March 11 of 2011 earthquake had a magnitude of 9.0. The main safety features of the Daiichi plant (substitution sources for energy provision) were not affected by the earthquake. The ensuing tsunami, however, destroyed most of Daiichi's emergency capacities [6]. A tsunami of this magnitude had not been anticipated nor implemented in the design of the Daiichi utility. In addition, TEPCO did not once reassess the Daiichi plant during its lifetime. Some reassessment of extreme tsunamis had been done by the Japanese Headquarters for Earthquake Research Promotion in 2002 which estimated that much larger tsunamis could occur than provided for by the plant design. Newer estimates by the Headquarters for Earthquake Research Promotion came to the conclusion that earthquakes of the magnitude 8.3 and tsunamis of around 15 m height might be possible. The TEPCO estimates for Fukushima Daiichi were not based on historical records, but on regional data without increased safety margins. In 2009 TEPCO estimated the maximum tsunami height at 6.1 m; only minor design changes were implemented (such as raising the motors of the pumps by a small margin) and further studies commissioned [6].

Defense in Depth

TEPCO only partially applied the international standard of "in depth defense" which demands that in case of severe accidents a) equipment for reliable normal operations, b) equipment for returning to a safe operation mode after an accident, c) manageable safety systems, d) preventive measures against progression of severe accidents should be provided for. The most decisive fourth measure was missing in TEPCO' emergency preparedness program.

Organizational Resilience

IEAE states a general overconfidence about the robustness of Japanese power plants against "low probability/high impact"-accidents. The events that led to the March 11 of 2011 accident were outside of the assumptions about hazards. At TEPCO headquarters "The risk of flooding triggering a nuclear accident was outside the basic assumption" [6]. TEPCO also excluded the possibility of common cause failure (a breakdown of several plant components because of one singly cause) which would lead to station blackout for multiple units [1]. Overall, the IEAE report concludes, the existing safety culture foreclosed the implications of interaction between human, organizational and technical features of the utility for its safety assessments.

TEPCO had a history of mismanagement and covering-up of incidents in its power plants. In July 2000 several plants of the company hat to shut down temporarily because of excessive radioactive emissions. An inside whistleblower had informed the public that TEPCO had deceived the regulatory authority and the public with false test reports. In 2002 the company announced that it had to close down all power plants because of false test reports. The president and vice-president of TEPCO resigned over this incident [4].

CONCLUSION AND DISCUSSION

Fragile complexity? Technical catastrophes and the social organizations of high-risk technologies

The failures of organization which run high technologies can be related to the fragile complexity of these organizations. Fragility is to mean here that the selectivity of decisions in organizations implies systematic non-knowledge about a multitude of events inside and outside the organization. It is for this reason that failures appear as surprises. It is not only the control of hazardous technologies which demands particular forms of alertness, it is also the selective preparedness for surprises which make these organizations accident-prone. The Fukushima accident resulted not simply from mismanagement, but from selective decisions about necessary and seemingly sufficient safety measures which, however, did not process enough available knowledge about possible environmental events threatening the operations of the power plants. These failures led to desastrous consequences for the livelihood of many people, but also brought the organization to the brink of collapse –and, in short, demonstrated the fragility of organizations dealing with high-risk technologies and their societal and natural environments.

REFERENCES

[1] S. C. Debnath, M. Kuhara, "Large and complex organizations and the unforeseeable crises: Was fukushima crisis an organizational failure for TEPCO or an unavoidable natural desaster?," College of Business Administration, Ritsumeikan University, Discussion Paper, 2014.

[2] L. Niklas, "*Soziologie Des Risikos*," Berlin: de Gruyter, 2003.

[3] J. Klaus, "Zur soziologie der katastrophe. In: Clausen, Lars et al. (ed.), Entsetzliche *soziale Prozesse. Theorie und Empirie der Katastrophen*," Münster: Lit, 2003, pp. 77-90.

[4] P. Charles, "*The Next Catastrophe. Reducing our Vulnerabilities to Natural, Industrial, and Terrorist Desasters*," Princeton: Princeton University Press, 2010.

[5] S. Scott, "*The Limits Of Safety. Organizations, Accidents, and Nuclear Weapons*," Princeton: Princeton University Press, 1995.

[6] International Atomic Energy Agency (IAEA), "The fukushima daiichi accident," Vienna: IAEA.

[7] M. Baba, "Fukushima accident: what happened?," *Radiation Measurements*, vol. 55, pp. 17-21, 2013.

[8] J. H. Song, and T. W. Kim, "Severe accident issues raised by the Fukushima accident and improvements suggested," *Nuclear Engineering and Technology*, vol. 46, no. 2, pp. 207-216, 2014.