A Mathematical Approach for Information Disclosure and an Application to Establishment of the Regulatory System for Safety Management

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ABSTRACT

In an effort to avoid repeating the Fukushima Dai-ichi Nuclear Plant accident, a disclosure method for unusual information on nuclear emergencies and radiological consequences is investigated from the perspective of mathematical analysis. Since such information involving so many factors is different from general information, there is a possibility of having a failure of local symmetry in the system which defines the information state function and we can not disclose such information. We call the extraordinary information anomalous information. Assuming that the information is regarded as anomalous information, we then examine why a third regulatory agency is needed as a way of disclosing such information. After researching how to establish a new system for safety management in the aftermath of past nuclear accidents and based on the implications from our mathematical interpretation, we propose a new system for assessing the safety culture of an operator by a regulatory body.

I. INTRODUCTION

This study investigates how information on nuclear emergencies and radiological consequences had been handled when the Three Mile Island (TMI) and Chernobyl accidents occurred and how a new system had been set up for safety management in the aftermath of those accidents. And, we discuss the problems on information disclosure on nuclear emergencies and radiological consequences in the aftermath of the Fukushima Dai-ichi Nuclear Plant (Fukushima Dai-ichi) accident. Next, we examine information itself mathematically. Information on nuclear emergencies and radiological consequences is different from other information since there is a possibility of a failure of symmetry in some directions of the component space which defines the information state function. We call such extraordinary information anomalous information. Supposing that information on nuclear emergencies and radiological consequences is anomalous information, we examine why an independent regulatory agency should be needed as a way of disclosing the information. Based on the implication from our mathematical interpretation, we propose the implementation of a new system for assessment of safety culture of an operator by a regulatory body. This study provides new insights regarding a new approach for disclosure of general information.

Information on nuclear emergencies and radiological consequences whose impact is both socially and biologically significant is different from other general information. It is difficult to analyze the social influence of the information which is the contribution of a social impact coming from non-stochastic factor quantitatively and mathematically. Therefore, we introduce the state function and an operator symbol and mathematically discuss for substance by an observer not to impact on information itself. Furthermore, since the contribution from non-stochastic factor is great and different from general information, a new method for disclosing

the information is needed. By regarding the information as the result of an observation of information state function, the mathematical study regarding information symmetry in so-called economy system could be implemented in a different perspective. The characteristics of information depend on the subjects which handles the information. We propose a new disclosure method for anomalous information by applying information on nuclear emergencies and radiological consequences to anomalous information.

This study proceeds as follows: In Chapter 1 we discuss how information on nuclear emergencies and radiological consequences had been handled on the nuclear plant accidents in the past and what new systems had been set up in the aftermath of those accidents. We point out the problems regarding information disclosure in the aftermath of Fukushima Dai-ichi accident in chapter two. In chapter three, we investigate whether information on nuclear emergencies and radiological consequences can be regarded mathematically as anomalous information. Supposing the information is anomalous information, we examine why a neutral observation is necessary for disclosing such anomalous information in chapter four. In chapter five, we propose the establishment of an independent regulatory agency "Safety Information Disclosure Audit System (SMIDAS)" which assesses the safety management system of an operator as a solution for the problems in the aftermath of the Fukushima Dai-ichi accident. Also in chapter five, we suggest the function of the agency, each function of the committee of this agency, and the practice standard. We provide our conclusions in chapter six.

II. PROBLEMS REGARDING INFORMATION DISCLOSURE

A scientific rationale should be needed for establishing a new system. If we suppose that information on nuclear emergencies and radiological consequences in the aftermath of TMI and Chernobyl accidents is anomalous information, there is a possibility that a new system had been set up in the aftermath of those accidents. Therefore, we investigate what kind of

systems had been established in order to resolve the problems in the aftermath of those accidents. And, we point out the problems for information disclosure in the aftermath of Fukushima Dai-ichi accident through considering how the problems of the accidents in the past were resolved by those systems.

2. 1. New Systems in the aftermath of Three Mile Island (TMI) Accident

The TMI accident brought sweeping changes in the federal regulatory oversight of civilian nuclear power safety by the U. S. Nuclear Regulatory Commission (NRC) . The NRC had been reorganized from the Atomic Energy Commission by the Energy Reorganization Act of 1974. The NRC enhanced the regulatory oversight for the reactors and improved safety for the nuclear industry[1]. Also, a self-regulatory agency and a policy making institution in their own industry, Institution of Nuclear Power Operation (INPO) had been set up in the aftermath of the TMI accident. INPO, which consists of fifty-six nuclear plant companies which own or manufacture reactors and engineering companies, is not in a position to promote and advertise nuclear power propulsion in order to ensure the credibility and the neutrality from the federal regulatory agency and society (Suzuki et al. 2005, p.13). INPO has had no direct official relationships but had a clear relationship with the NRC which shares information through exchanging memoranda (Suzuki et al. 2005, p.15). INPO only possesses industry information and does not disclosure the information to the public. Although the functions of INPO have been evaluated by the NRC and society in the U. S., there is a controversy regarding the lack of disclosure to the public for important information (Suzuki et al. 2005, p.17).

2. 2. A New System in the aftermath of Chernobyl Accident

[1] Office of NRC, Backgrounder.

The International Nuclear Safety Advisory Group (INSAG), which had been set up in 1985, suggested "safety culture" as a priority for nuclear safety[2].INSAG is the institution which the IAEA created from high professionals for nuclear safety in 1985 and had been established as an advisory agency which was under the direct control of the director general of the IAEA. INSAG refers to safety culture in INSAG-1 in 1986 in the aftermath of Chernobyl accident and defines safety culture in INSAG-4 comprehensively in 1991, and offers the framework for a safety management system in order to attain the high level of safety organizationally and individually. We point out that a concept of "safety culture" should permeate through the reactor itself and regulatory agency for nuclear safety and that the safety management system which assesses the safety culture for a reactor had been focused in the aftermath of Chernobyl accident.

2. 3. The Problems in the aftermath of Fukushima Dai-ichi Accdient

The Nuclear Industry Safety Agency (NISA) in Japan announced the Rating of the International Nuclear and Radiological Event Scale (INES) Fukushima Dai-ichi accident as level 7[3] one month after the Great East Japan Earthquake and Tsunami. According to the Report of the Japanese Government to the IAEA, the government explains the reason of the delay as follows:

On April 12, regarding the accumulated amount of the radioactive materials released in the atmosphere, NISA announced the estimates from analytical results of the reactor status etc and NSC announced the

[2] As for the new system which had been set up in the aftermath of Chernobyl accident, see Suzuki and Nakashima (2011) for the details. Suzuki and Nakashima (2011) suggest that safety culture has been referred and the Convention regarding nuclear safety has been enacted as new systems in the aftermath of Chernobyl.

[3] Here are news resources:

http://ecocentric.blogs.time.com/2011/04/11/what-does-fukushima%E2%80%99s-new-%E2%80%9Clevel-7%E2%80%9D-status-mean/

http://www.world-nuclear-news.org/RS_Fukushima_moved_to_Level_7_1204111.html

http://www.facebook.com/notes/international-atomic-energy-agency-iaea/iaea-update-on-fukushima-nuclear-accident-12-april-2011-445-utc/209209679108826

estimates from dust monitoring data. (Please refer to VI. 1) The estimation by NISA was 370,000 TBq of radioactivity in iodine equivalent and the calculated value based on the estimate of NSC was 630,000 TBq. Based on these results, NISA announced provisional evaluation of Level 7 on the same day. Although one month passed between the third and the fourth report, the provisional INES evaluation should have been made more promptly and appropriately.

Then, why did they wait for two kinds of estimates to announce it to the public and who decided to wait for both estimates? What are the original causes of the delay for the announcement of the INES level 7 by the government? *The governmental policies regarding lack of "timely and prompt disclosure of accurate information to the public in Japan"* resulted in social dislocation and confusion in the Japanese. The concerns of the public come from no assurance for the accuracy of information itself which the government provides and the transparency of information disclosure. We consider that there are two original causes in the governmental policies to lack of timely and prompt disclosure of accurate information to the public in Japan: *a weakness or a lack of preparedness for emergencies based on safety management system and a weakness of independence and neutrality in the regulatory agency in Japan.*

The report by the INPO explained the regulatory structure as follows[4];

The Minister of Economy, Trade and Industry (METI) has jurisdiction over nuclear power reactor facility in Japan, and the METI clearly stipulates that Nuclear Industrial Safety Agency (NISA) is the "organization to ensure the safety of nuclear energy," and it is positioned as a special organization of the Agency for Natural Resources and Energy of METI. NISA has definitive authorities and functions for the safety regulation based on the provisions of the Reactor Regulation Act and the Electricity Business Act. The Minister of

[4] Institution of Nuclear Power Operations (INPO). 2011. Special Report on the Nuclear Accident at the Fukushima Daiichi Nuclear Power Station, INPO. http://cryptome.org/0005/daiichi-inpo.pdf

METI is responsible for the regulatory activities over the nuclear installation such as the license for reactor installment pursuant to the Reactor Regulation Act, and the approval of construction plan and pre-service inspection pursuant to the Electricity Business Act. The Minister of METI relegates these regulatory activities to NISA, which independently makes decisions or may consult its proposed decision with the Minister of METI without involvement of the Agency for Natural Resources and Energy. The Nuclear Safety Commission (NSC) [5] Japan is an organization established under the Office, independent from the ministries and agencies involved in the utilization of nuclear power. It supervises and audits the safety regulation implemented by the regulatory bodies from the independent perspective and has the authorities to make recommendations to the regulatory bodies through the Prime Minister, if necessary. Moreover, Nuclear Industrial Safety Agency (NISA) [6] established the Japan Nuclear Energy Safety Organization (JNES) [7] as their technical support organization in October, 2003. JNES conducts a part of inspection of nuclear facilities pursuant to the laws, and provides technical support to the safety review and assessment on the nuclear installations and the consolidation of the safety regulation standard conducted by NISA. Nuclear Emergency Preparedness system, and MEXT is supposed to support the local governments' emergency monitoring activities by mobilizing the emergency monitoring members and devices to dispatch to the site, with the cooperation by the designated public organizations (National Institute of Radiological Sciences and Japan Atomic Energy Agency) (INPO 2011).

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As INPO also explains in the report, "governmental responsibility for the safe operation of Japan's nuclear power plants is divided between multiple government agencies." Also, the IAEA mission report (IAEA 2011, p.14)[8] made the conclusion through the mission statement as follows:

[5] NSC. http://www.nsc.go.jp/panfu/20060601.pdf

[6] NISA. http://www.nisa.meti.go.jp/nisa/what/index.html

[7] JNES. http://www.jnes.go.jp/shoukai/kihan.html

[8] http://www-pub.iaea.org/MTCD/meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf

Conclusion 6: Japan has a well organized emergency preparedness and response system as demonstrated by the handling of the Fukushima accident. Nevertheless, complicated structures and organizations can result in delays in urgent decision making.

Although each agency is supposed to be independent, the emergent situation did not make them work independently. The former prime minister, the representative of TEPCO, and the representative of the NSC were in the Cabinet office in order to respond to the Fukushima Dai-ichi accident. The NISA was set up under the MEXT and the NSC was established under the office. The JNES was expected to be set up as the third independent agency. All three agencies with the responsibility for nuclear safety, the NISA, the NSC and the JNES did not work independently during the Fukushima Dai-ichi accident. Also, considering the background of the members, the members of each regulatory agency have a related association with MEXT or reactors, such as TEPCO. It cannot be said that there is independence and neutrality in the regulatory agencies. This seems to be the original cause of the governmental policies to lack of "timely and prompt disclosure of accurate information to the public in Japan. "

According to the Japan Nuclear Energy Safety Organization (JNES), they tried to establish the safety management system in a reactor[9] (JNES 2006, p.24). We consider that there were no sufficient systematic controls for nuclear safety based on the safety management system in a reactor and a regulator. And the functions of the regulatory agency which should assess and promote safety culture did not work well[10]. Therefore, we propose that a new regulatory agency should be established as the third independent agency in order to assure a safety management system in reactors and the fairness and the accuracy in information disclosure under emergency situations. The regulatory agency needs to be

[9] JNES 2006, http://www.nsc.go.jp/hakusyo/hakusyo17/pdf/01hen_syou2.pdf

[10] See the details, Suzuki and Nakashima (2011).

prepared for emergency situations based on their safety management system.

III. DEFINITION OF ANOMALOUS INFORMATION

Information on nuclear emergencies and radiological consequences has the following characteristics: The information from nuclear emergencies and radiological consequences relates to a huge number of elements in the social and ecological components. Considering the large half-life of a radioactive metal, the information is of a long-term effect on the earth. Radioactivity from metals is invisible and cannot be perfectly shielded. Some lower radioactivity leakage has continued from the Fukushima nuclear plants. Radioactive metals have been spread not only in the Fukushima area but also across the world.

We examine whether information on nuclear emergencies and radiological consequences can be anomalous information. Many studies regarding anomaly have been conducted in the research field of elementary particle physics (Adler 1969; Bell and Jackiw 1969; Fujikawa 1979; Jackiw and Rajaraman 1985; Faddeev and Shatashvili 1986; Fujiwara et al. 1990). For example, a variety of anomalies in 2D supergravity theory have been discussed from a canonical theoretical view point (Fujiwara et al. 1997).

When a probability of an event E is denoted by $p(E) = \frac{1}{2}$, the information size $I(E)$ is defined by

$$I(E) = -\log_2\big(p(E)\big)\,. \qquad (1)$$

A unit of the $I(E)$ has the bit. For an example, if a coin is tossed n-times, a probability of one event is denoted by $p(E) = \left(\frac{1}{2}\right)^n$. In this case this number of ways is represented by $p(E)^{-1} = 2^n$ and the required number of bits (i.e. information size) is shown by

$$I(E) = \log_2(p(E)^{-1}) = \log_2(2^n) = n \text{ [bit]} . \quad (2)$$

Therefore when the number of ways is large and a probability is few, the $I(E)$ gets larger. On the other hand, when the number of ways is small and probability is large, the $I(E)$ gets smaller. The dynamics of the system is determined by using the entropy on the system. The Entropy is defined by the $I(E)$. The information theory based on stochastic factors under the definitions using Equation (2) is well known as Shannon's information theory (Shannon, 1948). However, most generally, the information like news value or social impact is considered to be represented by stochastic factors and non-stochastic factors (e. g., Ozawa, 2011).

Generally, we define an information state function by $\phi\ (X_\nu^\mu)$ before the information is observed. Components X_ν^μ are variables of information factors. The index μ and ν on X_ν^μ run from 0 to n. Hence, we assume that the number of components of ϕ is depending on the type of information as;

$$\begin{aligned} &\text{Unitary Information} : \phi\left(X_0^\mu\right), \\ &\text{General Information} : \phi\left(X_0^\mu, X_1^\mu, \dots, X_n^\mu\right), \\ &\text{Super Information} : \phi\left(X_0^\mu, X_1^\mu, \dots, X_n^\mu, \dots, X_\infty^\mu\right). \end{aligned} \quad (3)$$

Hence, we consider that super information denotes the information state function of the information on nuclear emergencies and radiological consequences since such information is related to the huge number of factors. And there is a possibility that we may not handle the super information since the number of components goes to infinity. Therefore, it is necessary to project the super information to general information.

Here, we assume that the super information has been projected to general information[11]. And, for simplicity we treat it as unitary information instead of general information. Assuming

[11] This mathematical analysis will be the future works.

that each variable of X_ν^μ has time dependence, we can rewrite the information state function by $\phi(X_0^0, X_0^1) \rightarrow \phi\ (t, X)\ (= \phi(E))$ explicitly.

Next, $\phi(t, X)$ represents the state before the information is observed. Then, we define the operator by $\hat{O}$ in order to observe the event of information[12]as

$$I(E)\ =\ \hat{O}\phi\ (t, X). \tag{4}$$

We can know the amount of information after $\hat{O}$ operates on $\phi(t, X)$ for the first time. The probability density function is rewritten with $p(t, X)\ (= p(E))$ and the non-probability density function is rewritten with $\bar{p}(t)$, where X is a stochastic variable and t is the time. Here, we consider that $\phi(t, X)$ depends on the contribution of the amount of information from stochastic factors and non-stochastic factor by $F\big(p(t, X)\big)$ and $G\left(\bar{p}(t)\right)$. The ϕ is generally defined as

$$\phi\ (X, t) = F\big(p(t, X)\big) +\ G\big(\bar{p}(t)\big)\ . \tag{5}$$

We focus on regularity and recursiveness of a non-stochastic information state function $G\big(\bar{p}(t)\big)$. In general, the usual information is considered to be measurable. Then, $G\big(\bar{p}(t)\big)$ can be represented by holomorphic functions. However, when the information relates to a nuclear emergency or radiation accident, it may be impossible to measure the contribution from $G\big(\bar{p}(t)\big)$ because a radiation accident has a complex effect on terrestrial organisms. In such circumstances, for instance, it is possible that if we transform $\phi(t, X)$ by an infinitesimal transformation on t in the system, the regularity in the time direction is broken due to the singularity as

[12] Although $\hat{O}$ should be defined on a concrete form, we do not define it , because we can discuss the functional property of an information state function without knowing precise function form in this content.

$$\begin{aligned}\phi(t,X) \to \phi(t+dt,X) &= U_t\phi(t,X) \\ &= e^{dt\,\partial_t}\phi(t,X) \\ &= \phi'(t,X) + \text{ [Anomalous Term] .}\end{aligned} \tag{6}$$

In general, we need to consider a system on $\phi\left(X_\nu^\mu\right)$ in the limit $\nu \to \infty$ when dealing with super information. $\phi\left(X_\nu^\mu\right)$ which satisfied the Equation (6) is regarded as an anomalous information state function. And the information produced by anomalous $\phi\left(X_\nu^\mu\right)$ is defined as anomalous information. Anomalous information that is derived from super information should be projected to general information. In our study we think that the anomalous information occurs from the very serious event such as very sever nuclear accident. The very serious event may also include a plane crash accident. It is important that the anomalous information does not depend on whether it is bad news or good news but the anomalous information occurs when the number size of elements of serious event brings close to infinite.

IV. NECESSITY OF INDEPENDENT AUDITING

Suppose that information on nuclear emergencies and radiological consequences can be anomalous, a super-neutral regulatory agency should be established. Therefore, we discuss here why a super-neutral regulatory agency should be set up.

Assuming that the contribution from the singular part of the anomalous origin of the information exists, a non-stochastic information state function $G(t)$ is represented as

$$G(t) \to G_{sing}(t) = g_{reg}(t) + g_{sing}(t), \tag{7}$$

where $g_{reg}(t)$ has a contribution of regularity part and $g_{sing}(t)$ has a contribution of the

singular part $G_{sing}(t)$ caused by anomalous effect, therefore $G(\bar{p}(t))$ turned to $G_{sing}(t)$[13].

On the other hand, as an observer involved in the measurement of the information source (e. g., stakeholders), we can redefine the observed information state function as recursive information function. Here, the recursive function is represented as

$$\hat{\mathcal{O}}^{rec} g(t) \to \hat{\mathcal{O}}^{rec} g^{rec}(t) = g\left(t, \hat{\mathcal{O}}^{rec} G_{sing}(t)\right), \tag{8}$$

whether $g(t)$ is the singular or not. $\hat{\mathcal{O}}^{rec}$ denotes the operator for the observation involved in the measurement of the information source, even though the non-stochastic information state function is the singular. In general, in that case the observed information state function $\hat{\mathcal{O}} G_{sing}(t)$ is denoted as a non-recursive (i.e. usual) contribution employed $\hat{\mathcal{O}}$ and a recursive contribution employed $\hat{\mathcal{O}}^{rec}$ as

$$\hat{\mathcal{O}} G_{sing}(t) = \hat{\mathcal{O}} G_{sing}(t) + \hat{\mathcal{O}}^{rec} G_{sing}^{rec}\left(t, \hat{\mathcal{O}}^{rec} G_{sing}(t)\right). \tag{9}$$

The observed information state function $\hat{\mathcal{O}} G_{sing}(t)$ which has a contribution of the singular part can be expressed by Equation (7) and Equation (9) as

$$\begin{aligned} \hat{\mathcal{O}} G_{sing}(t) &= \hat{\mathcal{O}} G_{sing}(t) + \hat{\mathcal{O}}^{rec} G_{sing}^{rec}\left(t, \hat{\mathcal{O}}^{rec} G_{sing}(t)\right) \\ &= \hat{\mathcal{O}} g_{reg}(t) + \hat{\mathcal{O}} g_{sing}(t) \\ &\quad + \hat{\mathcal{O}}^{rec} g_{reg}^{rec}\left(t, \hat{\mathcal{O}}^{rec} G_{sing}(t)\right) \\ &\quad + \hat{\mathcal{O}}^{rec} g_{sing}^{rec}\left(t, \hat{\mathcal{O}}^{rec} G_{sing}(t)\right). \end{aligned} \tag{10}$$

Then, we can consider that the term $\hat{\mathcal{O}}^{rec} g_{reg}^{rec}\left(t, \hat{\mathcal{O}}^{rec} G_{sing}(t)\right)$ is recursively forbidden from the point of view of consistency for holomorphy. Therefore, this term should be renormalized. So, this observed information state function is denoted as

[13] $\bar{p}(t)$ is briefly displayed as t.

$$\hat{\mathcal{O}}G_{sing}(t) = \hat{\mathcal{O}}g_{reg}(t) + \hat{\mathcal{O}}g_{sing}(t) + \hat{\mathcal{O}}^{rec}g_{sing}^{rec}\left(t, \hat{\mathcal{O}}^{rec}G_{sing}(t)\right). \quad (11)$$

Unless the observer does not relate to the information, the last term $\hat{\mathcal{O}}^{rec}g_{sing}^{rec}\left(t, \hat{\mathcal{O}}^{rec}G_{sing}(t)\right)$ should be vanished. We can expect a better behavior of the observed information state function as

$$\hat{\mathcal{O}}G_{sing}(t) = \hat{\mathcal{O}}g_{reg}(t) + \hat{\mathcal{O}}g_{sing}(t). \quad (12)$$

Thus, we suggest that the operator $\hat{\mathcal{O}}$ for observation should be enforced by third parties such as a super-neutral independent auditing board.

The logical expansion above which contains several assumptions based on actual social data is not accompanied by a rigorous mathematical proof. For example, the structure of the information state function has not determined explicitly and the existence of anomalous symmetry on the super information space has not fixed, therefore many mathematical analyses remain as the future works. However, taken together, we can suggest the nature of an information state function by focusing on the regularity and the recursiveness of the function in this chapter.

V. SAFETY MANAGEMENT INFORMATION DISCLOSURE AUDITING SYSTEM

In order for people to prevent the reoccurrence of a nuclear plant accident, information on nuclear emergencies and radiological consequences should be analyzed quantitatively and systematically from the original level. Therefore, we introduce the mathematical approach for information which impacts on social economy and biological fields in the previous chapter.

And, we provide a proposal for applying the implication from the mathematical analysis to the real world.

As discussed in chapter two, we consider that the causes of the social dislocations and confusions among the public in Japan resulting from *the governmental policies to lack of "timely and prompt disclosure of accurate information to the public in Japan"* lie in *a weakness or a lack of preparedness for emergencies based on safety management system and a weakness of independence and neutrality in regulatory agency in Japan.* It seems that there is a dependency relationship with political bias between a regulatory agency and an operator or nuclear industry[14]. We propose a new system to improve the structure itself and the functions of a regulatory agency as a possible solution for the nuclear safety from a perspective of emergency preparedness and information disclosure.

5. 1. The Structure of the Regulatory Agency

INSAG-13 (IAEA 1999) asserts the role of a regulatory agency below:

15. The regulatory body promotes an effective safety management system in the operating organization by ensuring that there is critical self-assessment and correction (described as self-regulation) and avoids acting in a manner that diminishes the responsibility for safety of the regulated organization.

16. The body given the responsibility by the government to regulate the safety of nuclear plants has a significant influence on how operating organizations manage safety. The regulator ensures that the operating organization has an effective self regulating safety management system and the regulatory body monitors the effectiveness of the organization's safety management system as part of its scrutiny of safety performance. It is thus important that the regulatory body or bodies maintain open channels of communication with operating organizations.

[14] According to Asahi shinbun (January 1, 2012), twenty four members of eighty-nine members of NSC had received 85 million yen of contribution from nuclear related firms and industry by 2010 for five years. http://www.asahi.com/special/10005/OSK201112310119.html According to Asahi shinbun (November 12, 2011), the chairperson of NSC did not disclosure the relationship between members and a nuclear plant firms for two more years. http://www.asahi.com/special/10005/OSK201111110171.html

17. The regulatory body monitors the performance of the organization and takes action if ever the safety management system becomes ineffective or the safety performance of the organization declines. The regulatory body needs to be technically competent, and will be most effective if it works in a manner that is non-bureaucratic and avoids excessive detailed regulation. Furthermore, the regulatory body should not exercise direct control over the management of safety within the operating organization or impose detailed requirements on the form of the organization's safety management system. This could be counterproductive by weakening the system of self-regulation and diminishing and diluting the responsibility for safety assumed by the operating organization.

INSAG states the role of the regulatory agency as follows (IAEA 1999, p. 6):

15. The regulatory body promotes an effective safety management system in the operating organization by ensuring that there is critical self-assessment and correction (described as self-regulation) and avoids acting in a manner that diminishes the responsibility for safety of the regulated organization.

INSAG-13 suggests that the responsibility for nuclear safety lies in a reactor and sets up an effective safety management for the reactor to release the responsibility for the safety (IAEA 1999, p.3) and it is the function for the regulatory agency to check that. However, as discussed in chapter two, since there was no certified independent agency which provided assurance of the adequacy for the safety management system, the correspondence to the emergency did not work well. There was also no assurance for the fairness and the accuracy of information which they disclosed right after the Fukushima Dai-ichi accident.

Based on our mathematical analysis suggested in the previous chapter, the government and state and organizations which possess anomalous information should control information through the safety management system and assure the fairness and accuracy of information which they provide the public to release the accountability. INPO points out that emergency preparedness and implementation in Japan involve many organizations, including on site, off

site, national government, local government (s), regulators, and contractors. Therefore, INPO recommends as emergency plan, "One large-scale national emergency response drill is conducted each year to exercise the associated organizations and ensure the emergency plan is capable of fulfilling its intended function."

In order to fix this situation, we propose that an independent third organization be established which assures the adequacy for the safety management system and provide assurance for the fairness and accuracy of safety management information of the government, state and organizations. Here, we propose Safety Management Information Disclosure Audit System (SMIDAS) as the third independent regulatory agency.

The objective of SMIDAS is to provide assurance regarding whether safety management of the government, state and organizations have no weaknesses, and the fairness and the accuracy of information which the government, state and organizations disclose. Also, SMIDAS should express their opinions regarding comments based on the information which the government, state and organizations disclose. As for the safety management of the government, state and organizations, SMIDAS regulates whether their safety management works appropriately regardless of possessing ISO1400[15], and provides the assurance of the fairness and the accuracy of the safety information with which they provide. SMIDAS requires an operator to disclose whether the operator possesses recognized accreditation, and audits directly whether the operator set up an adequate safety management systems.

The Informal Gathering for Discussion was held at a nuclear safety committee on August 25, 2009. According to the report on transparency and neutrality for the safety assessment

[15] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=43241 The website explains below; ISO 14006:2011 provides guidelines to assist organizations in establishing, documenting, implementing, maintaining and continually improving their management of eco design as part of an environmental management system (EMS) . ISO 14006:2011 is intended to be used by those organizations that have implemented an EMS in accordance with ISO 14001, but can help in integrating eco design in other management systems. The guidelines are applicable to any organization regardless of its size or activity. ISO 14006:2011 applies to those product-related environmental aspects that the organization can control and those it can influence. ISO 14006:2011 does not establish by itself specific environmental performance criteria, and is not intended for certification purposes.

(NSC 2009) [16], the NSC regards the neutrality as the NSC's double check of the safety statement which the NISA prepares based on the auditing by the NISA. The double check does not mean the direct check of the safety management itself by the NSC.

This means that so called "direct reporting" [17] has not been introduced to the nuclear safety assessment of the operator. There are two problems: one is the double check is implemented under the government: the NISA is set up under the MEXT and the NSC is set up under the government cabinet. And, the other problem is so called "no direct auditing" for safety management. The NSC does not assess the safety for the reactor by the NSC directly. Therefore, it does not seem that there is sufficient independence and neutrality.

According to the Report of transparency and neutrality regarding the safety assessment (NSC 2009), they consider the transparency as all the disclosure of the process of decision to the public. However, we do not consider that all the information should be disclosed, since this is a national security issue, and the information should be kept confidential. To improve independence and neutrality, transparency is needed for the process of members selected or timing of information disclosure.

5. 2. The Functions of SMIDAS

Here, we explain the functions of the new regulatory agency (SMIDAS). The Law Concerning the Promotion of Business Activities with Environmental Consideration by Specified Corporations, etc., by Facilitating Access to Environmental Information, and Other Measure (Kankyo Hairyo Sokushin Ho) was enacted since April, 2005[18]. The Law requires the state and profit-organizations to disclose the situation of their environmental

[16] As for transparency and neutrality regarding the safety assessment, the informal gathering for discussion was held at nuclear safety committee on August 25, 2009. http://www.nsc.go.jp/senmon/soki/anzen_kon/anzen_kon_so01.pdf

[17] Internal Controls System in Japan (J-SOX) does not require the direct reporting for the internal controls system. The CPAs check the internal control statements which CEOs and CFOs prepare but do not audit the internal control system by themselves.

[18] http://www.env.go.jp/en/laws/policy/business.pdf

considerations[1920.] The state and profit-organizations have the responsibility to disclose fair and accurate information regarding the environment to the public and the related parties timely and objectively[21]. Especially, profit-organizations are required not only to prepare and disclose information regarding the environment, but also reasonable efforts are required to have assessments by the third auditor in order to improve the credibility of information.

However, in the aftermath of the Great East Japan Tsunami and Earthquake, the public receives information indirectly and directly from the government, state and profit-organizations without assurance of the fairness and the accuracy of information. The public in Japan has a great concern under no assurance of the content of information. People in some areas suffer from the damages caused by rumors.

The current situation of disclosure regarding environmental information is as follows: full disclosure to the public (50%), no disclosure to the public (more than 40%), limited disclosure (7.7%) [22]. According to the results of the survey, firms answer as the best way for improving creditability of the environmental statement: to receive comments from the third agency (30.3%), to implement internal assessment (21.8%), to have an assessment by the third agency (15.1%) (Ministry of Environment 2010).

Considering the above survey results, although the law was enacted, there is the situation of un-prevailing of the law to the public in Japan. Especially, in the aftermath of the Great

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[19] As for the environmental statement and CSR (Corporate Social Responsibility) statement, if we consider the percentages of disclosure of environmental statements by dividing into listed or non-listed markets, although the percentage of environmental statements disclosure is decreasing for listed markets, the percentage of CSR statements is a bit increasing. Both of the percentage of environmental statements and CSR statements disclosure are decreasing for non-listed markets.

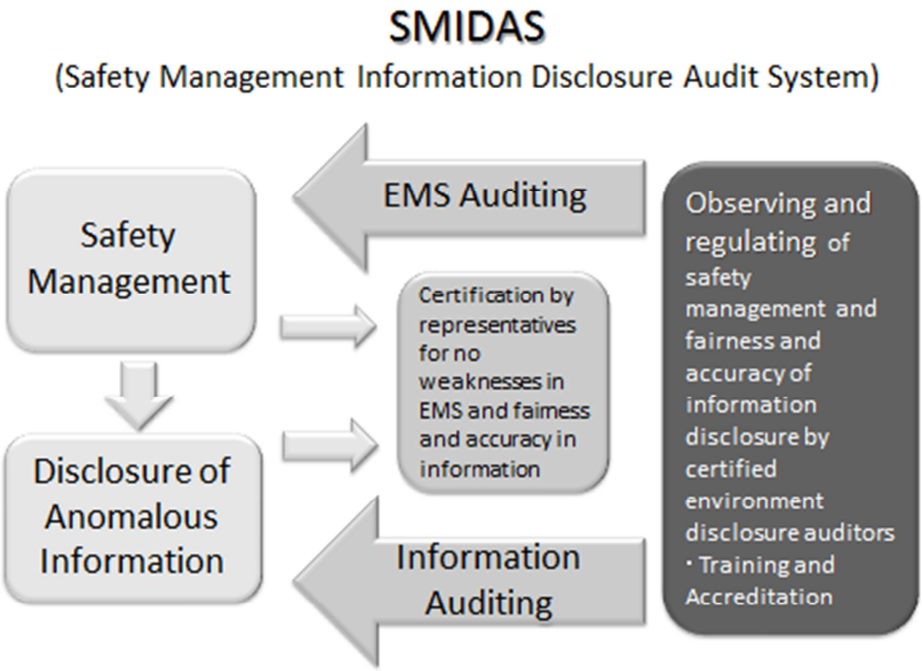
[20]Article 6 (Publication of information on the State of Environmentally Considerate Activities of the State) The heads of each ministry and agency (heads of each ministry and agency provided in Article 20.2 in Law No. 34 of 1947; Public Finance Law) must publish each fiscal year through the Internet or by other means information on the state of their environmental consideration (including numerical data indicating the environmental load produced by their administrative work or projects; hereinafter the same) with regard to the mandated work of the respective ministry or agency for the previous year. Article 7 (Publication of information on the State of Environmentally Considerate Activities of Local Governments) The heads of each local government shall strive to publish each fiscal year through the Internet or by other means information on the state of their environmental consideration with regard to the mandated work of the local government for the previous year.

[21] As for the situation of preparation and disclosure of environmental statement, 6.5% of 3,036 firms prepare and disclose the environmental statement in 2004 but 37.8% in 2005. The percentage increases until 2005 but goes down by 40% after 2006 and 35.9% in 2009, that is 2.4 decreases compared to 2008.

[22] Although Law Concerning the Promotion of Business Activities with Environmental Consideration was enacted, according to "the Survey regarding Environment Friendly Corporate Activities in 2009" by Ministry of Environment, half of the firms knows the Law and the content, but 30% of the firms do know the Law itself but do not know the content.

East Japan Tsunami and Earthquake, the public in Japan receives information without the assurance of the fairness and accuracy of the information which the state and organizations disclose directly and indirectly. Therefore, in order for the state and organizations to release their accountability, the adequacy of the safety management and the fairness and accuracy the information which they disclose should be assured.

The functions of the SMIDAS are different from the functions of the environmental accounting systems[23]. Environment accounting systems focus on environment accounting of profit-organizations. However, SMIDAS focuses on not only the safety management system and the information of profit-organizations but also the safety management system and the information of the government, state and organizations which possess anomalous information. The SMIDAS should be the system which audits the environment management system of the government, state, and organizations which improves the safety culture and provides the public with the assurance of the fairness and accuracy of anomalous information. Below is the figure for the functions of the SMIDAS.



[23] http://www.env.go.jp/press/file_view.php?serial=6396&hou_id=5722

In the previous section, we focused on the regulatory agency structure in order to properly and promptly correspond to the emergency for nuclear safety. Here, we focus on the functions of SMIDAS in order to prevent the public from the confusion of information disclosure on nuclear emergencies and radiological consequences and to work as a third agency with independence from the government and state[24]. SMIDAS organizes the following committees for each function:

1. SMIDAS should choose and approve the organizations that possess anomalous information. The committee for the accreditation requires a reactor not to take the ISO 140001 but to disclose the situation of possessing of ISO 140001.
2. SMIDAS should audit the safety management of the organizations that possess anomalous information and the fairness and the accuracy of the information they provide.
3. SMIDAS should manage the web-site for the public of the anomalous information that the organizations provide, such as EDGAR or EDINET. The committee organizes the web-site for people all over the world to access the safety management information except confidential information related to national security.

SMIDAS has the following three standards for information:

1. Adequacy of safety management :

   The government, state and organizations set up rigorous safety assessment management and systematically enhance the safety culture.

2. Creditability of disclosed information:

[24] The reason why we propose the auditing by SMIDAS for information on nuclear emergencies and radiological consequences is because the auditing by one board SMIDAS with no relation with any organization can keep more neutrality and objectivity than the auditing for each organization by their charged auditors.

Information from the government, state and organizations maintains its creditability through assurance by professionals.

3 Neutrality of disclosed information:

The government, state and organizations keep neutrality with no relationship with individuals and organization of the reactors or nuclear industry.

Environmental information that government, state and organizations disclose should meet the standards. When the information meets the standard, "the trust" should be given. The certification is for members of SMIDAS, certified physicists in medicine to provide assurance regarding creditability of information which the government, state and organization disclose.

5. 3. Members of SMIDAS

The SMIDAS appoints radiation professionals, radiation physicians as "certified environmental disclosure auditors (CEDA)" and consists of members who do not have a relationship between the reactors and nuclear industry. Members should be in a full-time position and have a certification of physicist in medicine[25]. SMIDAS should be independent even from the government. MEXT has audited media information regarding nuclear safety[26]. The SMIDAS should be an independent agency from MEXT and audit the information that MEXT discloses. Secondary communication regarding disclosed information should not be audited.

VI. CONCLUSION

[25] Medical physicists in Japan are medical professionals who serve in perspective of physicists in medicine in order to implement medical practice through radiation appropriately.

[26] Tokyo Shinbun (2011), July 23. MEXT asked the organization whose trustees are directors to audit media information with 130 million yen and ask advertising firms to audit inaccurate internet information this year with 80 million yen.

First, we investigated what the problems were in the aftermath of the Fukushima Dai-ichi accident by discussing the new system in the aftermath of TMI and Chernobyl accidents. Second, we found out that the governmental policies to lack of "timely and prompt disclosure of accurate information to the public" are resulting from a weakness or a lack of preparedness for emergencies based on safety management system and a weakness of independence and neutrality in the regulatory agency in Japan. Third, we explained whether information on nuclear emergencies and radiological consequences is anomalous information through mathematical approaches. When the information on nuclear emergencies and radiological consequences is regarded as anomalous information, we employ the different approach for handling such extraordinary information. Forth, we interpreted the reason why a third independent agency is needed for nuclear safety management by mathematical approaches. Fifth, we suggested the functions and members of SMIDAS as the third agency.

The establishment of the SMIDAS is necessary for reactors to enhance their safety culture and prevent the reoccurrence of the nuclear plant accidents and early realization of SMIDAS would be expected. Although we propose the appointment of certified information disclosure auditors during the early period of the establishment, we should discuss how the exams for the certified auditors for safety management should be implemented to train the auditors.

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