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Safety Culture Implementation Based on Occupational Health and Safety Assessment

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***Abstract*—**Safety or the state of being safe can be described as a condition of being not dangerous or not harmful. It is necessary for an individual to avoid dangerous situations every day. Also, an organization is subject to legal requirements for the health and safety of persons inside and around the immediate workplace, or who are exposed to the workplace activities. Although it might be difficult to keep a situation where complete safety is ensured, efforts must nonetheless be made to consider ways of removing any potential danger within an organization. In order to ensure a safe working environment, the capability of responding (i.e., resilience) to signals (i.e., information concerning events that could pose future problems that must be taken into account) that occur in and around corporations is necessary. The ability to evaluate this essential point is thus one way in which safety and security can be managed. This study focuses on OHSAS18001, an internationally applied standard for the construction and operation of occupational health and safety management systems, by using IDEF0 for Function Modeling (IDEF0) and the Resilience Matrix originally made by Bracco. Further, this study discusses a method for evaluating a manner in which Occupational Health and Safety Assessment Series (OHSAS) systematically functions within corporations. Based on the findings, this study clarifies the potential structural objection for corporations when implementing and operating the OHSAS standard.

***Keywords*—**OHSAS18001, IDEF0, safety culture, resilience engineering.

I. Introduction

AIMING to guarantee a safe working environment, there is two need for abilities to respond to signals (information to events that could imply in future issues, and therefore, need to be taken into account) that occur in and around process of manufacturing corporations. However, in a corporation, technical knowhow of a person frequently cannot be completely passed down to another person due to changes in the corporation. Thus, persons with ability to respond to such signals may be limited to just a few veterans working on a plant for example, hence rendering such knowledge specialized. Literature [1], therefore, discloses that it is necessary to think of a way to harness such tacit knowledge and specialized skillsets possessed by the few veterans, to share it with others in order to improve the organization's resilience, and to consider a framework where flexible responses to signals become possible.

In this paper, OHSAS18001, an internationally applied standard for the construction and operation of occupational health and safety management systems, is analyzed by using IDEF0 for structuring the standard's context and a resilience matrix for classifying the standard's contents based on Rasmussen's SRK (Skill, Rule, and Knowledge) model and organizational (Individual, Group, and Organization) levels.

Based on the above mentioned analysis, this study clarifies potential structural issues for the corporations when implementing and operating the OHSAS standard. Furthermore, PDCA actions that should be taken along with OHSAS to increase organizational resilience are proposed for a practical approach to achieve safety culture.

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II. Analysis of OHSAS Specifications

A. Analysis of OHSAS Specifications

OHSAS is a standard that define statements of all potential risks and countermeasures related to occupational health and safety concerns in a working environment, clarification of a personnel that bears ultimate responsibility in such contexts, and thorough implementation of programs at all manufacturing sites. However, while OHSAS is being adopted in domestic manufacturing industries, OHSAS may not specify the personnel who ought to perform certain actions under particular circumstances. This paper discusses and analyzes Chapter 4 of the 2007 edition of OHSAS, which contains directives on activities relating to health and safety.

The analysis of OHSAS was conducted by deconstructing and categorizing clauses from the following perspectives (Table I): showed

1) Chapter titles, subtitles
2) Number
3) Sentences location
4) Sentences (extracting only the sections on recommendations for actions relating to health and safety)
5) Subjects, objects, and verbs within sentences
6) Verb, objects, and verbs within sentences
7) Knowledge, skill, rule

The results showed that the entity in-charge of safety is primarily the "organization," and there is no mention in the standard of "who" should actually "act". Furthermore, when the object was extracted during the analysis, hardly any details were mentioned, and it was hence not clear what action should be taken within the organization. Table I shows only top a few lines as an example of the analysis of the standard clauses.

Basically, the OHSAS standard was written by the rule-base. There are many rules in the OHSAS standard. Then under the rules, method and knowledge of other skills are necessary. The OHSAS standard does not indicate how to meet the

requirements and rules.

TABLE I
ANALYSIS SAMPLE OF THE CLAUSES OF THE OHSAS STANDARD

Subtitle	No	Location	Work	Subject	Verb	Object	Knowledge	Rule	Skill
4.3.1Hazard identification, risk assessment and determining controls	1	29-32 row from the top, page 90	Hazard identification, risk assessment and determining controls The organization shall establish, implement and maintain a procedure(s) for the ongoing hazard identification, risk assessment, and determination of necessary controls.	organization	planning	risk assessment		○	
	2	22 row from the top, page 92-16 row from the top, page 93	The procedure(s) for hazard identification and risk assessment shall take into account: a) routine and non-routine activities; b) activities of all persons having access to the workplace	organization	shall take into account	hazard risk assessment		○	
	3	21-26 row from the top, page 95	The organization's methodology for hazard identification and risk assessment shall: a) be defined with respect to its scope, nature and timing to ensure it is proactive rather than reactive; and b) Provide for the identification, prioritization and documentation of risks	organization	risk assessment shall	organization's methodology for hazard identification		○	
	4	24-27row from the top, page 97	For the management of change, the organization shall identify the OH&S hazards and OH&S risks associated with changes in the organization, the OH&S management system, or its activities, prior to the introduction of such changes.	organization	change	OH&S management system	○	○	
	5	1-2 row from the top, page 98	The organization shall ensure that the results of these assessments are considered when determining controls.	organization	shall ensure	determining control		○	

It is difficult for a foreign industrial company to use the OHSAS standard with a continued improvement because of a lot of misunderstanding. In [14], discussing is presented as to if there are requirements for different types of models for representing performance at skill, rule, and knowledge-based levels, together with a review of the different ways in which information is perceived at these different levels in terms of signals, signs, and symbols. Rasmussen remarked:

> "When we distinguish categories of human behavior according to basically different ways of representing the constraints in the behavior of a deterministic environment or system, three typical levels of performance emerge: skill-, rule-, and knowledge-based performance."

Skill-based behavior: represents sensory-motor performance during acts or activities which, following a statement of an intention, take place without conscious control as smooth, automated, and highly integrated patterns of behavior.

Rule-bases behavior: the composition of such a sequence of subroutines in a familiar work situation is typically controlled by a stored rule of procedure which may have been derived empirically during previous occasions, communicated from other person's know-how as instruction or a cook book recipe, or it may be prepared on occasion by conscious problems solving and planning.

Knowledge-based behavior: During unfamiliar situations, faced with an environment for which no know-how or rules for control are available from previous encounters, the control or performance must move to a higher conceptual level, in which performance is goal controlled and knowledge.

B. Literature Review

Many studies related to the "Safety Culture" have been carried out. We searched a few keyword's combination "Resilience Safety Culture", "Resilience OHSAS", "Safety Culture OHSAS". Table II shows title of the paper, authors, keyword combinations (Resilience Safety Culture, Resilience OHSAS, Safety Culture OHSAS), and approaches shown in the paper.

The results show that more papers refer to "Resilience Safety Culture". Total 6 papers refer to "Resilience Safety Culture" [4]-[6], [11]-[13]. There are descriptions in these literatures between "Resilience to Safety Culture" and "Safety Management" and some research methods and studies. Approaches for "Resilience to Safety Management" are also suggested. Further, two papers refer to Resilience and OHSAS [7], [8]. In these literatures, OHSAS18001 and ILO-OSH 2001 are analyzed but any methodology is not mentioned. Finally, there are a few papers referring OHSAS and Safety culture [8]-[10]. This is the reason need to introduce an organizational structure that emerges from the implementation of the OHSAS standard.

C. Setting up the Issue

The following questions/issues are posed when a structure of each activity is set up and evaluated to ensure occupational safety within each organization that has implemented the OHSAS standard:

1) Clarification of activities in OHSAS clauses—bases of OHSAS clauses, namely, determining the actions that should be performed, the order in which that they should be performed, and the considerations that should be taken into account while they are performed.
2) Determination of other actions inherent to the OHSAS process—actions that should be performed although they are not sufficiently detailed in the OHSAS clauses.
3) Development of a method to assess the culture of safety—considering a methodology to determine how a corporation might use an organizational structure to

provide a healthy and safe occupational environment.

TABLE II
SUMMARIZED REVIEW RESULT

RF	Title of the paper	Author	Resilience Safety Culture	Resilience OHSAS	Resilience OHSAS	Approach
[4]	Resilience Safety Culture in Aviation Organization	R. Akselsson, F.Koornneef, S.Stewart,	○			Psychological aspect, behavioral aspects, situational aspects
[5]	Safety culture as a rational myth: why developing safety culture implies engineering resilience?	Francois-Regis Chevreau	○			Use "ratinal myth", build a managerial approach of safety culture which takes in resilience
[6]	Safety Management Systems, Safety Culture and Resilience engineering: Comparison of Concepts	Lars Adolph, Bettina Lafrenz, Britta Grauel	○			The objective of this study is to analyse concrete possibilities how do develop organizations with already existing safety management systems and established safety culture further towards resilient organizations.
[7]	A Method for Assessing Health and Safety Management Systems from the Resilience Engineering Perspective	Tarcisio Abreu Saurin, Marcelo Fabiano Costella		○		The idems are sub-divided into statements, wich are the requirements that should be assessed based on interviews, analysis of document and direct observations. The selection of the elements assessed by the MAHS was made based on a literature OHSAS18001 and ILO-OSH 2001, as well as based on a literature review which covered three areas: health and safety management systems, RE and HS management systems audits.
[8]	Towards a new tool for measuring Safety Management Systems performance	J.Cambon, F.Guarnieri and J.Groeneweg		○	○	In the framework of this paper, Tripod is used as an input to measure the SMS operational performance. Both of the tools designed to measure the structural and operational performances of Safety Management Systems are then described.
[9]	Analysis of work practices from the resilience engineering perspective	Norros Leena	○			A concept of systems usability will be proposed as the quality criterion for evaluation of technologies. The evaluation exploits the analysis of performance outcome, practices and user experience and focuses on testing the tools' capability to facilitate resilience of the system.
[10]	Safety Performance Improvement Through Culture Change	Dr M K Fitzgerald, BEng (Hons), PhD, CEng, MIMechE			○	Introduces an approach to safety climate assessment that has been developed to enable cost-effective assessment of an organization. The tool that is described has also been used to track changes in safety climate, allowing improvement plans to be updated and refocused to maximise the effective use of resources. Some real examples
[11]	Framework for a resilience system in safety management: a simulation and visualization approach	Sang Uk Han, Sang Hyun Lee, Feniosky Pena-Mora	○			This paper presents a conceptual framework for a resilience system that uses a simulation and visualization approach to manage safety behavior. A computer vision technique capable of motion detection is introduced to monitor workers' behavior with video cameras and to automatically analyze their level of unsafe acts.
[12]	Resilience Engineering: Redefining the Culture of Safety and Risk Management	David D. Woods	○			When organizations are struggling to meet daily pressures, how can they tell the difference between ineffciencies and buffers against the unexpected? Resilience engineering is one new approach that can provide tools for proactive safety management.
[13]	Safety culture and organizational resilience in the nuclear industry throughout the different lifecycle phases	Pia Oedewald, Nadezhda Gotcheva, Kaupo Viitanen, Mikael Wahlström	○			A safety culture assessment methodology called DISC (Design for Integrated Safety Culture) which has been developed by VTT. We will clarify what kind of cultural characteristics are needed in order for an organization to have a good potential for safety. Furthermore, we will provide practical insights into the safety culture assessment process.

III. CLARIFICATION OF ACTIVITIES IN OHSAS CLAUSES

When a corporation implements OHSAS, it follows the relevant clauses in the OHSAS standard. The standard uses a PDCA [Plan, Do, Check (Evaluate), Act (review and implementation)] structure, which includes OH&S policy, goals, health and safety planning, its implementation and operation, daily inspections and improvements, system audits, and regular review of the system itself. This system of business management is adopted by corporations due to its basic principle of continual improvement in each cycle caused by going through the PDCA motions. Research in [2] revealed three areas where information is unclear in the implementation and operation of OHSAS:

1) The input and output of a given activity
2) The main subject of a person who carries out the activity
3) The conditions on the limitations and resources that must be taken into account in executing the activity

To identify these elements in the clauses of the OHSAS document, IDEF0, a function modeling methodology, is used.

The activity in IDEF0 can be identified as the verbs in the standard clauses of OHSAS. Concomitantly, whatever is fed in order to execute this activity is expressed as the input, and the results of executing the input through the activity can be expressed as the output. The control is done by limiting condition in executing the activity, and a mechanism is formed in a manner in which the execution of the activity is supported. This is expressed as the resource (especially the executor of the activity) to execute the activity.

Fig. 1 shows the determination of the source of a hazard, a risk assessment, and decision making on the management

method based on clauses in 4.3.1 of the OHSAS standard document. Existing activities are a determination of the source of the hazard, the risk assessment, and the establishment of steps to determine how to manage, implement, maintain, and disseminate those steps. Four steps—"establishment of the steps," "implementation of the steps," "maintaining the steps," and "the dissemination of the steps"—form the basic structure of activities in all the OHSAS clauses.

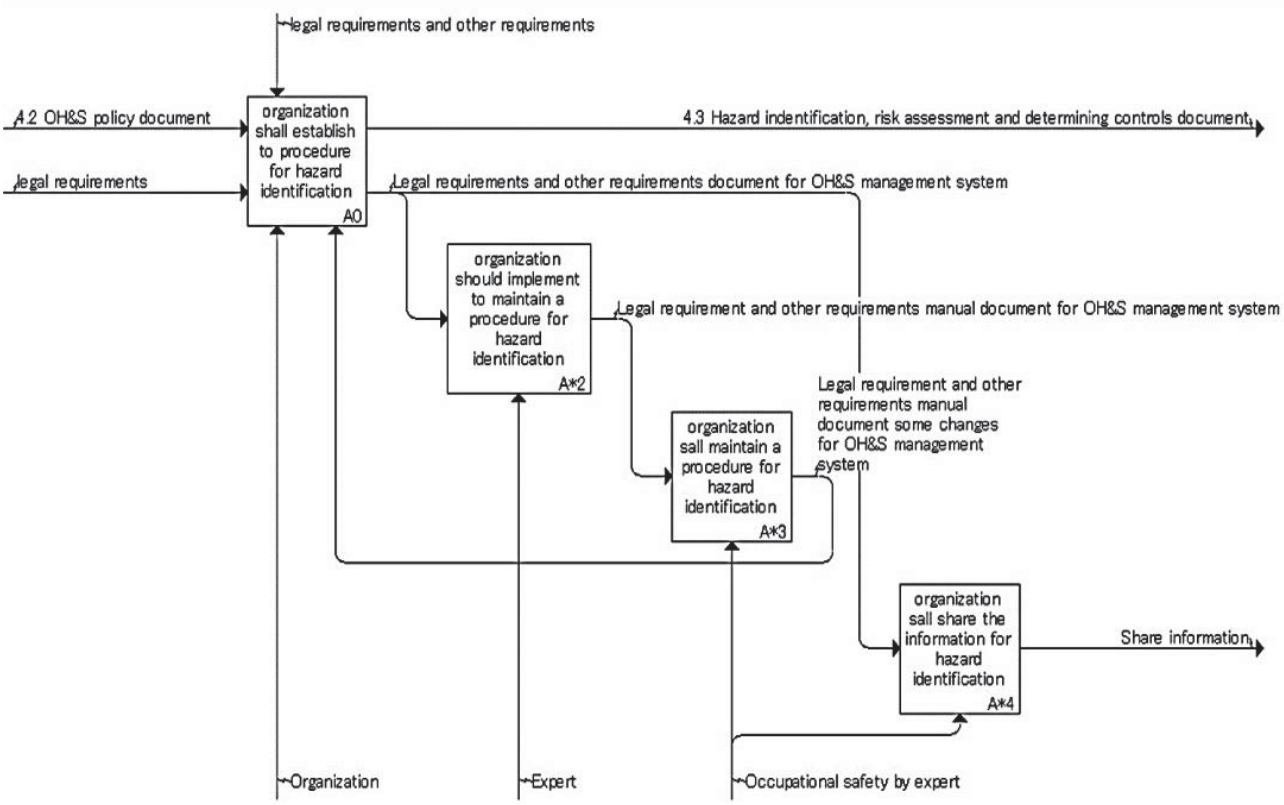

Fig. 1 Sample IDEF0 diagram of an OHSAS clause

A. Determination of Inherent Actions within the OHSAS Process

The model of the OHSAS standard expressed through using IDEF0 is transformed into a resilience matrix (RM) to determine inherent activities. The resilience matrix was proposed in [3], and is a model where capacity to respond (i.e., resilience) to signals (i.e., information concerning events that could pose future problems that must be taken into account) is considered in the context of an organization.

The RM is a three-by-three matrix consisting of nine cells, with the horizontal axis representing the response provider (individual, group, organization) to the signals, and the vertical axis representing the ease with which the signals change (in three stages from low to high). Each of the nine cells shows that a certain response provider should take a certain kind of action to enhance resilience within an organization in response to varying signals.

B. Operational Steps of RM

Fig. 2 shows the RM used by Bracco [3]. In this matrix, Rasmussen's SRK (Skill, Rule, and Knowledge) model and organizational (Individual, Group, and organization) levels are combined in the three-by-three chart.

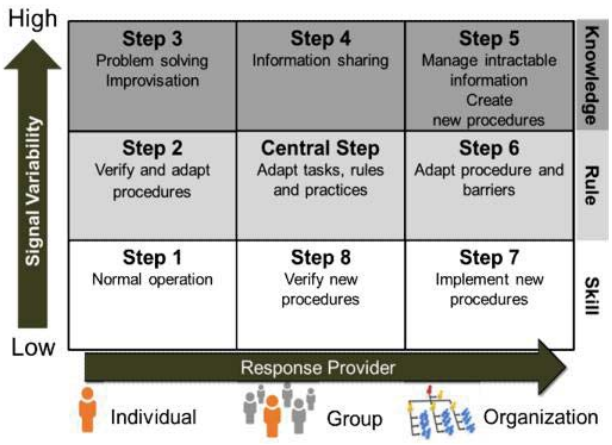

Fig. 2 Resilience matrix

The steps in the RM are as follows:

Step 1: It is easy to handle signals, which are to be responded to, within normal business operations through skill-based responses.

Step 2: Although a response may occur in a reaction to unpredictable signals, a certain set of operational

procedures can nonetheless be followed. Thus, it is possible to respond through certain set rules even in such cases.

Step 3: Even if the signals become harder to predict and handle, the response shifts from rule-based response to knowledge-based response.

Step 4: In order to respond the signals, individuals must have superior capability to recognize difficult-to-detect signals. Therefore, it is necessary to share information with other members for the responses in such cases. Central Step: If the signals being responded to can be handled through group-level operational procedures, the response should be formed by applying business operations, regulations, and precedents.

Step 5: The response in Central Step should be demonstrated as a new operational procedure in day-to-day training and work towards dropping the signal to a point where it is sufficiently easy to handle with a skill-based response.

Step 6: When the group fails to deliver adequate knowledge-based response in Step 4, and when the signal can only be managed at a higher level, the relevant information must be reported to the organization in order for it to respond.

Step 7: New and difficult-to-handle signals flow in from groups in Step 5. In case of too many incoming signals, the organization should create an operation procedure and respond by changing or updating the operational manual and the regulations.

Step 8: When operational procedures are strengthened to handle weaker signals, the new operational procedure is adopted.

By the end of this resilience cycle, a new signal is incorporated into regulations, procedures, and precedents, thus becoming standardized. It is subsequently part of the routine business of frontline operators.

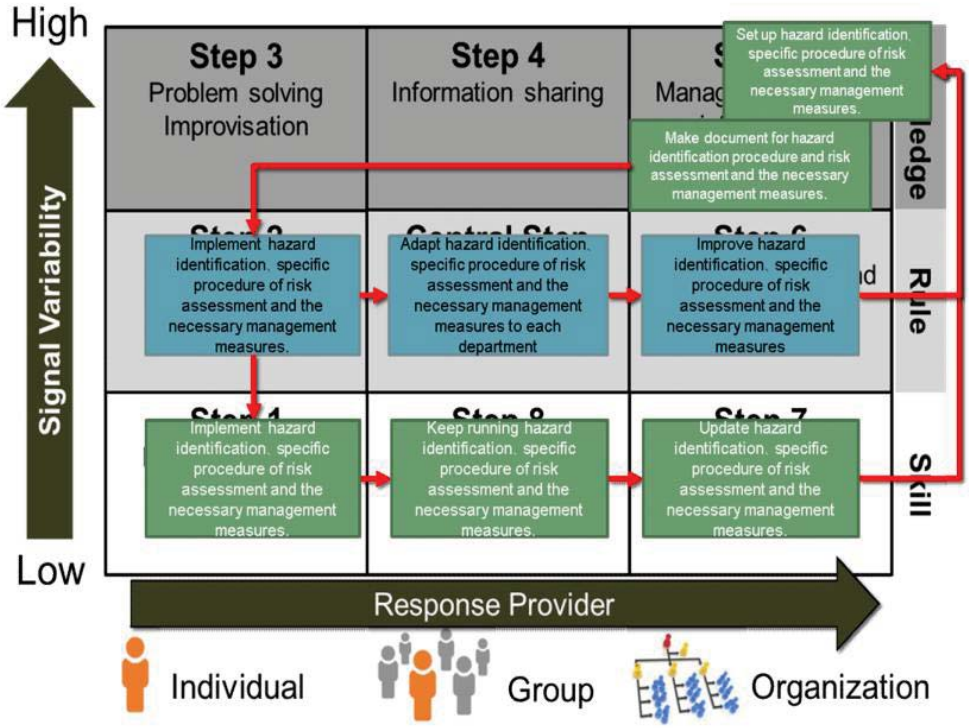

Fig. 3 IDEF0 placed onto RM

IV. RM-Based OHSAS-IDEF0 Model

The RM can be defined as a cycle to develop new operational procedures, for individuals to implement it, and provide feedback regarding its ease of use as a group in order to maintain and increase organizational resilience. Furthermore, it covers activities that occur during establishment, implementation, and maintenance. Accordingly, it seems to be appropriate to place the IDEF0 model of the OHSAS standard into the RM in order to specify the structure of the organizational activity cycle and identify inherent activities.

Fig. 4 shows the OHSAS clauses expressed in IDEF0 and transferred to the RM as well as the addition of the relevant inherent activities. The activities in Steps 1, 5, 8, and 7 are from OHSAS clauses, whereas Step 2 and the Central Step are inherent activities specified according to the RM. With the representation of the IDEF0 version of the OHSAS clauses, the "establishment of procedures" by the "organization" is connected to input and output through the "implementation of the procedure" by the "individual."

There are no activities in Step 2, Central Step, and Step 6. However, a procedure that is set up by an organization will be difficult to convey to an individual in another department, who will in turn find it difficult to implement as a consequence. Therefore, based on the newly established procedure, the current procedure is revised and activities are added based on the RM. Specifically, the new procedures are to be implemented by each department, and individuals belonging to each of these departments are to validate and implement them.

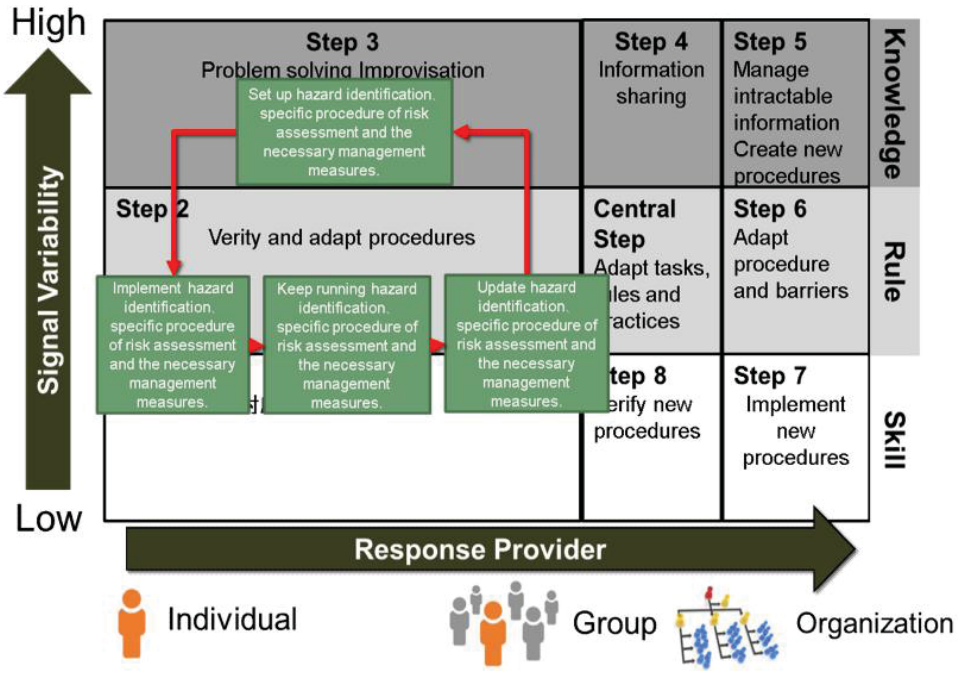

Fig. 4 An organizational model where an activity cycle is completed by a single response provider

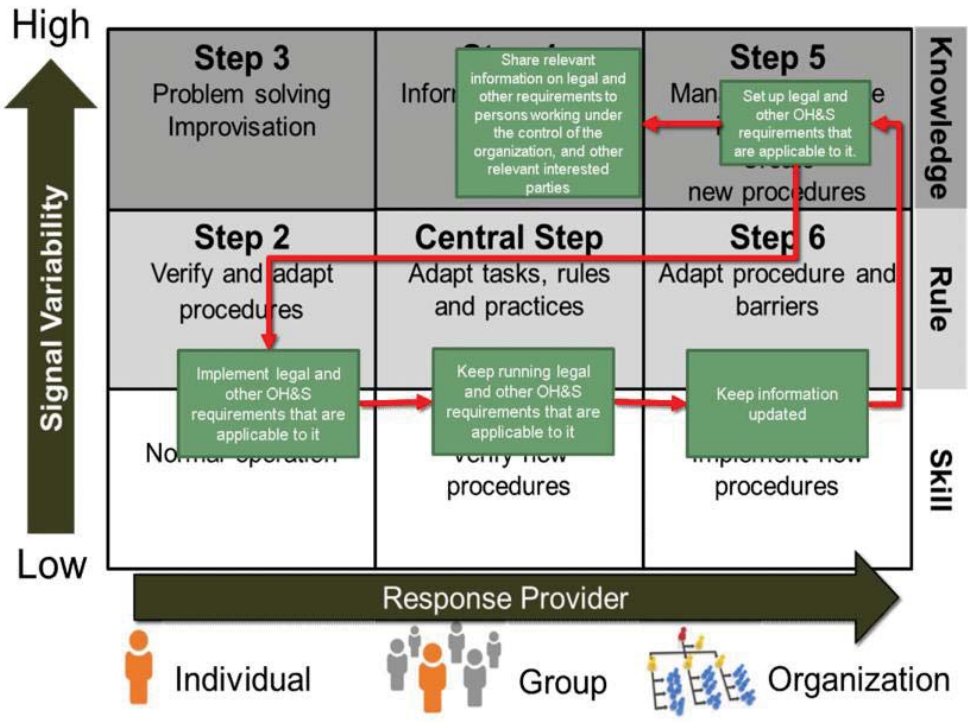

Fig. 5 An organizational model where the information dissemination cycle is disrupted

V. Method to Evaluate the Culture/Climate of Safety

The proposed method to evaluate the culture of safety involves placing activities, which have been specified in manuals in corporations based on OHSAS on to an RM and determining the necessary activities that the corporation's OHSAS had not covered. This methodology can thus develop a structure where a culture and climate of safety can be organizationally created.

A. Non-Resilient Organizational Model

By setting and specifying a structure based on the IDEF0 model of the OHSAS standard through an RM as a resilient organizational model, an organizational model that is not resilient can be raised as follows.

1) The completion of an activity cycle by a single response provider (Fig. 4):

- All activities are carried out by an "individual" response provider, and the activity cycle is completed by the single response provider.
- Individuals who belong to multiple departments use their knowledge to develop, operate, and maintain procedures, respectively. Improvement in such procedures is brought about only within the departments to which those individuals belong.
- The organization use organizational model where other response providers, departments, and the organization are not involved in the establishment, implementation, or the maintenance of such procedures.

2) The disruption of information dissemination activity (Fig. 5):

- The organizational model where output is based on an activity to disseminate information to other personnel within an organization is disrupted before it connects to any other activity.

B. The Issues Arising out of a Non-Resilient Organizational Model

1) An Issue of Having a Single Response Provider Complete a Response on His/Her Own

If an organization is not involved in any part of an activity cycle, it is not possible to reflect establishment, implementation, and maintenance of a procedure when deciding its occupational health and safety policies. This means that the PDCA cycle meant to assist in improving the organization as a whole does not properly operate. The cycle is rendered non-functional when the "organization" establishes the procedure, the "individual" implements the procedure, and the "department" or "group" provide feedback based on the experience of individuals in implementing the procedure in order to improve organizational procedure. When this cycle is completed by the "individual," the specific and more appropriate skillset of the "individual" will not be fed back into the "department" and the "organization." Thus, when revising and improving the procedures, those skills will not be reflected in the revision. Furthermore, when the "individuals" within each department are left on their own to complete cycles, each department ends up with different procedures. When this happens, the organization finds that a common and organizationally unified framework to respond to signals is not shared across departments, thus making it difficult to flexibly response to a given situation.

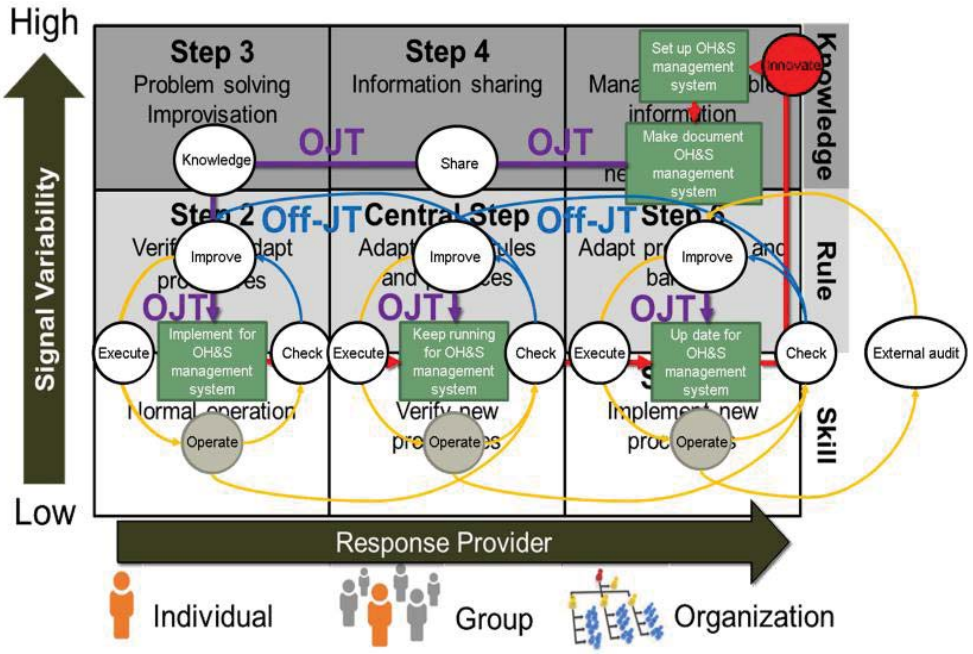

Fig. 6 Resilient organizational model

2) Issues Due to the Disruption of Information Dissemination Activity

When an activity to disseminate informational output does not link up with the next activity, the personnel of the organization cannot determine how to use the disseminated information based on the OHSAS clauses. Therefore, each official of the organization uses his/her own discretion in using the disseminated information.

Based on these issues it can be assumed that a resilient organizational model should look like that shown in Fig. 6. This is a PDCA cycle that helps disseminate the OHSAS standard throughout the company. In order to run this company-wide PDCA cycle continually without failure, it is necessary to establish a section-based PDCA cycle at each stage of the cycle. Fig. 6 shows where it is possible to establish its own cycle within the individual, group, and at the corporate level.

3) In an Organizational Structure with a Section-Based PDCA Cycle

- Each section goes through the implementation → maintenance → improvement process.
- Subsequently, the improvement must be checked and tested. If it passes the check, one can move on to the next stage.
- If the improvement fails the check, one goes back to an improvement section, provides safety instructions, and returns to the cycle.
- This is repeated in each responding section of the organization.

VI. Conclusion

In this paper, we proposed a model to enhance safety culture in organizations that have adopted and operate the OHSAS occupational health and safety standards. In future research, we will consider an educational method to make the PDCA cycle work properly for each section.

Acknowledgment

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