End User Involvement in the Development of Procedures and Safety Management Systems

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Abstract: IT-based Safety Management Systems contains procedures, safety standards, checklists and descriptions on how different tasks should be performed, and are usually designed at an executive level in the organization, and then communicated to the lower level in the organization where they are being applied. This paper presents data collected from qualitative interviews with executives and operators from two companies in the gas and petroleum industry. The executives generally regard Safety Management Systems as important tools for all work in hazardous environments, while the operators weren't that enthusiastic. How can end user involvement in the development phase of procedures and Safety Management System improve use? A central argument is that Human Factors must be involved as early as possible in the development phase, and that operators need to understand the purpose of the management system in order to use it as intended. The informants that had been involved in the development of the procedures at least to some extent, felt an ownership to the management system, while the ones who hadn't been involved at all felt no ownership to the management system, and did not see the purpose of it.

Keywords: Safety Management System, Procedures, Communication, Human Factors

1. Introduction

In industries operating in hazardous environment there has been a development towards controlling the daily workflow through various forms of management system. IT-based Safety Management Systems contains procedures, safety standards, checklists and descriptions on how different tasks should be performed. Safety standards and work procedures are often, but not always, designed at an executive level in the organization, and then communicated to the lower level in the organization where they are being applied. The purpose of using IT-based Safety Management System is to code and share best practices, create corporate knowledge directories and to create solid knowledge networks within the organization. Executives generally regard Safety Management Systems as important tools for all work in hazardous environments, while the operators aren't always that enthusiastic. The questions investigated in this paper are:

1) How was Human Factors involved in the design of a safety management system for one petroleum company?
2) How does use of Human Factors knowledge increase the operators' satisfaction with and use of the safety management system?

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2. Theory

2.1. Safety Management Systems

Safety management refers to the actual practices, roles and functions associated with remaining safe [1]. Safety management is "the policies, strategies, procedures and activities implemented or followed by the management of an organization targeting safety of their employees" [2, p. 283]. A Safety Management System is hence a formalized way of dealing with these practices, roles, policies and procedures. Safety Management Systems can be seen as "a socio-technical system for knowledge transfer […], through documented experiences, best practices, and expert references" [3, p. 2]. Safety Management Systems are integrated mechanisms in the organizations, and the purpose is to control the hazards that can affect workers' health and safety [4, 5], to maintain risk within an acceptable range in the operations of any organization [6, 7], and to help the organization meet the regulatory requirements (4, 7, 8, 9]. This is not only a matter of coordinating between tasks, but also the accumulation and diffusion of organizational experience, and to turn tacit knowledge into explicit and shared knowledge [10]. There is also a general agreement that Safety Management Systems is a means to change safety management from being reactive to being proactive [11], and anticipating hazardous situations before they occur, and not just acting after an accident has occurred, or phrased differently; to protect against human error [8, 12, 13, 14]. There is also the matter of defining legal responsibility if incidents should occur [8].

Safety Management Systems in professional organizations has in several cases been less successful. One of the reasons is that in the development and implementation phases the emphasis has been mainly on the technical requirements, ignoring the social and cultural facets of knowledge management [5, 15]. It is also because designers tend to focus primarily on the technology and its features, and forget to look at the use of the system from the human point of view [16].

2.2. Human Factors

According to the European Committee for Standardization human beings should be considered as "the main factor and an integral part of the system" when work systems are being designed (17, p.3). This includes the work processes and the work environment. Several researchers stress the importance of giving high priority to the action of human beings when procedures are being designed [18]. When experts design systems, they are not always able to predict what kind of difficulties other people will experience when using their system. The experts are so familiar with their own system, they know very well how it works and how to control it, that it comes natural for them, but they often forget that the users don't necessarily have the same familiarity with the system. The users don't have the same mental models as the designers, and it may also be that they don't interact with the system frequently enough to develop the same mental models [16]. Another factor is that experts are often distributed across various locations which makes is difficult for them to have general knowledge of the installations and what impact different components might have on each other [19]. A related factor is that onshore workers sometimes lack awareness of offshore processes; they don't have the same direct sensory experience as offshore workers, and they don't have the tacit knowledge and impressions gained while working on the installation [19].

Well intended efforts to promote safety may marginalize the local and system specific knowledge inherent in the organization, and safety professionals must be aware of this. Since employees close to the work are the best qualified persons to make suggestions for improvements, they can be consulted before making final decisions, especially for those decisions that affect the employees. A successful approach on many occasions has been to incorporate users as actual members from beginning to end, although one must be aware that users working with design teams might become so familiar with how the designers think, and so familiar with the system they are designing, that the same problem arises. Therefor it is advisable to bring in a different group of users for the various stages of usability testing [16]. This empowerment of workers provides them with authority, responsibility and accountability for required decisions and ensures that both employees and managements are involved in setting goals and objectives [2]. There is also evidence to suggest that a greater level of commitment and adherence

to procedures can be achieved by keeping procedures few and simple and by emphasizing broad and direct worker participation in the process of implementing the procedures [8].

An important part of the design sequence is to analyze the typical user in order to ensure that their needs and the demands of the work situation are understood. One need to clarify the following; who users are, what main functions are to be performed by the system, what are the environmental conditions under which the system will be used, and what are the user's preferences or requirements for the system [16]. This particularly applies to the informations-processing characteristics of the system. Insights from human factors can be very useful here, as it relates to the interaction between human and the system. The precise boundaries of the discipline of human factors cannot be tightly defined but are closely related to ergonomics, engineering psychology, and cognitive engineering [16]. Human factors have often been concerned with the physical aspects of work, but the scope also includes cognitive thinking and knowledge-related aspects and mental interactions with the system [16, 19, 20]. Human factors revolves around the central importance of the user, and the goal of human factors is to enhance performance, increase safety and increase user satisfaction. This includes the communication and cognitive processes involved in using the system. If human factors methods and principles are applied as early as possible in the development of a system; in predesign analysis, technical design, and final test and evaluation, many of the human factors deficiencies will be avoided before they are inflicted on systems design [16].

The European Committee for Standardization state that ergonomic effort should be greatest at the beginning of the design process, as it is here the most important decisions that have consequences in the design are made [17]. This goes for human factors methods and principals as well, which should be applied in all stages of the design: predesign analysis, technical design and final test an evaluation [16]. Hence, human factors should be applied at an early phase in determining how the Safety Management System and the procedures should be developed, and how the staff training should be. Human factors principles are too often either left out entirely, or brought in too late in the development process when the product design is already completed and handed to a human factors expert. This only places everyone at odds with each other [16]. Rather, human factors must be a part of the process from the very beginning of the planning and development of procedures and Safety Management Systems in order to get a balanced development of the technical and human aspects [16, 20]. To achieve this it is important that workers are allowed to be involved in the design process [17].

2.3. Communication

Any Safety Management System, no matter how it is constructed, is communication. It can be convenient to pretend that this is one-way communication, but it's not, because the user interprets the information in the Safety Management System and turns it into knowledge, adding his or her prior experience. This is also part of the communication process which must be addressed as part of the user analysis, to consider the cognitive characteristics of the user. The cognitive strengths of humans must be emphasized, but also how operators feel and interact with operations and management and designed objects [21]. For example, a Norwegian study showed that the workers often thought it was difficult to find the relevant governing documentation within the safety management system, so they needed to use more effort and time in order to find what they needed [22]. This makes it unnecessary difficult for the workers to find the information they need in order to fulfill their tasks and to make the necessary decisions. Not only shall machines be designed to suit the physical abilities of the expected user, but instructions and procedures shall be designed to fit their mental abilities; the cognitive, informational end emotional processes in the human being [21].

If this is not done successfully, we have several studies indicating that workers will deviate from the procedures if they know a better way of doing it [13, 23, 26]. When workers deviate from procedures, one must either figure out how to ensure compliance, or see if they might have a good reason for deviating from the procedures. Have they for instance actually found a better/safer way of doing the job than the procedures prescribe? Safety Management Systems are living systems and should always open for evaluation, adjustment and changes. A Safety Management System is never completely finalized in its making. Ideally it should always be developed on the basis of new experience, in order

to replicate success. Three ingredients are particularly important for a successful match between procedures and practice: There should be feedback from the lower to the upper tiers of the organization, the adjustment of procedures should be based on the views of those directly involved, and the time interval between worker feedback and implementing changes should be as short as possible [8]. In existing system one must study the interaction between human and system to find to identify various problems and deficiencies [16].

2.4. Tacit knowledge

In any organization there will always be tacit knowledge, and much effort is made to turn tacit knowledge into explicit and shared knowledge, and to make invisible work processes visible and transparent. If those who actually perform the work are the only ones who knows how it is done, the ability to account for this invisible work and the tacit knowledge that accompanies it, can strengthen the organization`s performance significantly [10]. However, tacit knowledge can be so complex that it is difficult to articulate in a way that makes sense, and many professions demand a certain experience in order to be able to make complex considerations [27]. This is not to say that tacit knowledge needs to remain tacit. With Choo's definition of tacit knowledge as "the personal knowledge that is learned through extended periods of experiencing and doing a task, during which the individual develops a feel for and a capacity to make intuitive judgments about the successful execution of the activity" [28], it is clear that this type of knowledge can also be made explicit and brought forward to other workers who lack the experience, which the management systems is an attempt to systematize. This way the separating lines between tacit and explicit knowledge will be moved, so that knowledge that was tacit yesterday is explicit today [27]. This can be done, at least to some degree. It's easier said than done, but it naturally involves the workers in a dynamic communication with the managers and the safety experts.

3. Method

3.1. Subject

The empirical data is collected by conducting qualitative in-depth interviews with 27 employees in two different companies in the Norwegian oil and gas production sector, hereby named Company A and Company B. The first three informants from Company A were onshore executives who have had an active role in the development of the company's Safety Management System, and these were interviewed in a preparatory study. In the same company five offshore executives and ten offshore workers, representing different disciplines; mechanics, electricians, logistics and lab technician, were interviewed on board at the oil and gas producing installation. The third round of interviews was in conducted on land, with nine foremen and offshore installations leaders in Company B, a company that provides contract workers to an oil and gas producing company (not Company A).

3.2. Data-collection process

The interviews were conducted in a separate room during the normal working hour of the informants. The interviews followed a semi-structured interview guide, where certain topics were planned in advance, but also allowing for the informant to bring new topics to the table, and also allowing for the structure for each interview to be different according to how the informant associated the various topics. The interview started off by letting the informants tell about their routines for an ordinary work day and to describe the Safety Management System and the purpose of it. The questions then became more detailed about which procedures they used and in which situations, how they learnt about the Safety Management System, about the user friendliness of the system, shortcomings and advantages. Each interview lasted for 30-45 minutes, with a few exceptions. The interviews with the offshore executives generally lasted longer than the interviews with the workers. The interviews were conducted and transcribed by the first author of this paper.

3.3. Data analysis

The data was analyzed using a thematic analysis. Thematic analysis offers a theoretically-flexible approach to analyze the major themes to be found in interviews (or other qualitative data) [29, 30, 31].

The first step was familiarizing with the data by transcribing the audio interview files. The transcribed material was then fed into the software program NVIVO 10 and coded into many categories and sub-categories (nodes is the term used in NVIVO 10). This first round of coding was rather broad, where each interview segment could be coded in several categories, where relevant surrounding data was kept to keep track of the context. After the initial coding some categories were developed into themes while other categories were too small to qualify as themes. The themes were not necessarily the same as the topics in the interview guide, some were of course, but new themes also arrived during the interviews, and some themes emerged when looking at certain keywords mentioned by some of the informants, and by looking at in which context they mentioned these words. After re-reading the coding of each theme, some themes collapsed into each other whilst other themes were broken down into separate themes. The initial codes were partly derived from the interview guides, but several new and sometimes unexpected codes emerged from the interview material. What eventually became themes was mainly guided by the interview material, and not theory driven.

4. Results and discussion

4.1. Purpose

One important basic factor in using a management system is to understand the purpose of it, and the basis of the procedure and its intended higher-level goals. The informants who were able to say something about the background for the development of the procedures and the purpose of the Safety Management System, had a much better use of it than those who couldn't.

In Company A, the Safety Management System was developed by an external consulting company. The consultants had a few meetings with the top management in Company A, but end users weren't involved in testing until it was almost time to launch the management system. The head of the designers said that user friendliness was not given high priority.

> A3: Not really. User friendliness is… well, it is a prerequisite for the management system as a whole that the user can click his way through a browser.

They did not involve Human Factors in the development of the management system, but had mainly a technical focus. This was partly due to financial and time restrictions, but also because the procedures had already been developed separately by a different company.

> A3: We met a forest of procedures that had been developed by another company. And we had to make a superstructure that should match all those procedures. And what you discover when you start to adjust it, is that it doesn't fit.

It will be better to have a more coherent process when developing the procedures and the management system, and to involve Human Factors and end users in the development. The executives in Company A acknowledged that the workers didn't have any sense of ownership to the management system and that this was a problem. The only informants in Company A that felt ownership to the management system were onshore executives who had been involved in the development of the system. The operators in Company A were not able to explain the purpose of the Safety Management System, and hence, they didn't see the point in using it. They acknowledged that it was necessary to have a management system, but couldn't explain why. They said that it had something to do with safety, but saw their own experience and competence as more important for safe conduct.

> A11: We are perfectly able to do the job without having to sit for an hour reading documents before we start. They have to explain why we should go through all these documents. (…) Why should we sit here and read for an hour when we can just go out and do the job?

When the operators in Company A tried to explain the purpose of the Safety Management System they focused more on responsibility than on safety, and saw the Safety Management System as a way for the management to cover their backs in case of accidents. This has an effect on how they understand the Safety Management System as less important, and negatively influences their motivation for use. In contrast, foremen and offshore installation managers in both companies saw the procedures and the Safety Management System as a collection of best practice principles guided by many years of collective industrial experience. The informants in Company B often worked as contract workers for a large gas and oil producing company, using the management system of the hiring company. But Company B also had their own management system, a smaller entity where several of the informants had been involved in the redevelopment of. This has given them a better understanding of the basic idea of having a management system as a storing and categorising of experience to form a knowledge foundation to evaluate the line of action for a new task.

> B24: It's the best of [the company's] 40 years of experience in oil production. (…) What they have gathered there, is the best praxis. How to perform a task and how to relate to HSE and everything we're in touch with. But it is never elaborative. In the end it's still we that have to put the final piece to the puzzle, because it is a lot of good stuff in there, but it can't tell you everything. It doesn't tell you what the weather's going to be like that day, for example. You still have to think.

Antonsen has shown how seamen often interpret attempts to govern work by formal rules as a negation of the seamen`s professional expertise. This will no doubt affect their respect for and their motivation for using the formal procedures. In addition, formal procedures have their origin in onshore organizations, like regulatory authorities and oil companies. This is outside the seaman community, or the ones doing the practical work, and this influences how the seamen interpret the formal safety management. The seamen in Antonsen`s study saw the procedures as based on the theoretical knowledge of some "office worker", and not as based on the practical knowledge possessed by competent seamen, and for them this undermines the legitimacy of formal procedures [12]. By involving the workers in the development of the procedures they will not see it as a negation of their own competence, but rather as an appraisal of their experience and competence, and it will increase ownership to the procedures.

4.2. Language

One of the more specific complaints the informants in Company A had concerned the language used in the Safety Management System. They would prefer it to be in Norwegian and not English. They also though it was a bit "academic" English, with some difficult words and grammar they were unfamiliar with. Both operators and offshore executives mentioned this.

> A10: I think Norwegians have pretty good competence in the English language, but it seems to me as if those who use English a lot use a lot of words that we are not familiar with, the common people. I think they do it to impress. They write it wrong. That's what I think.

User tests and user involvement will no doubt help to avoid misunderstandings caused by unfamiliar grammar and vocabulary.

4.3. Adaption

In order to operate safely it is necessary to be able to adapt the written procedures to local and immediate circumstances [8, 13, 23]. The informants in Company B pointed to the general purpose and the basic idea of a management system, as a storing and categorization of experience that forms a basis that should be used when evaluation how a specific task should be carried out. Note that they express that individual evaluation is still necessary.

> B26: It's a bit like the Bible, you know. (…) You get an answer, but you have to interpret that answer. It's not very unambiguous. (…) Some places it is very unambiguous, but other places it might be a bit uncertain, and you can experience that they interpret it differently on different installations.

In contrast, the operators in Company A said that they had to do their own evaluations as to how to perform a certain task when the written procedures were useless, instead of letting the procedures form a basis for the decision making process. Informants from both companies valued the workers experience and competence, but in a slightly different way. The informants in Company A saw experience as necessary to compensate for flaws in the procedures were, while the informants in Company B saw experience as necessary to use the procedures as a basis for their evaluation on how a job should be performed.

The informants in Company B saw experience as an important ingredient in cases where the management system didn't give elaborative information. They expressed the opinion that there will always be some situations where the procedures are not entirely elaborate or where they are not entirely in accordance with reality, and in these cases they must adapt the procedures based on their own experience and competence.

> B27: It doesn't always say in the management system, but it's a bit like based on experience and such, so we say to each other "shouldn't we rather do this and that to be a hundred percent sure", you know. That's how it is. Based on experience, really.

With management systems and procedures there will always be a question how detailed they should be and how strict the guidelines should be. In this respect it is important that the management system gives unambiguous information as to where the procedures must be followed to the letter and where there is room for adaptions [13]. Anyhow, the definitive responsibility for safe conduct still lies on the operators who perform the task.

4.4. Informal procedures

Sociological studies of work very often reveal that workers tend to create their own informal work procedures that can be very different from formal procedures, and the existence of informal procedures that guide decisions and actions are a central part of the popular definition of organizational culture as 'the way we do things around here' [8]. This particularly happens when the formal procedures get to bothersome to deal with. In Company A some of the workers had created their own solutions that they found easier and more convenient to use than the Safety Management System. One of their solutions was to simply print out a stack of check lists and keep them in a pile, so they don't have to go into the Safety Management System every time they need a checklist. An obvious drawback with such a solution is that they won't get the updates if there should be any changes on the checklists or procedures. The informants themselves acknowledged this drawback, but still found it to be the more practical solution. Another solution of the workers' own design was a specially made web page with links directly to all the documents they used on a regular basis. There is a potential here to pick up the experience made by the workers, and utilize them in the ever ongoing updating and development of

the management system. This is also in accordance with the general guideline that the operator should feel that they have retained control over the system [17].

5. Sum up and conclusion

Procedures and Safety Management Systems are usually developed by management experts who are not involved at the operational level. A key challenge here is to involve the workers in the development of the procedures and Safety Management System. These must be constructed so that they increase ownership of work, and not decrease ownership of work. One should utilize the competence and experience of the workers when developing the procedures. The workers should also have the opportunity to give feedback on how useful the procedures and the management system are. The communication that a Safety Management System constitutes is mainly a linear communication from the upper tiers of the organization to the lower, but one should not forget the cognitive process that takes place when workers interpret and adapt the given procedures. There should also be feedback travelling the other direction as well, so that that adjustments or procedures can be based on the views of those directly involved. It is also important that the time interval between worker feedback and implementing changes is as short as possible.

Broad and direct worker participation in the process of implementing the procedures has been shown to lead to a greater level of commitment and adherence to procedures. Employee involvement will be rewarded by an increased feeling of ownership to the procedures. It will have a positive effect on the employee`s use of the procedures when they get the sense that the procedures have originated from themselves, and not from some pencil pusher in an office. However, there are limitations as to how much every individual employee can be involved in the development of the procedures, with respect to money and time, and with respect to what kind of competence is needed in order to develop good procedures and a thoroughly thought-through Safety Management System.

Human Factors-analysis should be a part of the development of procedures and Safety Management Systems to assure user friendliness. Human factors revolves around the central importance of the user, and the goal of human factors is to enhance performance, increase safety and increase user satisfaction. This includes the communication and cognitive processes involved in using the Safety Management System. If human factors methods and principles are applied as early as possible in the development of a Safety Management System, in predesign analysis, technical design, and final test and evaluation, many of the human factors deficiencies will be avoided before they are inflicted on systems design.

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