# Managerial Sense-making During Technological Changes

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In this paper, we investigate how managers enhance sense-making during technological changes in safety-critical industries. Implementation of new technologies is not a linear and predictable process. Technologies evolve faster than we can fully prepare for. This means that new challenges are introduced into the sociotechnical system in which the technology is embedded, leading to shifts in paradigms, interpretation, and business practices. These new technology-induced changes have been less the focus of previous work on sense-making compared to the more traditional paradigms and core practices. In this paper, we focus on the managerial role in these changes. We examine the relevant literature on technological change implementation and organizational sense-making in the past three years and use thematic analysis to capture the main themes plausible within the scope of the paper. Several themes and sub-themes are derived and presented. The resulting themes shed light on what the managers need to be aware of and do to support and enhance the sense-making process during technological changes, which leads to empowerment of the employees to do their own sense-making and maintain reliable operations.

*Keywords*: Technology, change, sense-making, management, complexity, sociotechnical system, safety

## 1. Introduction

This paper investigates how managers could approach sense-making during technological changes in safety-critical industries. Technologies evolve faster than we can fully understand and control. This is referred to as "unruly technology" as mentioned by Dekker (2011). They behave in unpredictable ways and introduce new challenges and risks into their sociotechnical system, marked by interrelated social and technological factors in an organization which is interacting with its environment (Pasmore et al. 1982). The challenges for management in complex systems of interrelated variables is that the system transforms and adapts over time. This makes it difficult to predict the effect of the decisions and changes as posited by LeCoze (2005). This also applied to foreseeing and mitigating potential problems caused by novel technologies. According to Namvar et al. (2018), these new challenges result in new business processes, communication platforms, and learning methods in organizations. Namvar et al. (2018) state that these new technology-induced changes have been less emphasized in previous work on sense-making compared to the more traditional business processes. This gap also calls for a closer look at the manager's role in conducting sense-making during technology changes in modern sociotechnical systems that are faced with increased complexity. The research question in this paper is: how can management steer and increase sense-making during technological changes? A brief overview of the theoretical framework on sense-making and safety in complex systems is presented, followed by the method, results, discussion and the conclusion.

### 1.1 *Sense-making*

To understand how managers can enhance sense-making, it is important to understand what sense-making is and how different interpretations of technology changes form amongst employees. There are various definitions of the term "sense-making" in the literature. Weick et al. (2005, p. 409) described it as "the ongoing retrospective development of plausible images that rationalize what people are doing." In effect, sense-making is

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a social construction process that tries to give meaning and rationalize the current experiences and situations that people are currently involved in, with retrospection of how it was developed. Simultaneously, those actors involved act upon the situation and determine the nature of the events that are unfolding (Maitlis and Sonenshein 2010). Namvar et al. (2018, p. 2) describe sense-making as "a process of clarifying and removing ambiguity and uncertainty by searching for and organizing similarities and differences from data sources through which goal-directed interpretations for decision-making are established." Sense-making as a learning process increases knowledge and understanding and improves decision-making (Namvar et al. 2018). According to Weick (1995, 2008, p. 1404-1405), sense-making has seven properties. The first one is "identity," referring to how the individual and the organization view themselves in terms of their skill and experience and the organization's culture and structure. The second property is the "social context," referring to perceptions about social interactions, norms, and values that influence sense-making. The third one is "retrospection," referring to reflection on the past and trying to understand what escaped attention that could be relevant to the current situation. The fourth one is "salient cues," referring to the hints that can help with data interpretation (patterns or metrics). The fifth one is the "ongoing" and continuous nature of sense-making, as constant incoming information further modifies ongoing interpretation. The sixth one is "plausibility" of the interpretations rather than accuracy, as absolute certainty in complex system is rare. The seventh property is "enactment," which is about navigating the situation to understand it and to plan action. Organizational change gives rise to emerging interpretations and narratives that guide sense-making into the actual behaviors, action, and practice of organizing (Aaltonen et al. 2019). A shortcoming of sense-making mentioned by Namvar et al. (2018, p. 5) has been with its use "as a methodology for dealing with complex organizational phenomena" rather than a tool that can assist technology-driven decision making. This leads to shift from making sense of technological changes to making sense with technological changes paradigm (Namvar et al. 2018).

### 1.2 *Safety*

Changes in the sociotechnical system require adjustment in our definitions. Safety is one of these notions that has gone through transformation in meaning and practices. Safety has been traditionally defined as a state of absence of accidents and incidents. This is referred to as Safety-I posited by Hollnagel et al. (2015), and it assumes that failure can be backtracked to the system's components (human, technology, organization). Risk can be mitigated by putting more barriers in the system, and failure can be eliminated. The Safety-I approach fails to see the frequent successes in daily tasks when things go right because people adjust and respond to a variety of conditions and do what is needed rather than merely doing what they are supposed to do. Increased complexity and technological evolution require greater adaptivity and responsiveness to changes. This is achieved by learning from what goes right and capturing the variety of responses in dealing with uncertainty. Hollnagel et al. (2015) has named this Safety-II and suggests that a combination of I and II is needed to learn from what goes wrong and what goes right. Management in this new paradigm must actively be present in the field of operation to understand the variability of daily operations and close the gap between Work-As-Done (how a task is done in reality) and Work-As-Imagined (how a task was designed and planned to be done), as mentioned by Hollnagel et al. (2015).

### 1.3 *Complex systems and changes*

There are different schools of thought about complex systems and safety. As contrasted by Rijpma (1997, p. 15), Perrow's (1984) Normal Accident Theory states that "accidents are inevitable in complex, tightly-coupled systems" while the Berkeley school of thought's High Reliability Theory posits that accidents in such systems can be prevented if organizations strive toward enhancing safety (Rijpma 1997) and learning from complexities. Dekker (2011) further suggests the notion of gradual "drift" in complex systems marked by unruly technologies that have surpassed our comprehension and ability to predict their behavior in operation. Drift occurs because of scarcity and competition. Signs of failure are ignored or justified and the local sense-making spreads to the rest of the system, leading to normalization and justification of

deviations. Dekker (2011) suggests that drift can be prevented by giving a voice to actors, developing resilience, promoting diversity, and readjusting organizational responses to the environment as early as possible before they become unmanageable. This seems to be the closer theory to technological changes in complex systems. The theories described here do not explicitly describe how organizations could deal with sense-making and safety during technological changes. This paper will present a review on strategies that the managers could use to increase sense-making during technological changes in safety critical industries.

## 2. Method

To explore how management can increase sense-making during technological changes, a literature review was performed. A qualitative research approach with thematic analysis was applied.

### 2.1 *Literature search*

Data collection took place in October 2019 in the ISI Web of Science database, with documents ranging from 2017 to October 2019. The literature review was done based on qualitative research methods. A Boolean search was conducted with the combination of key search terms including technology implementation, sense-making, safety, risk, resources, organization, change, and management. Furthermore, the truncation and exact phrase functions were used. The search criteria further included filtering for English language and full text availability. The search yielded 272 articles. Abstract screening resulted in filtering to 111 articles that were imported into the NVivo 12 software and further filtered based on the sector in which the research was conducted. Safety-critical industries were focused on (construction, maintenance, aviation, transportation, and manufacturing), which resulted in 48 articles. Critical reading of articles and thematic analysis was conducted following the guidelines of Savin-Baden and Howell Major (2013). Although it cannot be claimed that a literature search can encompass all the relevant work, by focusing on the recent literature in the cross-disciplinary and accredited database of ISI Web of Science, we attempted to provide a focused, brief, and up-to-date perspective on managerial sense-making.

### 2.2 *Data analysis*

The resulting literature was analyzed using thematic analysis, which offers flexibility with theoretical freedom, meaning that it can be used within various paradigms. Braun and Clarke (2006) posit that this method helps retrieve a rich and detailed account of the data on a salient and latent level, and it allows one to identify patterns. This patterned meaning corresponds to the notion of a "theme." During analysis, data were openly coded and further reviewed to capture salient and latent themes. Codes were reordered iteratively to prevent overlap and to ensure thoroughness in the analysis. Themes and sub-themes were identified. Due to the focus of the paper, the themes and sub-themes pertaining to managerial practices and strategies were chosen to answer the research question.

## 3. Results and Discussion

The relevant themes can be placed in two major categories: awareness-related themes (what the management should know) and action-related themes (what the management should do). Awareness and action are simultaneously happening, interacting with each another, and modifying each other as sense-making occurs. The awareness-related and action-related themes are shown in Figure 1. There may be some conceptual overlap and interdependency between the themes. In the following section, the awareness-related themes (vision and strategy, mindfulness, and context sensitivity) are presented and discussed.

### 3.1 *Vision and strategy*

This theme is about where the organization is headed and how. It brings focus and direction to sense-making.

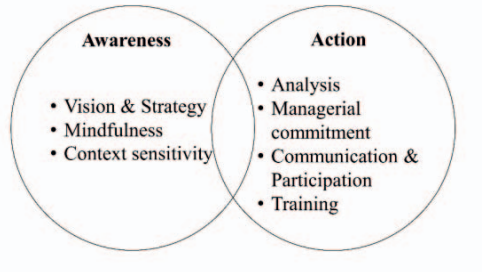


Fig. 1. The awareness and action themes of managerial sense-making during technological changes

The literature suggests that some organizations strategize for continuous innovation while others are focused on the betterment and maintenance of generic products or standard services (Lovrencic et al. 2017). While in most industries the priority is to increase their profit, achieve business objectives, and satisfy stakeholders (Amako et al. 2018), in safety-critical applications, reliable and safe operation should be prioritized, which ultimately leads to profit. The management is aware of the organization's vision and has access to tools and techniques (Kuzmina et al. 2018) that can assist them with decision-making and strategizing on safety, profit, logistics, and assessment of procedures (Che Ibrahim et al. 2018). Technology must be evaluated for how it assists the organization toward its vision and aligns with its strategy. The interaction between humans and technology impacts the system functionality and efficiency (Sepasgozar et al. 2018). When strategizing on centralization of processes, with the aim of minimizing costs and facilitating monitoring, automating technology can be used. Automation can enhance efficiency, but it could also lead to the loss of knowledgeable workforce that are now deemed redundant but would otherwise help deal with complexities during automation (Brundage et al. 2019). Centralization of operation centralizes authority. This could make people think they are being monitored and cause them to view technology as a surveillance tool (Maas et al. 2018) rather than an assistive tool and result in resistance. Maas et al. (2018) suggest using the strategy of control dissipation and maintaining an intermediate level of control during technology implementation to lower resistance. Therefore, management must center the organizational sense-making on vision while strategizing on what technology to use and how to implement it. Management must also be aware of possible effects of technology that can derail organizational performance and morale.

### 3.2 *Mindfulness*

This theme is about constant reflection on our approach toward a phenomenon. This is important for sense-making as it allows reflection on our mindset, our actions, and their consequences in the sociotechnical system. Mindfulness is defined by Jordan et al. (2009) as a mental state or the practice of questioning expectations, knowledge, and routines to raise awareness. In the literature, mindfulness is recommended at different levels of technology implementation. Blom et al. (2019) encouraged mindfulness of paradigm, suggesting a shift away from a functionalist and mechanistic view of technology implementation as it fails to fully capture how technology, humans, and the organization in a context are connected. Mindfulness of a system is to be aware of how technology and humans impact each another. Mindfulness of practices is about knowing how workload, quality of supervision, and support level influence performance (Brundage et al. 2019). Mindfulness of narratives is about acknowledging that there are different perceptions of the change based on different backgrounds and expertise and thus different motivations to accept or resist technological changes (Aaltonen et al. 2019). We suggest that if managers want to remain mindful, they should actively search for different perceptions and perspectives on the new technology, get information and feedback on how it affects the system and employees, and prepare for less explored scenarios of future challenges and opportunities with the use of the new technology.

### 3.3 *Context sensitivity*

We want to draw attention to the fluidity of context and its impact on sense-making. To understand context, it is important to know what constitutes context. According to Cooke (2018), context in organization has three layers. The first layer is the descriptive context that includes the demographic information of the individual, organization, or country. The second layer is the analytical context that focuses on cultural and structural features of the organization. The third layer is the subjective context featured by the cognitive processing of information to make sense of it. We would like to suggest that sense-making is also modified as it spreads from the local level (micro-contextual unit) to a broader level (macro-contextual unit). For example, local sense-making can move from one organizational silo to the whole organization, or further to the industrial environment in which the organization operates, and each level influences the sense-making as more stakeholders and new information is incorporated, and various perspectives can get involved. Management should be aware that sense-making of new technology might vary at different contextual levels across the organization

and be able to reconcile and balance them. They must look beyond micro-level contextual influence and be able to foresee the macro-level influences and to steer sense-making accordingly. In the next section, the action-related themes (analyses, management commitment, communication and participation, and training) are presented and discussed.

### 3.4 *Analyses*

There are several analyses that need to be conducted by the management prior, during, and after technology implementations to maintain safe and reliable performance based on informed sense-making and decision-making. The full scope of these analyses is discussed extensively in the literature. However, with respect to the scope of this paper, we briefly present the most salient ones from the managerial lens.

#### 3.4.1 *Technology selection*

Technologies must be selected based on their functionality and their fit to the organization's needs. While it is important to prepare the organizational culture for technological changes, it is equally important to see how technology shapes the organizational culture. Before implementing a technology to solve a problem, it is important to clarify which core organizational or cultural problems the technology is going to solve (Brundage et al. 2019) and how. As technology does not function in isolation, other elements in the system need to be considered as well. The management must analyze the narratives surrounding the technology, its integration to the existing system, its fit to the tasks deliverable, its responsiveness, and its adjustability to users' changing needs. This in turn will need further inspection of the technology's content, structure, quality, and usability based on the operator's capability level (Lovrencic et al. 2017). Technology is not a one-size-fits-all solution, and management must find the most cost-effective solution to optimize efficiency (Brundage et al. 2019). We suggest that the choice of technology must make sense as the first step in a functional sense-making process during technology implementation.

#### 3.4.2 *Error and risk analysis*

Having an overview of recurring and potential errors can help us to understand how they can be mitigated and what type of technology or cultural shift is needed (Brundage et al. 2019) to do so. Risks do not solely stem from humans or technology. They can occur as the result of human-technology interaction in a system. Cultural shift is as important of a mitigation strategy as the technological solution. Brundage et al. (2019) suggest that for some errors, low technology solutions could highlight the errors or give information about how to mitigate potential malfunctions, and for other errors a cultural shift is needed to enhance collaboration and learning from more experienced colleagues (the buddy system).

#### 3.4.3 *Pre-automation analysis*

Complex systems add to the cognitive load of human operators, and this increases their reliance on using heuristics that do not account for potential failure and errors and do not work in a lack of contextual information. Automation can be one solution to ease cognitive load and to assist human operator rather than replacing them, which can be perceived positively. However, an excessive automation feeds a dehumanized mechanistic culture (Blom et al. 2019) that can demotivate human actors. Therefore, before an organization decides to automate all or some of the manual tasks, the specific human skill and the manual processes of each task should be analyzed to gather vital information about the key processes and the complexity of the work involved. Charalambous et al. (2017) state that this will help management to decide which processes can be automated and what is best kept manual based on the advantages and disadvantages of manual performance versus automation and to make an informed decision.

We emphasize that management should also distinguish between automation versus augmentation technologies. To augment (augmented reality and virtual reality) is to enhance human abilities to take advantage of their cognitive potential and help alleviate errors (Brundage et al. 2019) rather than replacing humans. Therefore, it enhances the performance of humans, while automation does the job for humans. Management should pay attention to how they frame technology changes in terms of automation or augmentation. They must then conduct appropriate analyses to see which tasks could be automated, which tasks could be kept

manual, which tasks could be improved if humans' abilities are augmented by technology, and how this can be achieved.

3.4.4 *Organizational and human factor analysis*
The success of technology implementation depends on the interaction between people and technology (Blom et al. 2019). Inattention to human factors in design and implementation compromises the flexibility and reliability of the system (Charalambous et al. 2017). Technology can make up for what escapes the limits of human perception and response (Naweed and Rose 2018), but humans and technology must be completing and not competing with one another. In a system involving both technology and humans, the management must ensure that the role of the human in the system must be clarified early on and accounted for to prevent employee isolation and demotivation. The tasks must be continuously reviewed by management and the people at the frontline of the operation. This constant monitoring and continuous analysis help them to stay on top of how the roles shift and the consequences of these shifts. Furthermore, it can help with addressing the ergonomic constraints that emerge. Management should establish a support structures for people to cope with new technologies and use their feedback to improve the design and implementation process and reduce error and accidents.

**3.5** ***Management commitment***
This theme is about the managers walking their talk and showing dedication to the vision. The mechanism of commitment is by displaying it in action (Amoako et al. 2018). The sense-making process benefits from management commitment at every echelon because people see the gravity of the vision as the management acts as a role model (Charalambous et al. 2017) and becomes the change champion (Amoako et al. 2018) at every echelon, for their employees and for lower echelon's managers and employees. This motivates other managers and employees to take part and engage them in sense-making process, leading to collective decision-making.

3.5.1 *Allocation of resources*
An important part of showing commitment is to invest in the project through timely allocation of adequate resources. This includes approval of the budgetary needs and readjustment of procedures when needed, even at the expense of productivity and delayed technology implementation. Management at higher echelons can reconfigure resource allocation under changing circumstances regarding budget, time, project scope, and training needs (Amoako et al. 2018). This will in turn improve the morale of the personnel and help with positive and functional sense-making. Resource allocation also means making sure that the workforce receives what they need to function, reduce downtime, and mitigate losses (Sepasgozar et al. 2018), which will consequently increase operation efficiency.
Resources are often limited, and it is important for management to understand and decide on what kind of resources to focus on (e.g., available time, training, support) that different workers need to adjust to the new technological change.

3.5.2 *Social capital*
Social capital is described by Amoako et al. (2018, p. 81) as "the set of resources embedded in the relationships among actors in an organization. It is a resource residing within an organization that reflects the nature of social relations within the organization." By creating positive relationships and investing in social capital, the management can later reap the benefits and use the resources embedded within the social relations in the organizations (Amoako et al. 2018) including the knowledge, experience, and social networks of the members. In order to do that, management must shape the culture around what the team needs (Che Ibrahim et al. 2018). It must be an open culture to reporting and giving feedback to foster a collective sense of responsibility in facing challenges (Batuwangala et al. 2018). This also helps build trust, which in turn reduces conflicts, motivates people to share their experiences, knowledge, and resources, and nurtures relationships (Amoako et al. 2018) during sense-making and technology changes.

**3.6** ***Communication and Participation***
Open and honest communication and participation is about involving all actors in a dialogue that helps move the project forward. Management must use communication as a tool to resolve ambiguity surrounding the technology implementation projects. Communication should provide information about why the project is

important for the future of the organization, when and what will be changed, and how it will impact work. It must also justify the resources that will be allocated. This builds trust, which is crucial if there has been a history of past project failures (Amoako et al. 2018). The literature recommends involving employees during the change process based on their influence and experience rather than mere hierarchical position (Blom et al. 2019), especially in the initial stages. This reduces skepticism, dissipates control, and provides management with a more comprehensive overview of the situation as more voices are heard (Charalambous et al. 2017). For unionized industries, it is recommended to involve unions throughout the process (Charalambous et al. 2017). Namvar et al. (2018) also draw attention to the changing platforms and methods of communication that can alter the way of working and consequently the speed and process of sense-making. Employees can be accessed instantly through social media and augmented reality technology. These platforms facilitate instant learning, sharing, and problem solving that fit the modern remote work patterns and connect multiple parties simultaneously, thus enhancing the speed and quality of collective sense-making. We believe that sense-making drives on the wheels of communication and participation, and as their platforms and underlying technologies evolve, so does sense-making.

### 3.7 *Training*

Training creates learnings and understanding and hands-on experience with the technology. We believe that this interaction is a form of sense-making in and of itself. Training is seen as a platform to communicate the organizational vision and narrative (Batuwangala et al. 2018) aiming to promote acceptance of the technology among stakeholders by making it more accessible, especially when delivered by other major users Charalambous et al. 2017). Training dissipates anxiety and skepticism as users understand how it works (Sepasgozar et al. 2018). It can be tailored to the findings of the "error and risk analysis" but must be kept simple. Otherwise, negative training might result when the system seems too difficult to use (Blom et al. 2019). Therefore, it must be carefully planned. The information dissipated by trainers and trainees must be used for collective sense-making.

We argue that although the traditional views on sense-making in safety-critical industries are valuable, they may not be fully applicable to the current industrial arena. Many shifts have taken place in paradigms, definitions, and practices. There has been a transition from viewing "managing" as trying to control everything and constraining performance to what has worked previously, to developing a resilient and adaptive organizational culture that benefits from variability. There is a shift from reactive to proactive and interactive culture in safety-critical industries. With this increased interaction, any small change, including technological change, can create ripple effects in the system that spread to the rest of the system. Furthermore, as sense-making in one contextual unit spreads to other units, more stakeholders, components, and interactions get involved that affect sense-making. Managers can deal with these challenges by encouraging the organization to be observant of changes and to understand its current and future impact while keeping the sense-making grounded in the organization's vision and strategy.

## 4. Conclusion

This paper investigated how managers increase sense-making during technological changes. Managerial awareness- and action-related themes were found to enhance sense-making. Management provides the team with a focus on the vision, strategizes on how to enhance safety, remains mindful, is sensitive to context, and conducts necessary analyses before, during, and after implementing technology. Management provides the necessary resources and facilitates communication, participation, and training opportunities. They build trust between social networks. These actions result in employee empowerment and motivate them to carry out sense-making themselves, which will build a resilient culture over time. However, more clarity is needed about the view on sense-making of unruly technology as opposed to technology as an assistive tool to sense-making and the distinction between them and how to adjust our paradigm and practices for future technology implementations.

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