A methodology to share experiences in incident management

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Abstract. This article presents a methodology for the representation and sharing of experience gained during the management of incident and crisis situations. This methodology, which was initially developed for transportation accidents [1], is founded on the association of engineering and social sciences for the consideration of technical, human and organizational aspects of incident and crisis management.
Based on interviews of people having participated to the management of the situation at different hierarchical levels, this method formalizes the development of the accident as a series of decision cycles: the particles of experience.
The case study that is presented in this article occurred in a chemical plant, during the loading of a reactor with a dangerous chemical product. This accident has caused no casualties but its management has induced an interesting experience for the management of incidents that could produce harmful consequences.

Introduction

The behavior of a complex industrial system is predictable only for standard operating conditions for which it has been designed. Risk evaluation methods are generally based on the principle that *if every possible deviation from the standard conditions has been studied and if there are means to correct it, then the process is safe*. If this principle works 99.99% of the time, there is always a combination of events and conditions that has not been planned and that may endanger the most secure system. If the situation is not analyzed properly and fixed rapidly, accidents will inevitably occur. Among risk experts, the expression "normal accident" is used to denote the propensity of complex systems to cause accidents. "*The odd term normal accidents is meant to signal that, given the system characteristics, multiple and unexpected interactions of failures are inevitable*" [2]. In most cases, accidents are avoided because of the reaction of personnel (individuals or teams) that have identified the threat and have determined the corrective action to stop its effects and ensure the system's safety.

This kind of system resilience corresponds to the individual expertise of people, acquired along years of experience, which constitutes a major source of progress in risk reduction, if it can be capitalized and shared among staff and management.

Preventive or protective measures aim at acting on the three components of danger: the technical system (Pipes, valves, switches, etc), the human system (staff, management) and the organizational system (documentation, procedures). If the analysis of normal or expected situations requires explicit knowledge (regulations, possible scenarios, simulations), the management of unexpected and unplanned situations uses more implicit knowledge mostly obtained through experience. However, this experience is often individual and it is therefore a challenge to implement the organizational procedures required to collect the experience and to ensure that it is shared amongst all actors. If this objective is reached, the analysis of events and reactions to the disruptions becomes a source of knowledge on the system.

This article presents a methodology to identify, formalize and share this knowledge. The article further focuses on the need to prioritize both human and organizational aspects and on the need to create conditions to improve the image of all actors. This methodology is founded on an analysis of the mental representation of events and decisions.

Experience Management methodology

1. Preliminary remarks

The methodology that is presented hereunder does not claim to being universal, providing the answers to all questions on capitalization and sharing of experience. It must be seen as an example of an operational process for events that are significant or useful for training purposes.
In the organizations in which it was implemented [3], it was suggested that it be applied with a frequency of 3 to 4 analysis per year for each actor, this being a compromise between the time available and the foundation of a “ culture ” of experience sharing.
This methodology positions itself as a complement to more systematic approaches of collecting information on incidents like incident reports or databases.

2. Formalization of experience

When we want to memorize the management experience of accidents or crises, the first method generally applied consists in formalizing each accident as an elementary item. This approach is chosen for the design of most accident databases because it is efficient when used for statistics and epidemiology of accidents. On the other hand, it has the inconvenience of losing two types of key information: the way in which an accident unfolds, and the justification of decisions taken.
When we ask someone to talk about the management of a situation, the person normally retraces the unfolding of events, recalling a series of key moments, therefore making reference to his or her episodic memory. This type of memorization only retains events and actions that played an important part for him in the managing of a situation.

Taking into consideration that any formalism should be founded on familiar concepts or procedures in order to be accepted, we have chosen the narration of each actor and its episodic representation as our starting point. Our hypothesis is that these events, together with their associated decision cycles, form the basis of the actors' experience, which they refer to in the managing of new accidents.
A study that was carried out on the mental representations of actors during forest fires operations made it possible to identify a general representation of the unfolding of the management of an incident based on key events [4]. A more detailed analysis showed that each significant event is linked to a *decision cycle.* In order to represent the evolution of the situation between two key events, we have defined this decision cycle in four phases: *perception of the context, analysis, action and effects.*
This decision cycle represents the smallest element of experience in that it still holds on to its properties, allowing for the characterization of the dynamics of the management of an incident. This leads us to name it *particle of experience*, by analogy to the particle (atom) of material, which is the smallest part that keeps the properties of the element (particle of iron, oxygen, etc.).
The four phases of a particle of experience are:

- The perception phase that corresponds to the collecting of data and the observation of events that influence the evolution of the situation.
- The analysis phase that corresponds to the evaluation by the person of the consequences of the new situation and of the possible actions to take.
- The action phase that describes the details of decisions that have been selected and the executed actions.
- The effect phase that corresponds to the description of the tangible effects of actions undertaken.

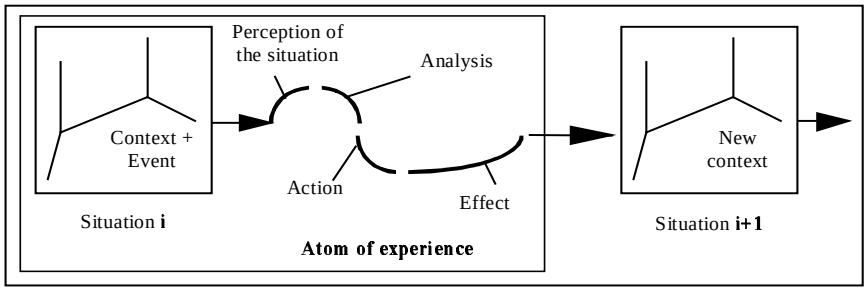

Figure 1. The particle of experience.

3. Collection and sharing of experience

The proposal of a dynamic model to represent incidents and crisis management is only a first step; one has also to define a method for collecting experience that will be widely accepted by the actors. The approach that we developed is based on the analysis of difficulties observed with incident reporting techniques that limit their implementation: "*The people at the bottom of the hierarchy did not feel that they could speak up and state their fears because they were afraid that they would be punished for speaking out against what was the norm, rather than rewarded for it*" [5].

The fist step in our approach was to chose a group of individuals that had participated in the managing of an incident and to ask them, individually and respecting the

anonymous character of their declarations, to talk freely about what happened. The interviewer's role was simply to look for key moments and to help recall them one by one in order to document each phase of the particles of experience, so as to optimize the level of concentration of the actor in the unfolding of the situation. Each of the actors is also asked to convey his or her experience in the form of the alternatives for each real particle of experience, in response to the question "in the same context, do you think one could have acted in a different manner or done something different?" These answers reveal tacit knowledge on past experiences by suggesting new or different actions. They are represented as *hypothetical particles of experience*.
The main benefit of this step is to offer the actor the possibility of talking about his or her experience in a precise context (a given particle of experience) and to recognize the value of positive actions that were executed or could have been envisioned. We are then referring to *hypothetical positive particles of experience.* The actor may also describe actions that could engender an aggravation of the situation. We then refer to *hypothetical negative particles of experience*.
In this stage of the method, the experience of each person is progressively incorporated in the collective representation, but people are not aware of who contributed to what particle of experience. Each narration is formalized in the form of a group of particles of experience, which correspond to units of comprehension. This set constitutes the support of formalization and of capitalization of experience. When all the actors have participated to the collection of knowledge, we have a model of the full set of individual experiences of the actors that were interviewed.
It is not essential that each narration contain the totality of the information and all the particles of experience because it is the very fusion of these individual knowledge representations that will be used to capitalize and share experiences.

We reach the essential stage of the process of experience sharing: the validation of the model constituted from the superposing of the individual experiences. Our approach consists in proposing a method allowing for the validation of a group of particles of experience as a satisfying representation of the collective memory of the group of people involved in a given incident. It is also an encouragement to experience sharing and appropriation by actors.
The collective validation stage and the sharing of experience take place in the form of a meeting between all the actors that participated in the construction of this model: *the mirror meeting*. The main idea is to project on a screen the graphic representation of the set of particles of experience, in order for all the actors to have a global view of the existing collective experience (each participant receives a copy of the full set of particles of experience). Dialog may then be initiated to discuss the knowledge and if needed, to complete and amend it. In order to avoid too long a discussion as well as personal conflicts, this meeting is arranged in two periods:

- Each decision cycle is considered at a time (real or hypothetical) and participants are given opportunities to comment, correct or complete it if necessary.
- A general discussion is launched on the positive aspects and on the solutions that might be considered in order to prevent or mitigate negative aspects.

An example in the chemical industry

1. Presentation of the incident

This example took place in an industrial site of AVENTIS, in the frame of the REXAO working group [3]. It retraces an incident that took place in a workshop during the loading of a reactor used to synthesize a commercial product. This incident had no consequences in terms of injuries to the operators and damage to the environment, but it is of interest in terms of experience in the management of disruptions that could lead to serious accidents.

Context. *Sodium amide* is employed in the first stage of the synthesis of a commercial product. It is a very corrosive and highly reactive chemical.
The loading of this chemical into the reactor is made possible by a loading buffer designed to create a sealed area between the barrel containing the sodium amide and the reactor into which it is loaded.
Initial situation. Around 20h20, the reactor, which is the first in a chain of four, is empty and a new loading process may be started. The reactor is located on the first floor of the building, at a level of +4m50. The first step is the loading of the four barrels of sodium amide. This process implies the placing of the loading buffer onto the reactor in the process room, then the activation of the valves from the control room, outside the loading area.
At the end of this stage, for some unexplained reason, there remains an undetected quantity of sodium amide between the upper part of the reactor and the loading buffer. The loading of the first barrel is considered complete. The "empty" barrel is lifted in order to start the loading process of barrel number 2. The remaining sodium amide between the loading buffer and the reactor spills out. Barrel number 1 is immediately put back down onto the reactor as a reflex action. About 1 kg of sodium amide has spilt onto the floor and onto the reactor, mostly on the dome of the reactor. The operators complete the loading of the product into the reactor after having covered the spilt sodium amide with cement, in order to stop all dangerous chemical reactions (sodium amide produces ammonia when in contact with humidity and cement absorbs humidity). The mixture (sodium amide + cement) is placed in a storage barrel which is then sealed off and brought down to the ground level.
New situation. Outside normal working hours, on the ground floor of the building, the mixture starts to react and to emit ammonia in a sealed off barrel. On his way back down to the control room in order to label the barrel, the operator notices that the barrel has inflated. After a brainstorming meeting, the barrel is pierced by one of the company's firemen, and the immediate danger is dealt with. The substance contained in the barrel is transferred into another barrel covered with fresh cement and placed in an adapted room to be decontaminated.
Final situation. The loading-box area is washed and dried. The production process can resume with a 10-hour delay from the schedule.

2. Formalization in the form of particles of experience

This brief narration shows the development of the initial incident (leakage of a dangerous substance), then the start of a second incident (risk of explosion of a barrel inflated by a dangerous gas), but it does not give access to the experience acquired by operators and management.
The methodology was applied to a group of people that had participated in different ways (depending on their qualifications and personal experience): operators, management, and firemen. It made it possible to better identify the know-how that had

not previously been identified, to create constructive dialogue between the actors and to implement solutions accepted by all.
The complete set of particles of experience (25) is made up of 2 event cycles, 11 decision cycles, 6 hypothetical negative cycles and 6 hypothetical positive cycles Three examples of particles of experience (event, decision and hypothetical) constituted by using this method on the management of this incident are presented in annex (Figures 2 to 4).

Conclusion

This methodology was applied to different types of risk management [3]:

- Railway accidents [1],
- Accidents in the chemical industry,
- Management of floods at the county level,
- Alerts and crisis in the food industry [7],

It has permitted the acquisition of more precise and in-depth knowledge on the unfolding of the events and actions taken during the management of incidents and crisis, on their representation in a simple and easy-to-read manner, and on how to share experience among the different actors.

Despite the time that had elapsed between the facts and the interviews (one week to more than 6 months in certain cases), this method made it possible to elaborate a precise image of the unfolding of the events and, more importantly, of the unfolding of the actions taken. All those interviewed brought up this point during the mirror meetings, and the corrections that were suggested were generally limited to details.

The integration of both human and organizational factors is extremely important in order to ensure successful implementation of the methodology. It is of particular interest to focus attention on communication aspects in the construction of such a methodology. Three aspects have been studied:

- The validation and feedback of information. Many people complain that when they are interviewed about the unfolding of an accident, they receive nothing in return, or only a summary information. In order to overcome this obstacle, a copy of the set of particles of experience was given to all the participants before the mirror meeting, so they have access to the complete picture of how the crisis was managed and of their particular role, as well as an opportunity to intervene in the discussion.
- The climate of confidence. The key actors in incident management often hold low positions in the hierarchical structure of the company. They may be in a difficult position to speak openly in the presence of others, especially in the presence of their superiors. All the interviews were carried out individually, and were anonymous, if necessary. This helped everyone to expand on his or her thoughts and to provide more complete and accurate information. It must be noted that we practically never encountered contradictions between different renderings of what occurred.
- The management of conflicts. The mirror meeting was organized so as to avoid, to the greatest possible extent, the questioning of certain individuals by others. The aim was, rather, to motivate the participants to look for solutions to negative elements. The organization of these meetings near the working sites was an

element to facilitate the management of conflicts, as most actors pay attention to the fact that the management takes into account the specificity's of their working environment.

The management of incidents and crisis is always the management of exceptional events, in highly dysfunctional situations. The experience that has been lived or experienced by the actors, with its successes and failures, constitute an invaluable source of knowledge on the system that should be used to strengthen its resilience.

The resilience of a system to disruptions is due to the same three factors that create disruptions and accidents: the technology, the actors and the organization. This study dealt mainly with human and organizational factors. The representation in particles of experience aims to extract specific elements from the management of an incident, elements that participate in the actors' competence in managing situations. The implementation of procedures to collect and share this knowledge between people and through the hierarchical levels could participate to the improvement of efficiency of the organization as a whole.

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Annex.

Incomplete unloading of the barrel

CONTEXT / SITUATION

Loading of the first barrel containing sodium amide in reactor K in building number 4. This implies:

- In the box where the loading takes place, the placing of a loading buffer onto the reactor;
- The operation of the valves in the control room (outside the loading area).

CAUSE (S)

3 hypotheses were put forth concerning the causes of initial dysfunction:

- Clotting of sodium amide in the barrel
- The reactors valve was closed too soon
- Problem with the arrival of the blowing nitrogen

EVENT (S)

Concerning the proposed hypotheses, 3 types of events are associated:

- A clot in the barrel could have hindered the steady flow of the product
- The opening and closing of the reactor valves is operated from the control room. The valve could have been closed too soon, when the barrel was not yet completely empty
- The intake of nitrogen (used to blow inside the barrel to make sure the all the product was emptied) is commanded locally and manually, from within the loading area. Errors in the operation sequences (opening and closing of valves) could be at the source of a bad nitrogen arrival and therefore of an incomplete unloading of the product from barrel number 1.

EFFECTS / CONSEQUENCES

There remains an undetected quantity of sodium amide between the upper part of the reactor and the loading buffer.

Figure 2. A particle of experience, “event” type

Spilling of sodium amide during the lifting of the barrel

CONTEXT / SITUATION

- The unloading of barrel number 1 is thought to have been accomplished.
- The operators do not detect the remaining sodium amide existing between the reactor and the loading buffer.

ANALYSIS

Before lifting the barrel, the operators tapped on the barrel in order to verify if it sounds hollow, thereby indicating the empty state of the barrel. However, the upper part of the reactor being made of a metal that is not resonant, is not compatible with this sort of verification. It is therefore impossible to detect if the barrel and the loading buffer are totally empty.

DECISION / ACTION

Lift up the “ empty ” barrel in order to start unloading barrel number 2 in the chain.

EFFECTS / CONSEQUENCES

The remaining undetected sodium amide existing between the reactor and the loading buffer spills out.

Figure 3. A particle of experience, “decision” type

Explosion of the barrel at the moment of it’s piercing

CONTEXT / SITUATION

- Due to the swelling of a barrel containing the spilt sodium amide in a building, a crisis unit is assembled and decided to pierce the barrel at a distance with a pointed rod of 4 meters long. A trial phase was executed on an empty barrel. However, the internal pressure is unknown, as well as the degree of the intensity of the chemical reaction taking place inside the barrel.

ANALYSIS

- The lid of the barrel can be punctured from a certain distance and the intervention can therefore take place on the real barrel.

DECISION / ACTION

- No decision is made on the person in charge of piercing the barrel, neither on the way it is to be done. Whilst the person in charge of the workshop is gearing himself, a fireman decides to go to level n° 1 and puncture the barrel.

EFFECTS / CONSEQUENCES

Even though the building had already been evacuated at the arrival of the firemen, the participants of the crisis unit found themselves in the vicinity during the intervention. If the barrel had been under intense pressure (close to bursting pressure), the piercing of the barrel would have resulted in a dangerous explosion.

⇒ Risk of a new accident: injury to operators.

Figure 4. A particle of experience, “hypothetical negative decision” type