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## Using simulation of accidents to assess resilience capacities of organizations

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**Abstract:** This paper deals with the organization of simulation exercises to train organizations to face emergencies. The original objective of simulations is to train people to emergency procedures and devices; we raise the question of training people to face potential crisis situations: are simulations fitted to that objective? Through the observation of a number of exercises by private companies and rescue services, we can answer that naïve interpretation of simulation results limits their benefits to the correction of gaps between prescribed and observed actions, without addressing complex organizational behavior. We introduce a method to organize simulations that gives access to this complexity and to the resilience capacities of the organization by giving specific roles to observers. This method uses a model of the organization seen as a combination of structures, relations and meaning.

### 1 INTRODUCTION

With the growing complexity of technological and organizational systems, companies and public bodies have recently developed simulations, exercises and drills in order to train their staff to face hazardous situations.

These simulations are related to emergency plans: dangerous situations or critical phenomena that have been identified as potential threats are played out and analyzed with the aim to define prevention and protection measures and to set up intervention plans. Exercise scenarios give people opportunities to “play the game” in realistic conditions, practice plans and test the use of technological devices.

Our observations and analysis of such simulations (toxic leak in a refinery, fire in a road tunnel, terrorist attack in the metro, etc.) have shown the benefits but also the limitations in terms of lessons (behaviors, decision making) learned by participants.

Among the benefits, the setting up of the exercise is in itself a good opportunity to gather the many stakeholders and to discuss “who is in charge of what”; this facilitates mutual knowledge among technical staff and shared values in the different organizations. The second kind of benefit is the test in quasi-real conditions of the technological devices and means (medical tents, fire extinction means, communications, etc.) and their use.

Among the limitations, the poor level of realism of the simulation is often an obstacle to the commitment of participants, who don’t react as they would in a real, stressful

situation. Another limitation lies in the evaluation method; people are evaluated for their strict application of plans, compared to “official” plans and procedures. Any difference in behavior is seen as a violation of rules and sanctioned or at least pointed to as an error, which strongly reduces people's willingness to innovate.

From this analysis, it can be concluded that simulations are efficient in creating opportunities for people to work together and to improve their practice of plans and procedures. But do simulations improve the ability of organizations to avoid or manage crises? Based on different non-participant observations and in-depth interviews, our answer is “no”, to the extent that their analysis is limited to the identification of deviations from the norm.

Wybo (2004) defines a crisis as a situation in which an organization is overwhelmed and destabilized, as compared with emergency management, a situation in which the organization remains in control, applying known plans and procedures. In this context, resilience is the ability of the organization (at any level) to remain under control when faced to hazardous situations, uncertainty, time pressure and threats, from outside and inside.

In observing simulations, we have identified individual and collective reactions to difficulties that were not foreseen in the emergency plans. When faced with unanticipated events or situations, some people (generally the most experienced) emerge from the group, commit themselves to “do something” and find innovations and adaptations of plans to cope with the real situation. In some situations, new organizational patterns emerge, for example the creation of new communication flows or an alternate distribution of tasks. With such actions, these individuals and groups demonstrate their capacity to contribute to a higher level of resilience in the organization.

In order to go further in this reflection, we have designed a method to observe and analyze simulation exercises, allowing the identification of such behaviors, the context in which they appear and the lessons that can be learned from this analysis in terms of resilience capacities.

## **2 THE ROLE OF SIMULATIONS**

### **2.1 Safety management and risk perception**

It is now widely accepted that safety management inside the organization has to consider, in addition to the physical characteristics of dangers in the working place, the way risks are perceived by those involved. Broadly defined, the study of risk perception inside organizations deals with the comprehension of tasks and the definition of the working situation when these may constitute a threat for the physical integrity of personnel, installations security, and even the safety and health of populations outside the organization.

Taking risk perception into account can be considered as one remedy for "normal accidents" as suggested by Weick (1986) who shows that systems vulnerable to normal accidents (Perrow, 1984) are at the same time contexts where individuals try to understand and manage complexity. Weick suggests preventive and learning actions through which individuals and groups become able to build elaborated interpretations of what they do and experience, leading them to analyze events other than those strictly limited to technical matters. Jacques & al. (1999) have shown, using cognitive mapping, the evolution of learning over time by using preventive learning technique.

The challenge is thus for the organization to integrate safety management in two manners: first by taking into account human and organizational and not only technical factors of safety, and second, through involving fully all the actors inside the organization. When the risk of accident concerns outside populations, a wide array of actors can be involved.

Safety integration can be achieved through training and preventive actions. A second way is through simulation. The specific advantage of simulation as a source of lessons is that it puts forward many aspects of what people prefer not to think about in their everyday working life situation: an accident. In terms of perception, a simulated accident makes manifest events which otherwise might remain unknown, unseen and unheard of.

The simulation of a large accident involves many different actors whose role is to intervene in case of accident. In normal times, these actors do not meet nor are they part of the high reliability organization. In the case of accident, they must cooperate and coordinate themselves. This very fact is in itself a complex organizational achievement, costly in terms of material and human resource mobilization.

Under normal operations, it is the occurrence of the accident that triggers a wide array of events, ranging from the focus of attention of personnel to the calling together of many outside actors. The accident has the upper hand. In the case of simulation, it is the human mind that takes the lead. What difference does this make? This is what we aim to distinguish here, principally in terms of learning, which is chief among the resilience capacities of organizations.

Put simply, one can say that simulation creates for the organization an intermediate state between normal operations and crisis situations. While some of the preparedness required to face potential crisis situations can be acquired during normal times, other levels of learning can be acquired only outside normal situations, i.e. during crisis or simulation situations.

We focus in this paper on learning during simulation situations. To understand the dynamics of this type of learning, we have to consider some aspects of safety management in ordinary times. How safety is recovered during and after a crisis can then be examined on that basis.

## 2.2 Safety management in normal times and during crisis

When a safety issue is raised, one may observe that everyone in the organization has an opinion on the question. While the starting point of this opinion is the shared objective to avoid accidents and prevent operational errors, reasoning and references, often implicit, may rapidly diverge. This can occur according to the position and role of the actor, his knowledge of risks and operations, possible defensive mechanisms linked to his profession (Dejours, 2000), orientations set by the hierarchy and the top management, etc.

In addition, the perceived contradiction between the *a priori* shared goal of a high level of safety and secondary divergences, can lead to misunderstandings or stalled situations, which in turn are counterproductive for safety. The extent and efficiency of preventive actions, as well as communication with stakeholders, thus can suffer.

Organizations are bound by many levels of requirement or obligation in regard to safety assurance (Poumadère and Mugnai, 2006). The first level is one of individual obligation, which includes to follow consignes and basic rules, such as wearing the mandatory individual protections. Obedience is a must, along with the notion of self protection and, in some cases, that of survival. In most settings and most of the time, this level of obligation can appear disconnected from the apparent requirements of tasks. However, during accident and crisis situations, this basic level plays its full role and it is expected to be automatically integrated in behaviors.

Another level is that of economic obligation; simple economic rationality favors investments in prevention so as to avoid the very high direct and indirect costs of accidents. This level is most often disregarded during accident and crisis, as urgency prevails and exceptional expenditures may be undertaken.

A managerial obligation resides in the fact that safety figures among collective performance factors and must be managed to that effect, in itself and alongside other performance factors with which it is in interaction. During accidents or crisis, this managerial coordination of decisions is likely to be crucial.

The legal obligation refers to the existence of the organization within a state of law, applied to all organizations which have to conform with established norms and prescriptions. Often this level prevails in the organization when safety is considered; i.e., safety actions and investments may be framed as responses to minimum legal requirements. However, during accident and crisis situations, the need to invent creative fixes may make that level less predominant.

Safety experts' best possible application of scientific and technical knowledge corresponds to the professional level of obligation. In some contexts all members of the organization are invited to integrate safety within their professional identity.

Interdependency and solidarity exist *de facto* within working relationships and make each of us responsible for others' safety. This corresponds to the reciprocity obligation, which can extend to relations with the environment of the organization and its

protection. The moral obligation puts forward the value of human life, primordial within our cultural ethics, and for which better safety for all is a goal.

These professional, reciprocal and moral obligations can play their role during a crisis situation and contribute to organizational resilience – if they have been nurtured before.

These levels of obligation influence perceptions at all levels of the organization and thereby influence safety practices. They are also known to outside actors and stakeholders, who may view them differently from those inside the organization. As shown above, obligations change in meaning and salience according to whether the organization is in a normal or crisis situation. It is thus useful in each context to assess safety obligation levels, both in ordinary times and for accident or crisis situations. This is what is done during the simulation exercises we study. The bridge built between these two different instants in organizational life can contribute to resilience.

### **2.3 Interpretations of simulations**

In the usual way of organizing exercises, one uses a rational model to measure the gaps between prescribed and observed actions as the scenario unfolds, and to explain in an objective way the causes of those deviations. This approach can be called “naïve”, as it doesn’t reach the complexity of the organization during emergencies and crisis. It can be associated with a “simple-loop learning”: measuring gaps and controlling them by known actions.

In this paper, we present a method to observe an organization during a simulation based on the plurality of specialized observers’ points of view. Taking their observations together allows us to address the complexity of organizational behavior, to generate meaning and learning from the post-simulation analysis and thereby go beyond the simple diagnosis of deviations from standard practice. The method is framed by a three dimensional model of organization: structures, relations and meaning:

*“that of structures in which actors’ games take place, that of relations between actors who set structures in motion, changing them through their games, giving rise to new organisational forms. This dimension also takes into account the principles of (sense making) legitimacy through which actors justify their games and their constructed orders.”* (Jacques and Specht, 2006, pp. 23)

Structures consist in what is prescribed by the organization, objectivable and measurable: the product of division of work, tasks, the means to achieve tasks, formal rules, procedures, technology, coordination tools, etc.; what Minsberg (1993) calls the hierarchy line, technostructure and support services.

Relations are often represented as the roles played by the different actors. Following Crozier and Friedberg (1977), this dimension takes into account the fact that the structure is a context for action, which includes relations among people. Each actor provides his resources, stakes, interests and power. This dimension can be observed at the micro/local level. It concerns verbal and non verbal, formal and non formal communication. It raises questions about the group’s dynamics.

Sense making is what people use to justify their actions; it is related to the notions of legitimacy, ethics, interests and values. The actor's representation of the situation influences his behavior. People belonging to different "worlds" have difficulties to act together for a common task (Boltansky and Thevenot, 1991), (Weick 1992).

### **3. ORGANIZATION OF SIMULATION EXERCISES**

In order to be prepared for emergency management activities, risk-prone companies and rescue services organize on a regular basis exercises that simulate accidents and catastrophes. The purpose of such exercises is to train people to apply procedures and plans, to become familiar with technical systems and locations, and to evaluate the efficiency and appropriateness of procedures. These practical sessions have one more advantage: they can be organized more frequently than staff turns over.

In this way, teams become accustomed to work together and if some need for improvement is identified, progress can be assessed during the next exercise, as it will be carried out by the same people in comparable conditions. This advantage is especially great when the exercise concerns very rare events and/or when the stakeholders have a high rate of turn-over. By running exercises at an appropriate frequency, the organization increases its robustness in the face of "known events".

#### **3.1 Prevention of crisis: the role of simulations**

When dealing with the management of crisis situations, the interest of exercises in terms of training can be questioned. Crises are situations in which plans and procedures are not appropriate, so how exercises can provide experience for such situations? How may exercises increase the resilience of organizations?

By placing observers in appropriate locations with precise missions during emergency exercises, it can be observed that people playing their roles in the exercise go beyond the procedures describing their tasks: they develop communication and coordination activities with other people (inside and outside their organization) and they adapt their activity to the real context in which they are. If the debriefing of the exercise is focused on the strict application of plans and procedures, such deviations and extensions are evaluated negatively or hidden by the participants.

*"Given the emphasis on plans, even those that are impossible to execute, it is not surprising that departing from them is often cited as evidence of a failure. Disasters, however, break the rules that guide the ordinary conduct of business and government, at least for a period of time. Disasters create new environments that must be explored, assessed, and comprehended, change the physical and social landscape, and therefore require a period of exploration, learning, and the development of new approaches",* (Kendra and Wachtendorf, 2003)

These deviations from the standard procedures are indicators of the ability of people to adapt to difficulties and by that, they reveal on one hand the need for adaptation of

procedures and on the other hand the resilience capacities of the organization: the ability of people to avoid destabilization and entry into a crisis.

### 3.2 Observation of exercises

Based on this analysis, the introduction of specialized observers was tested in several exercises, in order to identify these deviations from the prescribed world and to be able to get the full picture of the organization at work, from the combination of the points of view of the participants and the points of view of the different observers. Three kinds of observers were defined: those who observe the activity of key people (information they receive and emit, people with whom they collaborate, decisions they make, etc.), those who observe a specific task (how it is achieved, difficulties encountered, who participates, what resources are used, etc.) and those who observe a specific place (who is there, what is done, how this place is perceived by people, etc.).

Using this combination of points of view (people playing roles and specialized observers) during the debriefing session, a number of deviations have been identified, in particular the emergence of organizational patterns and communication flows among stakeholders, some of them proving efficient to prevent the situation from turning into crisis. Studying the character and value of these deviations makes it possible to capitalize on them to improve emergency procedures and plans (double-loop learning), and to increase the mutual knowledge and efficient cooperation of stakeholders (Wybo, 2006).

*“The reliability of learning of an organization is if it develops common understandings of its experience and makes its interpretation public, stable and shared.”* (March & al., 1991)

On the other side, it is also possible to observe and understand some drawbacks that would ruin the efficiency of emergency management in a real situation. In the simulation of an accident in a road tunnel, two observers were placed in the control room of the tunnel: one observing the manager on duty and the other observing the activity in the control room. At the same time, other observers were inside and outside the tunnel. When the simulated accident occurred, some of the car passengers were wandering on foot in the tunnel, looking for an emergency exit, and the rescue services took a long time to localize and shelter them.

By combining observers' data, we identified the organizational cause of this difficulty. The control room operator was facing a set of video screens in which it was possible to observe these people wandering in the tunnel. At the same time, in a corner of the room, the rescue services had established a radio terminal to communicate with their colleagues in the tunnel and they were listening to the conversations over the radio. Finally, the manager on duty was trying to assess the situation and to answer the requests that he was receiving.

But the operator had not been told to report to the manager what he saw on the videos (he was trained to answer questions) and the rescue officer managing the radio terminal was not trained to identify problems that his colleagues encountered in their actions



from what he heard over the radio, so none of them communicated to each other or to the manager.

When the analysis of the different observations (in the control room, in the tunnel, at the rescue headquarters, etc.) was carried out, this drawback appeared along with other negative and positive reactions and it was possible for the tunnel managers to share these observations with their staff and to set up improved emergency procedures that make sense for everyone.

## CONCLUSION

Simulations are one of the most efficient tools that can be used to train people to emergency situations, especially for situations with a low frequency of occurrence and a high potential of damage. Emergency services and risk-prone companies have gained significant experience in the setting up of exercises and this practice contributes to the robustness of their organizations to face “planned” emergencies.

In order to face situations that may turn into crisis, because of surprise, speed of development, lack of resources or difficulties in communications among stakeholders, organizations need to assess and develop their resilience capacities. In this paper we have shown that exercises can contribute to that on the condition that their analysis goes beyond naïve interpretations and gives access to the complexity of organizational behavior.

The method presented here provides means to reach this objective with only minor changes in the simulation set up. By defining specific missions for observers based on a model of organizational behavior, it is possible to identify more precisely the organization's resilience capacities and handicaps.

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