IMPROVING ORGANIZATIONAL EFFORTS IN RISK MANAGEMENT: LESSONS LEARNT FROM AN INDUSTRIAL ACCIDENT

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SUMMARY

The paper is focused on the emergency management procedures within an urban area exposed to chemical risks. Specifically, it reports some organizational and technical issues caused by an industrial accident that took place recently in a hazardous plant in Lombardia Region (North of Italy). This chemical accident, produced effects on the human health by intoxicating a number of people living outside of the plant, generating a real emergency that was managed by the local authorities of Civil Protection.

The real-life emergency showed a series of inter-organizational difficulties and technical discrepancies as the result of both cultural and psychological factors characterizing social relations. As a matter of fact, the emergency represents an extreme event where individual and collective actions come from cognitive and behavioral characteristics that influence perception of risk, decision making and implementation processes, either in the short or in the long term period. As shown in this paper, an emergency can be represented as an interactive disintegration of the roles structure and of the sense-making for an inter-institutional organization, such as Civil Protection.

1. FROM AN INDUSTRIAL EVENT TO A LOCAL EMERGENCY

Working under standard operating conditions, an accident occurred in a chemical plant in a rather small city of Lombardia Region, provoking the hazardous release of both liquid and gaseous monomers that were the reactants of the main polymerization process. The privately owned company is one of the hazardous activities within the urban district. It employs about one hundred people and supplies chemicals for the tanning industry. At present, it is not covered by the European Seveso Directives for the prevention of major accidents in hazardous plants, but it is covered by the more stringent Italian legislation about the prevention of chemical risks.

According to the existing Italian and Regional laws, this kind of activity has to elaborate a Technical Assessment Report (like a Safety Report) and an Informative Document to single out and evaluate specific industrial risks, besides the official regulations about the safety of workers. The specific Technical Report includes a number of top-events for each hazard activity. Contrary to the predicted top-events, the accident was neither forecast nor considered among the top-events. Nevertheless, it was so dangerous that it intoxicated nine people: four children of an elementary school, and a number of public safety officers and administrative technicians.

The accident was originated by a human error concerning the wrong loading of raw materials in the polymerization reactor. Inadvertently, the process operator loaded the reactor with a solvent different from that usually adopted for the polymerization process. The physical burst of the rupture disk of the reactor produced a gaseous emission. A fraction of the liquid reactants and products inside the stirred reactor was emitted at high pressure and collected to the blow-down system that worked properly as far as the liquid phase is concerned but that was not able to entrap the gas stream produced by the sudden depressurization. Consequently, a toxic gas stream was emitted from the stack of the plant.

The Technical Report, as prescribed by the Seveso directive, included a number of top-events, the worst being the release of a toxic substance (other than the emitted ones) involving a maximum distance of 70 m for the IDLH threshold (ERPG-2) and 10 m for the LC_{50} limit (ERPG-3). As aforementioned, the accident under consideration was neither forecast nor modeled among the top-

events. Nonetheless, the dispersion cloud, by reaching the significant distance of 1200 m, intoxicated four children of an elementary school (i.e. the IDLH (ERPG-2) impact area reached a distance of more than one kilometer).

Firstly, the toxic gas cloud was alerted by the four children of an elementary school at the center of the city. When this unusual odor drew the attention of the teachers at school, they decided to close the windows, while activating the internal emergency measures. However, this provoked and unexpected effect of poisoning: the alumni in a few minutes complained headache, nausea, vomiting, and mucosa irritation. The teachers alerted the emergency healthcare operators that took the students to the nearest hospital, where they received medical aid. Two of them were discharged in a few hours, the others stayed longer for safeguard.

The alert procedure was characterized by a helter-skelter communication chain. Within an hour, an institutional group for the crisis management went to the plant where the accident had occurred. Municipal public officials, traffic officers, policemen, technicians of the Regional Environmental Protection Agency and the Local Health Agency participated to the response activities with the aim of controlling the accident while reducing the damages to people and environment.

2. REMARKS ON THE EMERGENCY MANAGEMENT PROCESS

Even if agencies and subjects, representing the competent authorities for the local crisis, participated to the emergency response, nonetheless several inter-organizational discrepancies and communication weaknesses emerged.

For this reason, the emergency may be considered as an interactive disintegration of the role structure and sense-making in a minimal inter-institutional organization. As shown in the literature [1], the work of organizations is increasingly done in small temporary outfits in which the stakes are high and where foul-ups can have serious consequences. Thus, if we understand what happened when the accident occurred, we may be able to learn some valuable lessons on how to conceptualize and cope with the Civil Protection organizations acting in a crisis.

As far as the internal emergency management is concerned, the industry did not extensively put into action its Internal Emergency Plan. As reported by the safety staff, the accident was completely unexpected because it was the first occurrence of that kind in the industry. Furthermore, neither the administrator nor the safety manager informed the competent external authorities about the accident: above all the fire-fighters. When the accident occurred all the process operators, coordinated by the safety manager, focused their attention on the prompt shutdown of the reactor. They sprinkled the external surface of the reactor with a large amount of water to quench the reacting mixture so to reduce the internal pressure. By doing so, they reduced to a certain extent the emission of gaseous monomers present in the polymerization process. Unfortunately, the attention devoted to the process left the other procedural activities unattended. The safety manager forgot to alert and to advise any external competent authority. For this reason, the external emergency management was sluggish and was difficult to be activated.

Moreover, most of the Civil Protection Authorities did not consider the Local Operating Manual, which is a specifically structured document for the management of chemical emergencies within the Municipality [2]. Well established procedures and good practices were not applied by such Authorities, so that the coordination and relief efforts got behind schedule.

As far as the Local Operating Manual is concerned, it is worth underlining that in order to minimize the consequences of a potential major accident, the Italian Legislation absorbing the Seveso II Directive, states that Prefectures (as local authorities of Public Security) have to develop an External Emergency Plan to manage serious crisis situations caused by industrial accidents that have repercussions beyond the industrial borders. Moreover, the local Municipality has to develop a Municipal Emergency Plan, for any kind of risk existing in the concerned area with the aim to localize hazards and urban vulnerability, in one hand, and to define a general model of intervention in case of

emergency, in the other hand. The Mayor competent for the Municipality decided to develop a specific Local Operating Manual to assess the emergency preparedness as a consequence of possible chemical accidents. The Mayor assigned this complex activity to external researchers, the Authors of this paper, who formed a multi-disciplinary task force to address all the multi-faced aspects of the emergency plan. In order to define the correct actions and behaviors that the involved Actors have to take in case of an accident in a Seveso installation, complete scenarios of event were developed by considering the possible effects due to local risk characteristics. Firstly, accident scenarios were simulated by renowned emission-release software for each Seveso installation considering safety systems, chemical substances and products. Secondly, complete scenarios of event were analyzed by taking into account both expected chemical accidents (or accident scenarios) and elements of urban vulnerability (population distribution, urban development, schools, malls, infrastructures, hospitals, etc.) in order to forecast the expected effects of a possible accident caused by the hazardous release in the surrounding area. Thirdly, emergency procedures for each civil protection subject (Local Administration, Traffic Officers, Fire Department, Teams of Emergency Care, Police Departments, etc.) were identified on the basis of the elaboration of extended scenarios.

During the emergency, the Civil Protection Authorities placed erroneously the Operating Center inside the plant, while regulations and guidelines on this topic clearly suggest localizing it at a safe distance to avoid any intoxication, but rather close to the place of the accident for a prompt response. If this simple suggestion had been carried out, further human exposition to the dangerous substances would have been avoided. Conversely, two traffic officers, a local technician and two members of the Italian military station with civil police duties (Carabinieri) were intoxicated while participating to the rescue activities in the Operating Center. Since they did not wear any protective clothes for the toxic substances they were exposed to the chemical release for a few hours (the first symptoms being complained after only twenty minutes of exposure).

Moreover, the alert system as well as the institutional emergency organization took a long time before being activated. The Fire-fighters, who are the most rapid deployment force, in case of chemical emergencies, were alerted two hours after the accident had occurred. For this reason, they arrived at the accident site when the toxic cloud had dispersed in the atmosphere; consequently, they did not participate to the response and rescue activities. Oddly enough, other civil protection actors were informed much before the Fire Department, which is the only actor capable of dealing with toxic substances and of assessing the risk for both people and the environment.

A general perfunctory coordination characterized the operating interactions throughout the emergency process. There were also some lacks of knowledge regarding both the development of the event and the communication process.

It is not easy to understand how, when and by whom some authorities were alerted, e.g. the Prefecture. It is not easy to understand why just four children from the same class of the elementary school were intoxicated whilst the teachers and other students were not. Furthermore, close to the school and along the path covered by the toxic cloud there were some residences and a mall. As a matter of fact, nobody else experienced any disease.

In addition, the technicians of the Regional Environmental Protection Agency that participated to the response activities noticed a few inconsistencies between the data reported in the deposited documentation and what was declared by the industry. Particularly, they singled out an inconsistency among the break valve calibration overpressure certified by the constructor (1.80 bar), the break valve calibration figure accounted by the technical institutional report (0.49 bar), and finally the one indicated in the process recipe regarding the reactor where the accident occurred (0.70-1.00 bar).

If the procedures included in the Local Operating Manual were not extensively considered, this was presumably due to the not yet finalized elaboration of the guidebook. Another reason for the poor implementation of the emergency plan was the lack of both the informative communication and the official adoption of the Manual by the involved actors [3]. Most of the participants at the emergency response, those internal and those external to the Local Administration, were not aware of the

procedures and logistics included in the Manual. As a matter of fact, they did not participate actively and directly at the Manual drafting, with the exception of the Mayor, because they either chose not to attend to the round tables on the topic or they delegated the presence to other subordinates.

3. LEARNING FROM THE REAL-LIFE EVENT: WHAT CAN BE STRENGTHENED FROM THE EMERGENCY?

The lesson learnt by the real-life emergency was about new knowledge acquired during the event and several suggestions developed after the accident. These knowledge and suggestions allowed improving the Local Operating Manual, while enhancing the civil awareness on industrial risks and the organizational capabilities of the civil protection authorities.

First of all, it should be considered that the definition of both accident frequencies and impact areas are strictly dependent on the accomplishment of erroneous actions made by individuals. Through the adoption of a trans-disciplinary approach, Human Factors studies are devoted to understand and define the factors that intervene when individuals interact with and within a productive context [4]. When an individual interrelates with a productive context, different variables qualify working conditions and relations. The measurement and the ability to control these variables and their correlation, so as to minimize risks, are the main goals of human factors studies.

Moreover, the literature on inter-organizational studies shows that a gap in current understanding of organizations exists when an emergency occurs, because of the factors characterizing human cognition, social relations, inter-group dynamics, and team building. These factors are sources of resilience that make organizations vulnerable to disruption of their sense-making and their inter-organizational capability in case of crisis. Organizations should be characterized by interlocking routines and coordinated action patterns capable of bringing the same people together around the same activities in the same time and places [5]. Nevertheless, these everyday cosmologies are subject to disruption when an extreme event occurs such as an industrial accident. In front of a crisis, when people suddenly and deeply feel that the universe is not a rational and orderly system [1], both the sense of what is occurring and the means to rebuild that sense collapse altogether.

This happened in the experienced emergency: both the safety manager and the local administrators became more anxious and found it harder to make sense of what was happening, until they finally organized technical interventions. Decision-making preferences were unstable until the arrival of the technicians of the Regional Environmental Protection Agency who analyzed the risk in the plant and drove the emergency coordination, clearly showing as linkages between decisions and actions are loosely-coupled and synergistic rather than linear.

Institutions create and maintain traditions that express conceptions of right behavior and cultural beliefs. Nevertheless, even if during an emergency the contextual rationality is an action motivated by these behaviors and beliefs, people react and act in front of a crisis developing new meanings and order in the face of environments that impose contradictory demands.

4. CONCLUSIONS

In conclusion, the Mayor and the Actors who participated at the Manual development and coordination meetings acquired a new knowledge that was indirectly useful for the emergency deployment. Nevertheless this knowledge remained an individual, cultural and operative enrichment that was not easy to apply in the past emergency. Despite that, the accident may be considered a real-life simulation through which new knowledge, capabilities and needs were acquired at the administrative and organizational level. For this reason, it was acknowledged as a moment of social and inter-organizational learning (Table 1).

To this end, the basic idea of sense-making is an ongoing accomplishment that emerges from efforts to create order and make retrospective sense of what occurs. Sense-making emphasizes that people try to make things rationally accountable to themselves and others. Actually, this applied emergency should

be interpreted as the starting point for the first Manual update, for some arrangements internal to the administration, and for a communication process to the population.

Table 1 - Scheme of suggestions depending on lessons learnt during the real emergency

Facet	**Knowledge (lessons learnt)**	**Suggestions (improvements)**
Technical issues	The experienced accident was not expected: **accident scenarios are almost infinite, that means not all predictable**.	New hazards assessment.
	A human error influenced the accident evolution: **human factors intervene in the productive processes.**	Emergency training for the internal staff. Improvement of the testing and safety devices.
	Internal Emergency Plan was not applied: **the industrial safety manager and the rescue internal staff were not prepared to manage an internal emergency**.	
	Established procedures in the Local Operating Manual, to manage external chemical emergency, were not applied: **scheduled alarm procedures and roadblocks were not implemented.**	Revision of local roadblocks and ways of escape in case of an accident. Definition of alternative Operating Centers in the Town.
Socio-organizational resilience	Apprehension, anxiety, lack of understanding and collapse of sense-making: **individual reactions influence individual and collective behaviors.**	Communication to the public.
	Early warning and alarm systems were inadequate: **the need of an internal and external communication systems emerged**.	Coordination efforts between different institutional organizations responsible for the concerned Municipality.
	Established procedures in the Local Operating Manual, to manage external chemical emergency, were not applied: **lack of a coordination system.**	Improvement of coordination and relief efforts by the Mayor within the Municipality. Definition of a task force within the Municipality for the emergency management
	A **gap of understanding** emerged because of human cognition, social relations, inter-group dynamics, and team building.	Communication and coordination efforts by the Mayor and the Municipal staff to prepare people and institutional subjects.

As a matter of fact, the Mayor is promoting the communication of the guidebook contents to the population to increase the knowledge and awareness on industrial risks. At the same time, the Mayor is also coordinating the emergency preparedness between the Civil Protection actors through round tables, simulations and in field exercises in case of a new crisis. For this reason the Mayor is going to distribute a copy of the Manual to all the institutions and organizations competent for the Municipality. He is also studying the feasibility of elaborating an informative leaflet for the population.

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