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Integration of Organisational Aspects into Learning from Experience: Illustration with a Case Study

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ABSTRACT

In a recent study on learning from experience, INERIS acknowledged the organisational dimensions of major hazard accidents. The aim of this paper is to introduce the approach advocated in order to take into account the organisational aspects of accidents. This approach is based on a review of the literature on the organisational side of major accidents as well as on accident investigation methods.

Among the methods, the Accimap (J. Rasmussen, I. Svedung, 2000) was chosen to illustrate the global dimension of accident, and a method (MORT for management oversight and risk tree, Johnson, 1980) has been chosen as a tool to be developed at INERIS, with the collaboration of the Noordwijk Risk Initiative Foundation. This method integrates a normative organisational model and an approach to the accident investigation process, based on the principle of barriers. These two methods, though not completely compatible, have shown to be relevant for serving different objectives of INERIS.

Introduction

The organisational dimensions of major accidents has been widely emphasised in the last decades and shown in many accident investigations, as recently stated again in the Columbia accident investigation report (2003):

"In our view, the NASA organisational culture had as much to do with this accident as the foam."

Therefore, along with technical issues, the organisational side should be addressed in accident investigation. However the expertise required for technical and organisational investigations are different. Organisational investigation relates more to management, human science, and system science whereas technical investigation rely more one physics, chemistry, etc, the disciplines found at the base of the engineering culture and scientific background. One can say as well that a technical investigation is very analytical and associated to reductionism though organisational aspects are rather holistic and systemic by nature.

Indeed, organisational enquiries are looking for some dynamical understanding of accident, some kind of organisational behaviour towards accident, as J. Rasmussen (1997) quoted:

"It should be considered that commercial success in a competitive environment implies exploitation of the benefits from operating at the fringes of the usual, accepted practice. Closing in on and exploring the boundaries of normal and functionally acceptable boundaries of established practice during critical situations necessarily imply the risk of crossing the limits of safe practices. Correspondingly, court reports from several accidents such as Bhopal, Flixborough, Zeebrugge, and Chernobyl demonstrate that they have not been caused by a coincidence of independent failures and human errors. They were the effects of a systematic migration of organisational behaviour toward accident under the influence of pressure towards cost effectiveness in a aggressive, competitive environment."

Enquiring these aspects means going back into the history of the organisation, into its evolution, its transformation, its context, its wholeness and several dimensions. Such an approach reveals the complexity of the organisational life. In "Managing risk, critical issues for survival and success into the 21st century", the authors A.Waring and A.I. Glendon, illustrate very well these complexity:

industrial failures can't be understood without opening the systems and without taking into account the various dimensions and interactions. The items that would need to be taken into account are suggested in this table (table 1):

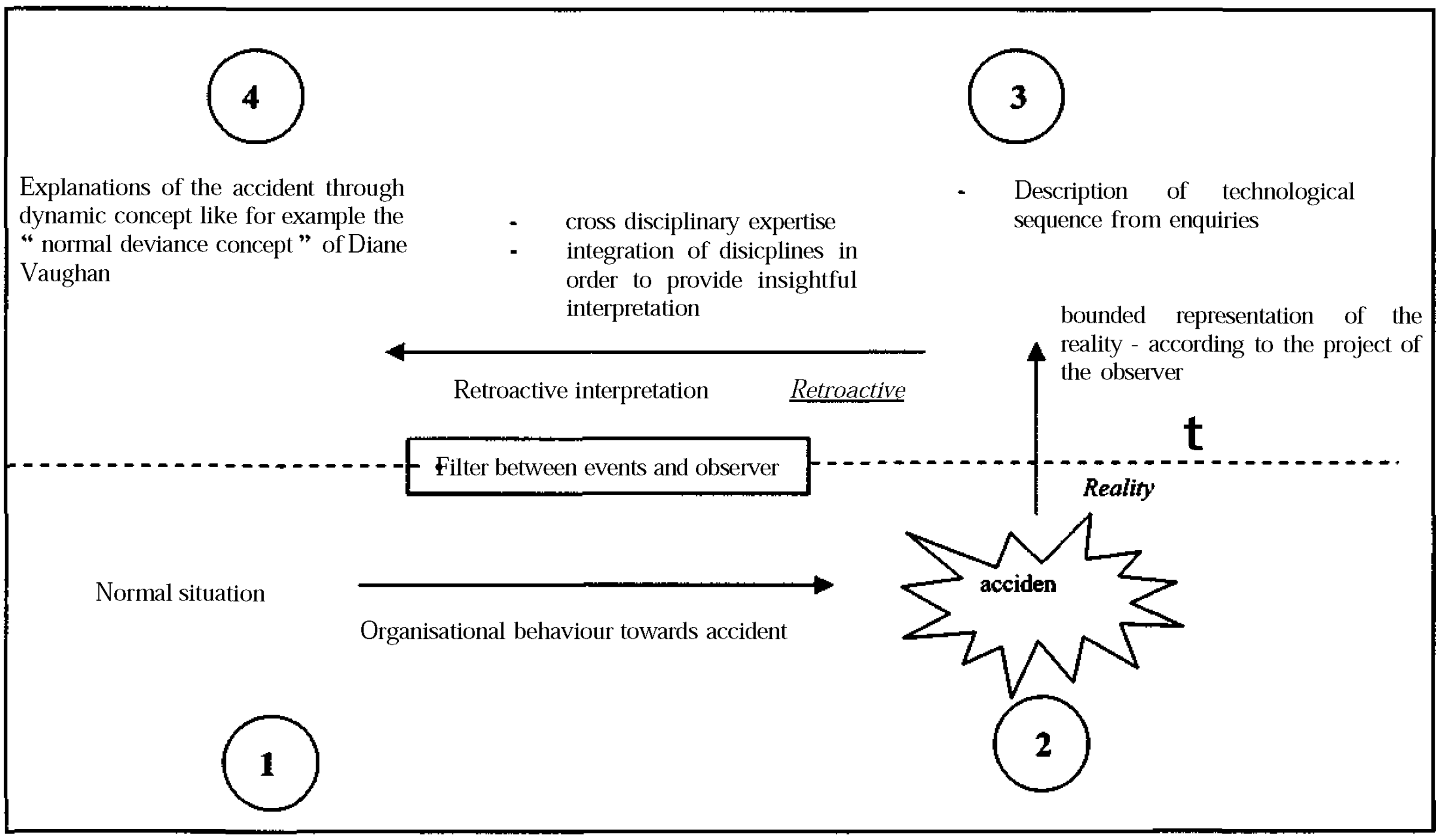
Risk contexts
Organisational environments
Economies and market
Public policy, legislation and regulation
Social and political climate
Technology
History, operating territories and conditions
Human Factors
Culture
Power relations, political processes and decision making
Perception, cognition and meanings of success
Formal coping arrangements
Risk management
Risk assessment
Management systems
Approaches to change

Table 1: Thematic table linking theoretical aspects of risk with empirical studies (A. Waring and A.I. Glendon, 1998)

The structure of this table has already been used in a real accident investigation at INERIS. It proved to be useful for organising the information collected through the interviews and to sort out interrelated dimensions. Indeed, each of these dimensions is relevant and allows relevant insights on the accident.

Ideally, an organisational investigation should therefore address all these dimensions, in order to sort out what is illustrated in the figure 1.

In 1, the situation is normal, there is no accident, between 1 and 2 an evolution has led the organisation toward a major accident. In 3 there is a technical investigation in order to understand the direct causes of the accident, and the technical causes are found. Between 3 and 4 an organisational investigation is carried out to understand the dynamic of the accident, to go back from the normal situation to the accidental situation. A good example of such an enquiry is the D.Vaughan work (1996) on the challenger accident. Her work shows how the culture of the NASA organisation, through a process of normalisation of deviance, finally produced the context for the decision to launch the shuttle in spite of the probability of having a disaster. Her study took her years to collect and interpret this phenomena, according to several levels and through the help of cross disciplinary perspectives.



Unfortunately, most of organisational investigations can't be carried out that way and there are levels of depth into the organisational investigation. One can represent through the use of filters these degrees of investigation, in terms of disciplinary competencies required and time as well as quality and quantity of information needed.

Levels of investigations

The figure 2 shows the levels of investigation:

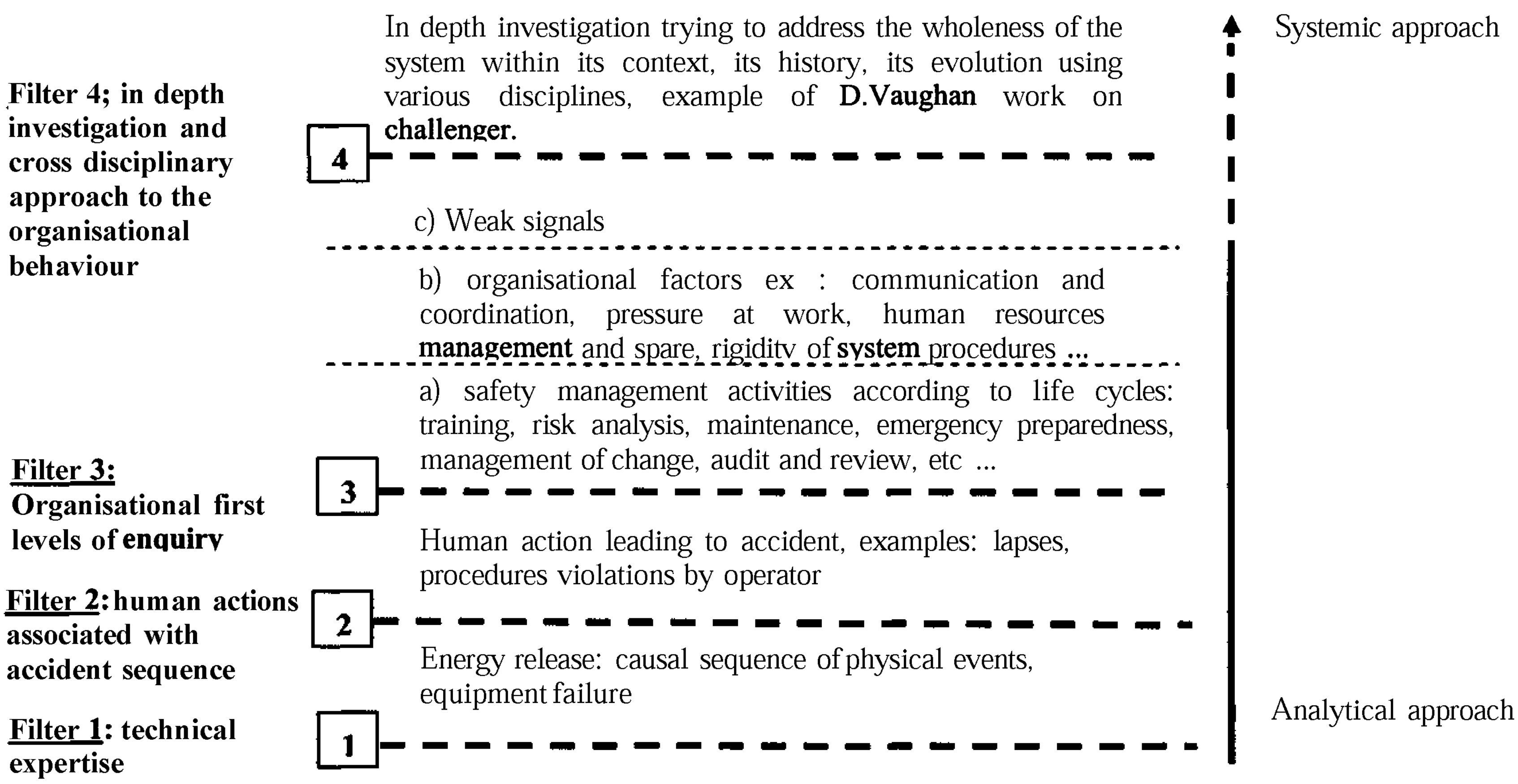


Figure 2: investigation depth, 4 filters

Technical and physical description of an accident brings information about the installation and its associated safety barriers. This constitutes the first filter. It requires technical competencies and technical type of information about the processes and products. Generally these technical description of accident - mainly often using fault trees - associate the human actions that are linked with it. These human actions are close to the accident in terms of time and space. They can be for example an operator opening a valve, an operator taking some kind of action in a control room following the alert given by warning signals. These are often part of what is called the technical analysis. These human actions are introduced in fault trees and are left at the bottom of them, for most of the time under the "human error" wording. This constitute the second filter of access to the accident. The treatment of this "error" depends on the ability of the investigator to put a context around this error in order to get into a level deeper, as a start to get into the organisational life. From filter 2 we go to filter 3.

The third filter is divided into three parts. The first part reflect the safety management activities that should be implemented, according to state of the art concerning safety management systems, in order to prevent the accident that occurred. These type of systems are normative one and include the safety related activities, like risk analysis, training, maintenance, emergency preparedness, auditing etc for all life cycles (design, commissioning, operating, maintenance, decommissioning) of the installation. Skills needed here are auditing techniques associated with understanding of safety management principles. This type of investigation requires an access to companies documents and traceability. It involves as well the interview of people to understand better the functioning of the organisation and how these safety management activities "live". The second part of this level is what has been called organisational factors as a way to go beyond the safety related activities and going a bit deeper into the way they work., more precisely with deeper assumptions on human and collective behaviour. Often defined as communication, co-ordination, risk perception, conflict, involvement, etc issues, these can be called as well as risk factors. Such a level of details requires skills related to human science to treat accordingly the necessary interviews carried out at that stage. The third part introduces the weak signal hypothesis. This assumption is distinguished from the two others because it raises the question of the ability of the organisation as a whole to generate appropriate representation of risks threatening its activity. The quantity and quality of information required is the same as the previous part.

Finally, the fourth filter would correspond to an organisational investigation that consider the organisation internally and externally with a systemic perspective in order to generate insights into the dynamic, that could be comparable to the work done by D. Vaughan for the Challenger accident. Such an approach is very time consuming and requires unlimited access to huge amount of information.

Selection of methods

This type of decomposition through filters allowed the selection of a certain numbers of methods, among which two were selected for their convenience in various respects. The first method is MORT, for Management Oversight Risk Tree (Johnson, 1980) and the second one is ACCIMAP (J. Rasmussen & I. Svedung, 2000). The advantage of MORT is its technical interface with the organisation based on barriers and control and its powerful normative safety management model. This normative model describe an activity level and a risk factor level that accordingly covers the third filter of our figure. However, such a method does not introduce explicitly environmental constraints of the companies that appears quite useful for certain purpose, for different actors (at the governance level for example). The ACCIMAP method allows graphically this, though it does not specify how to get into these dimensions, at the investigation step. It is nevertheless a very useful illustrative tool to emphasise interaction between various actors and decisions, and is as such, very close to soft system thinking techniques.

It has been therefore chosen to use MORT as a kind of very detailed guidance to get into an organisational analysis after accident and ACCIMAP for its broad perspective and graphic advantage.

An example is given in the next part of this paper. This simple example is illustrated with the ACCIMAP representation, and put in light the main safety management activities that would be investigated through the use of a MORT type of approach. That case has been enquired through extensive research on documents relating the accident like articles from newspapers, the legal judgment, administrative reports, etc.

Illustrated case

The accident investigation starts with the description of the company.

The company

The plant is located in Auzouer-en-Touraine, France about 200 km to the South of Paris. The site is skirted by the Brenne, a secondary effluent of the Loire river. In 1988, the company was in a successful economic situation, employed 150 people and manufactured diverse chemicals (about 800) used in the textile industry and the transformation of plastic materials. This plant was covered by the French law n°76-663 of July 19th 1976 relating to the classified facilities for the environment protection. This law deals with plants and industrial facilities operated or owned by any physical or moral person, public or private which can represent major hazards either for the environment including health, safety of the people and the protection of the natural resources (agriculture, monuments, etc.). It can be noticed that the plant was not submitted to the 1st Seveso Directive.

The plant is divided into two areas: the storage of chemicals and the reactors and other facilities in the North of the plant (Langlais, Martin & Combes, 1988; Buisson & al, 1988).

Description of the facilities and of the process involved in the accident

In continuous process, at night, the plant had a manpower reduced to a manufacturing worker, a foreman and a supervisor. The accident occurred in the zone Z, precisely in the workshop Z9. Solvents, raw materials and other reactors surrounded it.

In this workshop, the process consisted in manufacturing a waterproofing substance that had already been implemented 221 times. The process was modified in August 1987. On June 8th, 1988, the day of the accident, the new process was used for the second time. The procedure was to mix different basic alcoholates, called Surfarox, then to add hydrochloric acid before adding silicone oil. This oil is flammable and must stay in an acid pH to avoid release of hydrogen (Langlais, 1988; Buisson, 1988; TGI de Tours, 1992).

Safety systems and safety management

According to our documents, it seems that no specific safety device was implemented in the Z9 area. The plant had a safety team only trained to use fire extinguishers as safety means. (Langlais, 1988; Buisson, 1988; TGI de Tours, 1992)

The accident

During the night, a supervisor and 9 workers were on site. Hired 6 months ago, assigned for a short time at his position and alone on the zone Z, an operator was manufacturing a waterproofing product with silicone oil and additives, like SURFAROX, a very basic alcoholate. The plant had realized this for a long time but the procedure had just been modified. At around 3 a.m., a hydrogen release, due to the rough addition of the alcoholate Surfarox with the silicone oil which is incompatible with bases, led to an explosion and a fire. The operator was found burnt about 10 meters from the reactor. The fire ignited about 500 tons of products, of which a significant amount of alcohol. It seems that some employees tried to fight the fire themselves at the very beginning.

It is a citizen who warned the rescue services. The nearest rescue center was informed but not the professional firemen of the city of Tours. The first means displayed at 3.20 a.m. had no effect. At 4 a.m., about ten people living in houses close to the plant were evacuated. Then, the fire gained in surface and intensity. The high temperatures eased the decomposition of the stored chemicals. The HCN, CO, NOx and halogens concentrations were checked. Only traces of CO and NOx were detected. At around 7 a.m., the fire was controlled by the firemen, requiring lots of fire-fighting facilities. The use of a large amount of foam and water prevented the fire to be propagated to close storage of dangerous products.

But the fire flow, not recovered due to the presence of natural ditches between the site and the river and no containment basin, poured into the **Brenne** river. During the response period, the lift pumps were still running and filling gradually the basin of 600 m^3 of the wastewater treatment plant situated on the other side of the Brenne. Thus, the effluents loaded the day before were normally evacuated from the plant.

Yet, at the end of the response, an electrical feed loss switched off the working of the lift pumps while the basin was 3/4 full. Whereas the fire had been put out for 3 hours, the restart of the wastewater plant by the company owner led to a new spill during 7 hours of 630 m^3 of toxic effluents.

The following day, dangerous chemical substances were detected in the Loire river which led the Prefect to demand the immediate shutdown of the pumping in the river. The supply in drinking water of the city of Tours and its surroundings (200,000 inhabitants) was stopped. The supplies in water were ensured in about sixty delivery points by trucks ad tank cars. Some producers closed their plants; restaurants and hotels got empty. After ten days, the inhabitants of Tours found back tap water.

ACCIMAP representation of the accident

The ACCIMAP shows the interaction between the several levels and actors and allows to illustrate the accident, with the **refering** letters.

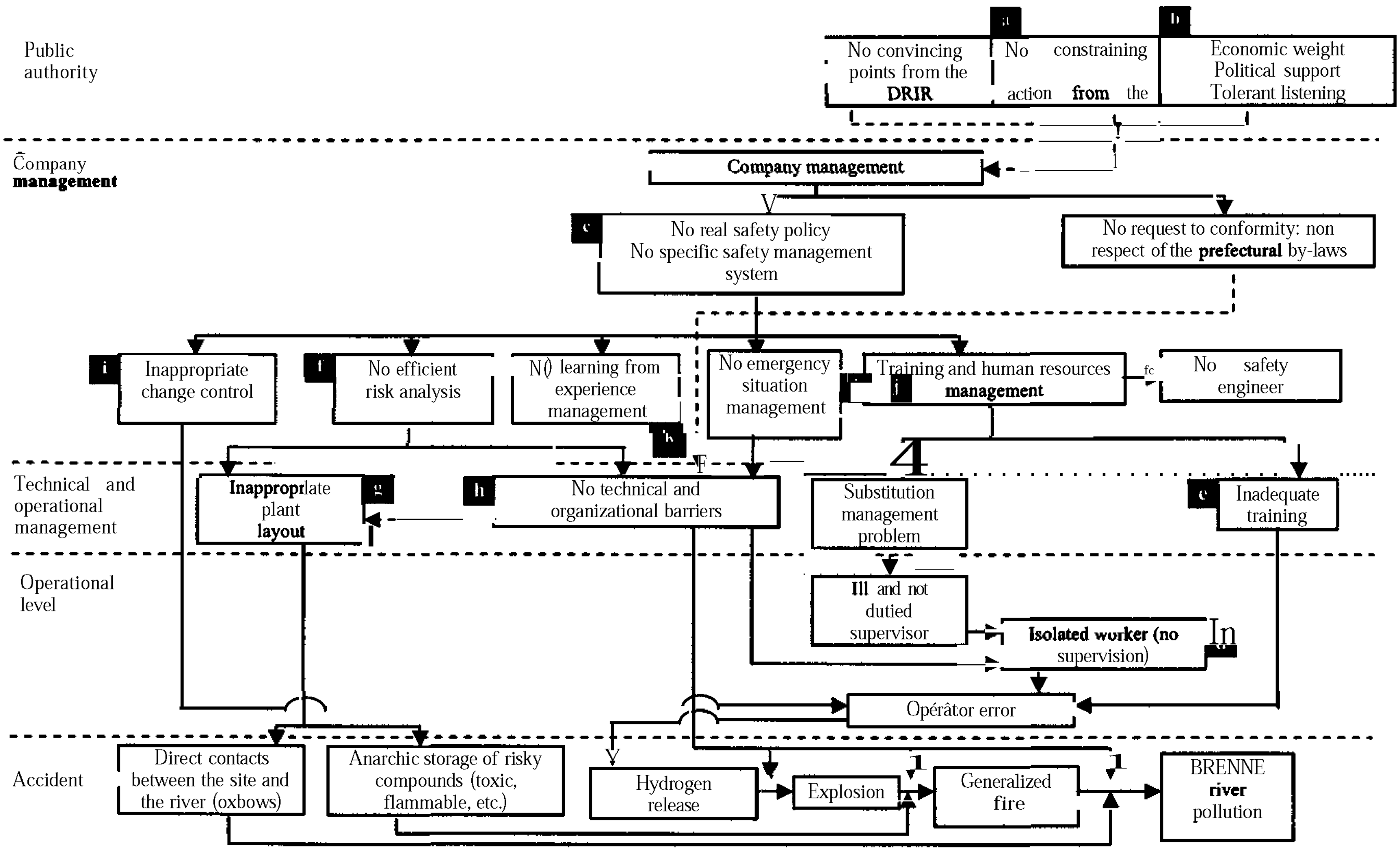


Figure 3: Description of the accident from an organizational point of view

Accident background

The relations between the company and the competent authorities contributed indirectly but significantly to the accident. Between 1963 and **1987,** about fifty minutes were addressed by fishing guards due to pollution statements. Besides, since its foundation, the company had 9 complementary authorization orders. On several occasions, like in 1985, the **DRIR**[2] reminded the company of bringing efforts on the limitations of consequences after a potential accident. In August 1987, the DRIR gave formal notice to the company but the manager obtained from the Prefect a delay, as it was previously already done for the request concerning an emergency planning in December 1986. The arrival of a new Prefect in January **1988** did not make any change (TGI de Tours, **1992,** Lascoumes, **1993).**

a. Thus it was clear that the administration was not inactive, on the contrary: 27 visits by the DRIR between 1978 and 1988. Nevertheless, the argumentation of the DRIR was inadequate towards the manager and towards the Prefects to obtain a **regularization** of the situation.

b. In the region, the company had a significant power. Besides, it received an important political support and a tolerant listening from the préfectoral authorities. Here, one deals with a politico-administrative inertia paralyzing any action (Lascoumes, 1993).

c. One can assume that the manufacturer, without any constraints, focused his policy on productivity to the detriment of safety: no specific safety management system was set up.

On the basis of the structure of the Safety Management System (SMS) which was not compulsory by the legislation at that time, we divided the management system of the company in 1988 into different items discussed below.

Training and organizational management

In 1980, after several accidents within the company, the Departmental Fire & Rescue Services Inspector recommended the creation of a safety engineer position and some safety systems. But nothing was done (Langlais, 1988).

d. On the night of the accident, the operator was left alone without any supervision (TGI de Tours, 1992) whereas the manufacturing process was tricky to carry out. Many reasons for that: additional to the non-existing compensatory measures from the management, the supervisor was sick and not on duty.

e. Personnel's training was insufficient. The operator who manipulated the products has received a short training without any awareness to the risks related to the chemicals used in the processes within the company. Besides, no safety policy was carried out on site (Langlais, 1988, TGI de Tours, 1992).

No risk analysis

f. No systematic risk analysis was performed on site.

g. The site layout was inadequate:

- the anarchic storage of risky products led to the fire spreading,
- the direct contacts between the plant and the river **through** natural ditches led to the discharges of fire flow into the river.

h. The lack of risk analysis led to the lack of determination of technical and organizational barriers for that kind of accidental sequence: no prevention and protection systems in the very workshop, insufficient water capacity for the rescue services, no wastewater and fire flow collection network, no containment basin, insufficient separation systems between the plant and the river with dikes, etc.

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[2] DRIR stands for Regional Industry and Research Authority. In 1992, it became DRIRE with E for Environment. In the field of the environment protection, the DRIRE works for the Environment Ministry under the authority of the prefect. Its main mission is to control the industrial activities that could have an impact on environment in the framework of the regulation on classified facilities for environment protection.

Management of change

i. The new manufacturing process had several flaws: the products incorporation order had a higher potential danger than the previous one (**H_2** release possibility). The material safety data sheet was not with the other manufacturing documents. This lack of dissemination of safety information was approached during the Working Conditions, Health and Security Committee sessions but no efficient measures were taken. Besides, no risk analysis (to check its influence on safety) was performed after the process was modified (TGI de Tours, 1992).

These failures associated with the lack of supervision and training contributing to worsen the poor practice of the new manufacturing procedure by the operator.

Management of emergency situations

j. The setting of an emergency planning in December 1986 was postponed to June 1987 but was still not into practice at the time of the accident (**Langlais,** 1988).

Learning from experience management

k. Two accidents in 1979 and 1980 occurred at night on totally different chemical reactions. No lessons were learnt and the whole manufacturing processes were not assessed at all. It means also that safety systems were insufficient (Langlais, 1988).

Conclusion

This paper intended to present the depth of organisational investigation and the related time, quality and quantity of information as well as type of competence involved. Levels of inquiry have been suggested through the use of 4 filters, each of them going deeper in the understanding of the organisational side of accidents.

This representation helped to consider the usefulness of various methods and to select two of them for what appeared to be two complementary angles. MORT is a normative model facilitating the investigation into safety management systems thanks to barriers and control interface and **ACCIMAP** is a graphic representation that intends to consider the system as a whole and its various actors influencing organisational behaviour.

The example chosen was quite simple to allow a quick description and illustration through the use of the ACCIMAP and the systematic kind of inquiry suggested by MORT.

Investigations has been carried out by **INERIS,** following such a type of mix approach and proved its interest.

Much work is currently carried out to create an approach integrating these two kind of perspectives.

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