Learning From Experience of Incidents in Public Transportation: A New Form of Experience Reflection for Organizational Learning

Cheila Colardelle & Jean-Luc Wybo

Ecole des Mines de Paris, Pôle Cindyniques
P.O. Box 207, F-06904 Sophia Antipolis (France)
Colardelle@cindy.cma.fr

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Abstract
Experience reflection is a management method in which people having participated in the management of an action (an incident or an accident) analyze the development of the situation, learn lessons, and apply decisions to avoid problems in the future. The following article describes a reflection review process, which is distinct from the typical processes, in that it focuses on a new form: the *positive experience reflection* (PER). The PER method uses the development of a real event as an opportunity to collect individual experience of several actors and assemble them into a collective experience. It was successfully validated in 1999 when applied to several rail incidents of the RATP, the French collective transportation company operating in the region of Paris. The PER method accentuates the need for capitalization of all types of experience and know-how, by proposing a simple and structured way in which these can be shared and perpetuated among all actors of a particular system at any given time. By means of three main graphic supports, the PER allows for a reliable analysis of past incidents and near-miss incidents. It traces the unfolding in time and propagation in space of each incident and potential incident situation. It equally allows for a reliable and complete evaluation of the degree of danger and status of the failing system. The dynamic evolution of dangerous situations is thus better understood and the actors' reaction to the system breakdown and crisis management skills is also greatly improved.

1. Introduction

The development of emergency management experience depends largely on debriefing sessions and individual learning from operations. Debriefing consists of the analysis of the crisis and lessons learnt from the evaluation of decisions and actions. Individual learning is the result of the analysis that each manager carries out of events, decisions and actions, from his point of view (hierarchical level, position during the incident, etc.).

Collective learning is mainly based on an *experience reflection*[1] (ER) process. It is a post-operational evaluation activity that is used to learn from incidents, accidents and crisis to reduce their occurrence. ER is composed of four phases: collect events, analyze events, learn lessons, and apply new decisions.

[1] From the French expression "Retour d'experience"

The ER process is practiced widely today and is commonly viewed as one of the critical building blocks in all effective security plans. The process makes it possible:

- To react to the probability of risks by avoiding the repetition of past errors,
- To react to the gravity of risks by studying how to limit danger,
- To intervene more effectively during the evolution of crisis situations.

The ER process, as we know it today, was practiced informally by the RATP as early as the beginning of the 20th century. By the early 90s, the method was officially established as a compulsory procedure when analyzing rail incidents. Since the last 5 years, procedures are established by the RATP to store information about incidents and accidents in a database.

Although the ER process significantly reduced the probability of occurrence and the gravity of the effects of rail incidents in general, it was however, far from being fully effective. One of the reasons was that the ER consisted of applying a "bottom-up approach" by identifying technical problems and supplying solutions at the design and operational levels. The benefits that the field agents received from the ER process were insignificant if not non-existent, limiting the effectiveness of the ER in practice. The idea and birth of the *positive experience reflection* (PER) method was thus imminent. There was a need for a more interactive ER method, placing emphasis on the sharing of experience between actors belonging to a dysfunctional system.

2. The Positive Experience Reflection Method

The PER method takes into account the complexity of the systems to which it is applied, one of the reasons being that danger cannot be fully assessed in isolation. This is the law of *Cindynics reticularity*, one of the concepts proposed by G. Y. Kervern [Kervern 94]: all the layers of a system must be considered in order to fully grasp the correlation between complexity and vulnerability. The complexity of the system can be represented by the analysis of three sub-systems:

- Human: employees of all activities;
- Organizational: documents and procedures;
- Technological: technical equipment and machinery.

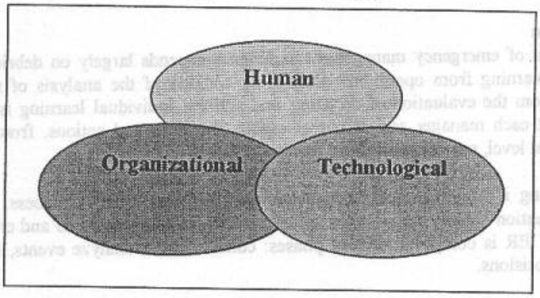

Fig. 1: The three sub-systems

We present the application of the PER method to:

- The derailing of a rail gravel car, in the process of renewal of rail lines[2].
- The malfunction of electrical devices[3] (remote-controlled switchboards).

These two incidents merited special attention in that:

- They were considered by the actors of the system as being "normal", an acceptable part of the system, due to the frequency with which they occur (twice a year, on the average). Our aim was to highlight the fact that these types of incidents, no matter how apparently negligible, generate substantial losses in the long term and should therefore be diminished if not altogether eradicated from the system.
- These particular incidents had taken place a little over a month before the beginning of this study, therefore the actors still had the incidents "fresh in their minds," making interchange of experience all the more interactive.

The PER method has been developed to be applied to any past, present and future incident or malfunction[4]. Five separate but complementary steps make up the PER method:

- Step 1: Perception. The maximum amount of data dealing with the incident is collected from available sources to constitute a comprehensive database on the incident. The data sources are: observation of the work environment, written reports, interviews, departmental meetings, informal conversations, etc. This step is the most time- and energy-consuming due to the length of investigation and the variety of dispersed accounts.
- Step 2: Analysis. The data is vetted and a questionnaire is compiled, which provides questions covering a *string of key events*[5] in the systems breakdown. The questionnaire (series of key events) is presented to two categories of actors: those who were directly involved and those who were not present when the incident unfolded. The incidents are dissected in order to identify key events that led to their occurrence. Once each key event is identified, it is detailed into the 4 phases of what we call a "particle of experience": a situation, a decision, an action, and its effect.
- Step 3: Validation. After having been interviewed individually, the actors receive the results of their interview (a set of particles of experience) and approve or modify them. Lastly, a collective meeting of all the actors of the system is convened in which the final results are discussed and, if necessary, modified. This is the "mirror effect" stage, practiced at individual and collective levels.
- Step 4: Modeling and support to the sharing of experience. Three graphic support methods are used: the String of Key Events Graph used mainly in step 3, the Fault Tree and the Cindynics HyperSpace, used in step 5.
- Step 5: Proposal of measures. Practical measures are proposed for the three sub-systems: Human/Organizational/Technological, based on the experience of actors.

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2 in French: "Déraillement d'une ballastière lors du renouvellement des voies ballastées".

3 in French: "Dysfonctionnement des sectionneurs d'isolement télécommandes".

4 Past: referring to the use of past written or oral records; Present: incidents which have just taken place; Future: study of procedures.

5 From the French expression "Fil Conducteur".

3. Formalization of experience

The first method that can be used is to store incidents or accidents as elementary items. This is the approach chosen in most databases of accidents, because it is appropriate for statistical use and for epidemiology of accidents. An analysis of accidents and incidents in different databases shows that each type of accident corresponds to a series of events that differ by the context, the development, or the consequences. A study of mental representation of actors in the development of risk management activities [Therrien 98] has permitted the identification of a generic structure for the development of the incident or accident, based on key events. A more detailed analysis shows that each of these meaningful events is associated with a *decision cycle*: identification of context and event, situation analysis, and actions. These key events are more frequent than incidents, as each incident or accident is very often the succession of such key events.

These events constitute, with the associated decision cycles, the basis of experience of actors that they use for the management of new incidents. Analogy is the main reasoning process used with experience: if the actor has already experienced the same event in a similar context, he uses the memory of his analysis and actions, weighted by the corresponding effects (decrease or increase of danger) to take a decision in the current situation.

Our objective is to develop a methodology to collect experience and to promote its sharing amongst actors. We therefore use a key event, the associated decision cycle, and the evaluation of effects to propose the concept of a *particle of experience*. It represents the smallest element of experience that still holds onto its properties, still rendering information without distortion and hence preserving most of the complexity of the situation.

A particle of experience is composed of four main aspects:

- Situation: what was happening at that particular moment in time (event & context),
- Decision: after analyzing the situation, what decisions concerning actions are taken,
- Action: what is the action taken,
- Effect: what is the effect of the action taken until the next key event.

This structure is an adaptation of the model proposed by H.A. Simon [Simon 96] for the representation of the decision process.

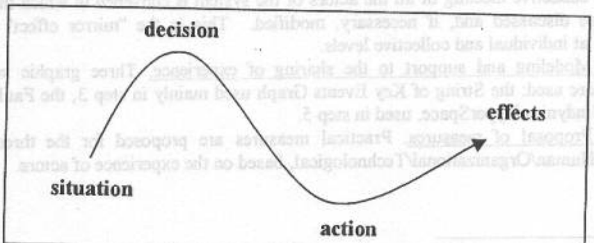

Fig. 2: Particle of Experience: key event and decision cycle

From this generic model, we have defined the set of data corresponding to the two types of incidents that we have studied. Once all the relevant information has been identified, a questionnaire is drawn up. The questionnaire serves to identify the key events in the unraveling of the incident. Each key event (particle of experience) is presented on one page, to serve as a basis of discussion.

The questionnaires are completely anonymous, having no mention of the names or functions of the actors that participate. The aim is to eliminate the fear of being reprimanded and to thus create a free and open dialogue. As we will see later, this proved to be effective. The objective of this questionnaire is to make it possible to communicate on common ground with the actors of the system and to collect particles of experience.

The collection of particles of experience is achieved in three steps:

- One of the actors initiates the process by telling the story of the incident development, using the questionnaire. This story is formalized as a set of particles of experience.
- Each of the other actors is interviewed on the basis of the current set of particles of experience (one at a time), to collect his individual experience: Did he experienced a similar key event? Does he have proposals to manage differently the same key event? This step represents an opportunity to collect positive experience from actors.
- When all actors have been interviewed, the full set of particles of experience that has been assembled constitutes the collective experience.

In order to facilitate the collection of particles of experience and the validation along the capitalization process, a graphical representation has been designed: the *string of key events* (SKE).

This SKE graph (fig. 3) is used after individual interviews and, later, during collective interviews in order to confirm as closely as possible the accuracy and hence the reliability of the data. The string of key events is designed to guide the actors in their line of reasoning, in order for their answers to be complete and structured.

To collect the positive experience reflection, the actors are asked to go through each key event and asked what they would have done in a similar situation. Two kinds of possibilities were identified:

- Possible positive action: action that could have been applied in order to avoid/stop the system breakdown. Had it been applied, this action may have made it possible to avoid the occurrence of the incident altogether. This is a possible action that the actors would want to encourage;
- Possible negative action: this relates to feasible action that could have been applied, but that would have led to another incident or that may have even aggravated the deterioration of the system. This is a possible action that actors would want to avoid.

Emphasis is placed not only on what actually happened, but also, and more importantly, on what could have happened. Each of the actors interviewed is able to provide his or her know-how freely and share this experience with other participants.

4. Validation

After each interview, the actors receive a copy of the questionnaire results in the form of a SKE Graph that traces:

- The exact events that took place during the period in which the system malfunctioned in the form of real particles of experience (i.e. tracing what really happened).
- The possible positive and negative events that could have occurred in a similar situation in the form of hypothetical particles of experience.

We call this step "mirror effect meeting." It was applied to each actor on a one-to-one basis (after his or her individual interview) and in a group meeting that was held after all the actors had partaken in the individual interviews.

This collective validation step allows for the coming together of actors in the same department, actors belonging to different departments, and those with different functions and responsibilities, who would not normally meet or be seen together. It allows for communication between the actors, elicitation of tacit knowledge, and sharing of positive experience, because each actor is encouraged to submit and review possible actions and solutions.

Individual and collective learning thus takes place and the actors acquire an increased sense of team spirit. This was confirmed by a number of actors after the collective "mirror effect meeting": the actors felt motivated by this participative process and expressed the feeling that they had at long last been able to communicate their feelings, to interchange ideas, be heard, and even to learn from the experience of others.

5. Modeling and Support to the Sharing of Experience

The efficiency of the PER method is supported by three graphic representations: SKE graph (String of Key Events), Fault Tree graph, and Cindynics hyperSpace. The benefits of graphic representations should in no way be underestimated. Indeed, they proved to be an invaluable comprehension aid, allowing the actors to better visualize the different aspects of the incidents.

The String of Key Events Graph (fig. 3) is a visual support, tracing the actual and possible key events that played a part in the evolution of the system malfunction. Real and possible key events were identified thanks to the individual and collective experiences of the actors. In this way, the PER method was able to draw from experience and know-how in order to identify real and what could-be key events:

- From the start (system deterioration);
- During the actual incident (system breakdown);
- Through to the end (normalization of the situation: system is back in its "normal" state).

The central line represents the development of the incident as the succession of key events and decision cycles that really occur. On the left side are represented the decision cycles that make the situation easier (decrease the danger or stop the incident); on the right side, those cycles that aggravate the situation (increase danger or create a new incident) are given.

The Fault Tree Method (fig. 4) was incorporated in the PER method for various reasons: Firstly, because it is one of the most commonly used methods in the field of safety analysis. Secondly, and contrary to the SKE Graph that traces the unraveling in time of an incident, the Fault Tree Method represents, at a given moment in time, all the possible combinations of events that could lead to the system breaking down. It includes also *safety barriers* (devices, procedures or human actions aiming at reducing/stopping the propagation of the incident). The fault tree is created during the design of the system. At each occurrence of an incident or accident that was not identified, it must be updated to take into account the causes and determine the appropriate safety barriers. The PER method has proved to be efficient in supporting this update.

The Cindynics HyperSpace Method (Fig. 5) helps to grasp the level of danger inherent to the malfunctioning system at any given time: before, during, and after the incident. This qualitative method can be seen as a framework to assess the global level of danger, which is represented by means of five *Cindynics dimensions*:

- Statistical dimension: information on the system[6], past incidents, databases,
- Epistemic dimension: models, representations of the system,
- Objectives dimension: the direct finalities and objectives of the system,
- Rules dimension: organizational rules and procedures governing the system,
- Values dimension: the fundamental values of the system.

Before and after each particle of experience, each dimension of the HyperSpace is analyzed and elements affecting the danger of the situation are highlighted along the corresponding axis. Through this approach, it is possible to visualize the variations in the level of danger during this cycle.

6. Conclusions

In this application to rail incidents and accidents, the PER method has demonstrated a significant potential to improve the efficiency of incident and accident management by eliciting tacit knowledge. It allows for:

- Crisis Management. The actor draws on past experiences and is thus better equipped to deal with incidents, should these arise.
- Prevention. The sharing of experiences allows for the compilation of security barriers, better adapted measures to be applied in order to reduce the likelihood of occurrence and the gravity of the incidents.
- Establishing of a collective memory. The PER method promotes the capitalization and the perpetuating of the experience and know-how of the actors in a system.
- Strengthening communication channels between actors. Cooperation of actors in the same department as well as different departments is reinforced if not completely established.

It is a straightforward and structured method, applicable to any type of incident of the past, present and future. Despite the benefits of the PER method, there were obstacles that arose, namely:

- Difficulty in ensuring the participation of all the actors in the PER method. The usual ER process is viewed mainly as an inquisition, in that senior management often associates the experience reflection process to inspection, reprimands, and sanctions.
- Different levels of involvement on the part of certain departments. Some departments

[6] By System, we mean human, technical, and organizational aspects.

especially those not directly involved in high-risk activities, felt less concerned with safety and security measures, and gave little importance to their participation in the PER method. Indeed, there is still much to be accomplished in the field of risk awareness.

There are plans in place for the PER method to be applied to several problems of risk management in industrial companies, within the framework of a research and development group involving both academic and industrial partners.

7. References

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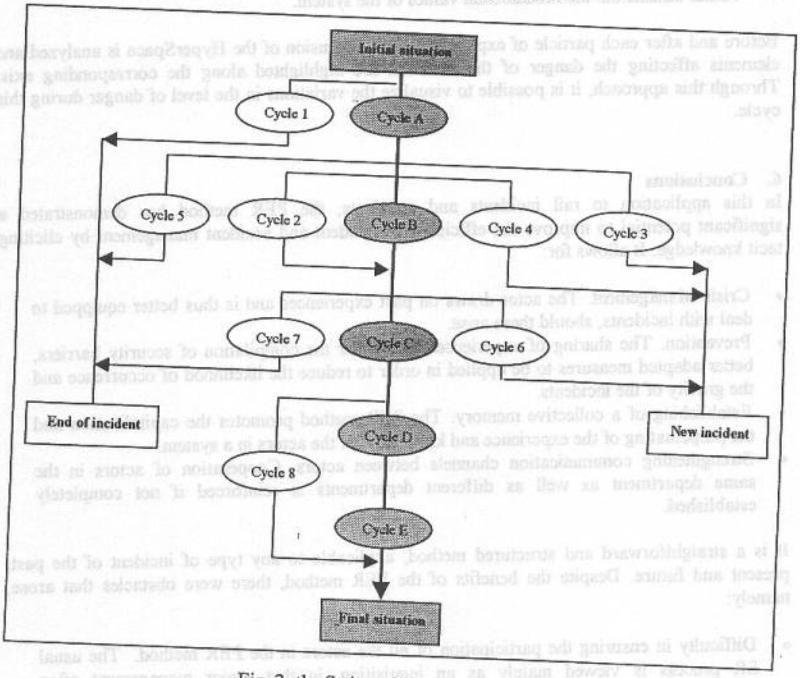

Fig. 3: the String of Key Events Graph

Real Cycles

Cycle A: Definition and cutting electrical current of sectors where works will take place,
Cycle B: Power restored to sectors that underwent works,
Cycle C: Incident on line due to the non-uniformity of electrical current,
Cycle D: First measures applied following electrical current incident,
Cycle E: Technical solution found for the electrical current incident.

Hypothetical Cycles

Positive

Cycle 1: Maintenance of infrastructures outside working hours,
Cycle 2: Power supply switched off individually for all the electrical devices in the sector where the works will take place,
Cycle 5: Electrical device testing included in the works planning schedule,
Cycle 7: Increase of responsibility actor awareness,
Cycle 8: Information Supplied to passengers.

Negative

Cycle 3: Power on, and works done on the electrical devices in the work site,
Cycle 4: Lack of respect for safety regulations before works on site,
Cycle 6: Lack of respect for rules and regulations that should be observed in a work site.

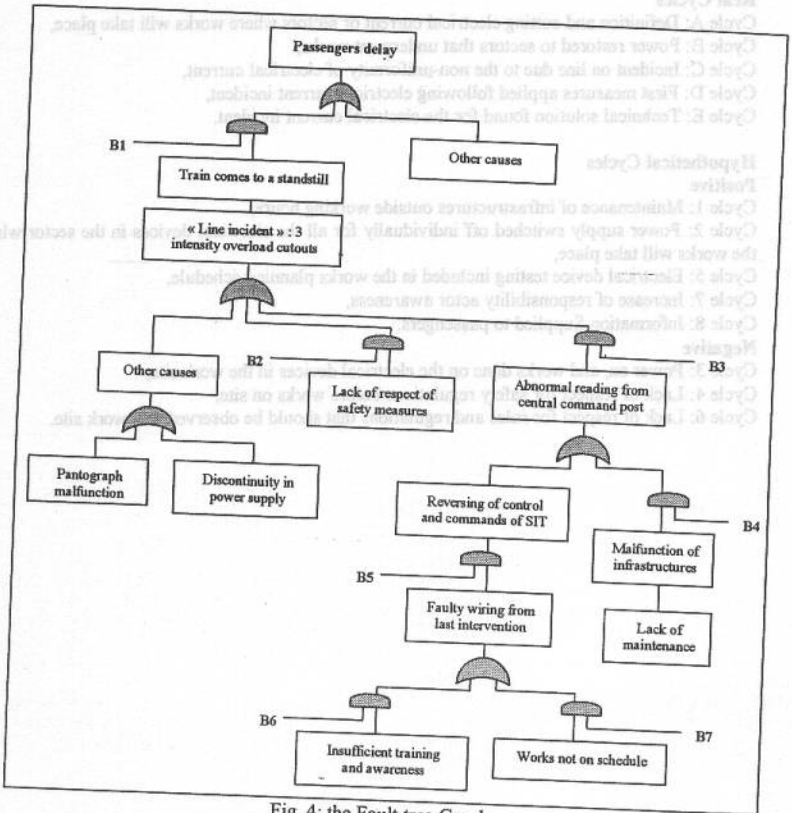

Fig. 4: the Fault tree Graph

Safety Barriers

B1: Passengers notified via loudspeakers and visual announcements
B2: Awareness of latent risks
B3: ESE department notified of malfunction; emergency plan activated
B4: Drawing up of control measures following works
B5: Annual electrical tests outside working hours
B6: Awareness of actors promoted about the consequences of unsatisfactory work
B7: Begin works on time and if not possible, do less during the night

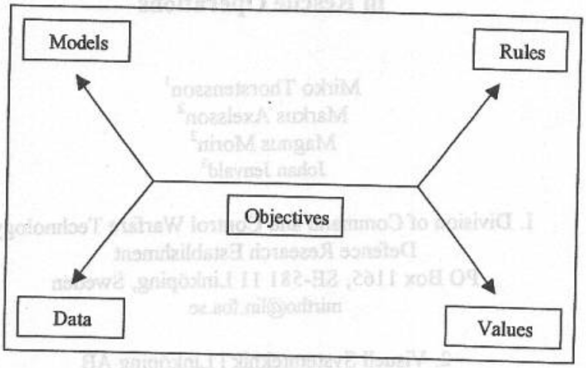

Figure 5: the Cindynics HyperSpace graph

Dimension of danger	Start of the incident (after Cycle A)	End of the incident (after Cycle C)
Data	Experience of actors in this type of incident	Experience of other electrical current incidents
Models	Methods applied during works and maintenance	Methods applied towards the end of working hours
Objectives	Carry out working orders 525 and 527	Handing over of fixed infrastructures in good working order and on time
Rules	Night works planning schedule and safety regulations	Measures to be implemented after electrical current incidents
Values	Stick to the works planning schedule	Observe safety regulations