THE AEX METHOD AND ITS INSTRUMENTATION

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Abstract: We aim at elaborating a decision support system to manage concrete experience, using Artificial Intelligence methods, such as Case-Based Reasoning. We target any organization that wishes to capture and exploit its employees' experience. This paper focuses on a key point: the method to obtain the system memory. We present AEX, an experience feedback method that we developed and instrumented for risk managers to help them share their experience and to support their critical tasks (e.g., intervention). The elaboration of AEX was based on the analysis and modeling of the risk managers' real activity (esp., their decision-making and knowledge management processes). The instrumentation of AEX resulted in a computer tool based on a corporate memory. The paper reviews the AEX method, and illustrates and discusses its use through a scenario related to Forest Fire Fighting Management. The paper also describes how the method was instrumented, focusing on the feasibility of the instrumentation. Perspectives on the future of the method and of its instrumentation are presented.

1 INTRODUCTION

This paper proposes an experience feedback method centered on a corporate memory, regarded as an active organizational memory (Sorli,1999) which favors organizational learning for individuals and groups as in (VanHeijst,1996). We present this method, named AEX, and its instrumentation to facilitate risk management. AEX aims at capturing and re-using the experience from a specific risk management activity of an organization to learn lessons and to improve this activity (Lagadec,1997), (Greenlee,1998). Our method focuses on the *intervention part* in risk management like in (Xanthopoulos,1994), (Avesani,1993) but by reusing the experience itself which is regarded as a new way to assist emergency management (Huet,1999). During intervention, people (called *managers* in the following) have to decide about the actions to undertake. Our approach formalizes the related experience and capitalizes it in a corporate memory. Contrary to other knowledge management approaches, we do not store transformed experience (*e.g.*, in the form of statistics) but the experience "as is" because experience, when transformed may lose part of its meaningfulness and usefulness. Moreover, we capitalize the experience not only during the post-operational phase but also during the operational phase which is seldom exploited as a source of knowledge to be capitalized. The method goals are:

− Help managers collect their own experience (in the corporate memory).
− Provide them with an access to other managers' past experiences and help them select the useful ones for the current situation.

The first section shows the dynamics of a real intervention on an example; the second one outlines the general method and illustrates it with the example. We then discuss the method and its

application. Finally, we detail the computer instrumentation of the method and discuss some perspectives.

2 FOREST FIRE FIGHTING MANAGEMENT: A SCENARIO

We have put our approach into practice within the Andalusian organization of Forest Fire Fighting Management (FFFM).

A fire is too complex to be manageable as a whole. That is why, according to managers' behavior, we have decomposed the fire evolution chronologically into different key management steps, called *situations*. Thus, FFFM is described by a temporal sequence of situations. Each situation represents the state of fire fighting at any moment. During and after the intervention we identify the relevant information that may be reused and we provide managers with a set of forms to capture it. In the Andalusian organization, the managers have already been used to fill out forms during and after a fire: that is why we decided to continue with the same media.

This section shows on a realistic example how managers may use the methodology and tools we promote.

The example fire starts in a place named Otivar at 1h50 p.m., in a pine forest, on three main fronts. When the fire manager arrives, 15 ha have already been burned and the available resources are four land staffs and two helicopters.

To complement the temporal decomposition of FFFM into situations, fire managers spatially decompose a situation into *sectors*. A sector is a geographic zone with given vegetation, topography or infrastructures which necessitate a specific fighting sub-plan. Thus, there are two levels of description of FFFM corresponding to the fighting situations (global level) and their sectors (local level).

To each sector managers assign resources, operations to perform and a local goal to achieve, depending on the global situation, the danger, and their past experience. A sector sub-plan is defined by a set of operations (*e.g.,* "lower the flame height") and resources (*e.g.,* an helicopter) to achieve a fighting goal, local to a sector (*e.g.,* "allow the land staff to fight"). The manager describes the initial situation in a form indicating the global context of the fire (location, time, meteorology, etc.) as well as the current fighting plan, decomposed into sectors. This knowledge should be stored for future sharing. In order to match the two kinds of decomposition,

one situation form is split into sub-forms, one for each sector.

A "disruptive event" (e.g., an accident of a fighting resource) necessitates to revise some current fighting (sub) plan leading to a new fighting situation. These events determine the temporal sequencing of situations. In the example, boulders have suddenly been thrown over the fire front. This produced fire spots north-east and west of the burned area, as shown in Figure 1.

This makes the fighting sub-plan of the eastern sector no longer valid, so it must be revised. Since the western part of the burned area is not easily accessible, this sector sub-plan cannot be immediately revised. The manager fills out a new form for the new situation. In addition to the previous information it records the plan modifications that have been applied and their effects, which represent both a solution to the problem of revising the plan and an assessment about this solution. In the example, the fire manager has redistributed the land resources in the eastern sector and ordered four new fighting operations (on the fire spot and on the eastern sector front). The new situation is reported in the form in Figure 2. The new plan is described in the *Elaboration of fighting plan* part.
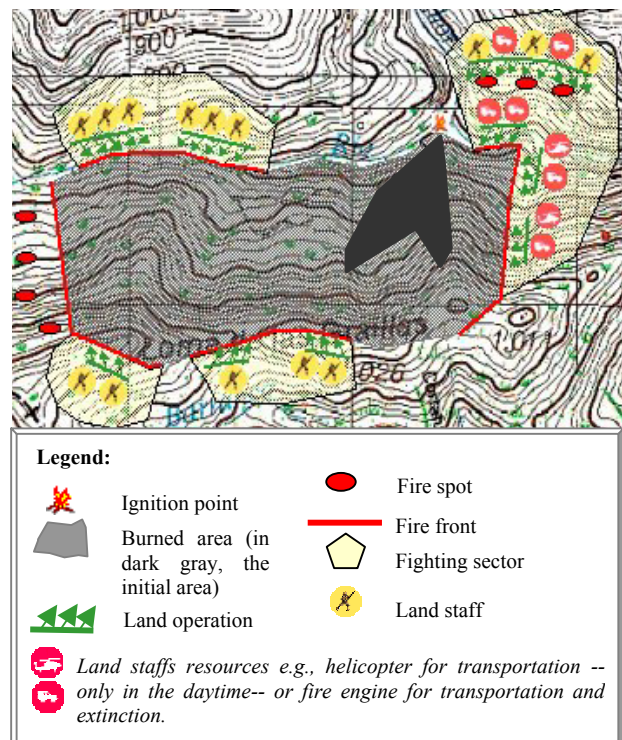

Figure 1: 4th situation of FFFM for the fire of Otivar

The fire eventually comes to an end after four days and 19 successive situations. The solution adopted to extinguish the fire is therefore described in the corresponding successive forms, split into sector sub-plans.

After the fire, the manager fills out other types of form to capture post-operational information on improvements or alternate solutions that would have been possible.

AEX 2 FORM	SITUATION REPORT	
SITUATION, N°: 4	DATE : 17 / 08 / 99	TIME : 5 h (a.m)
IDENTIFICATION OF FIRE		

DATE OF IGNITION: 16 / 08 / 99 HOUR OF IGNITION: 13 h 50	PROVINCE : Granada	LOCAL TERMINAL : OTIVAR

NEW SITUATION

CIRCUMSTANCES THAT INVOLVE A NEW FIGHTING PLAN :

☐ CHANGE OF METEO (WHICH):

☐ ENTRY OF RESOURCES (WHICH) :

…

☐ REACTIVATION (WHERE):

☑ OTHERS (DESCRIPTION AND WHERE): starting of fire spots (eastern and western sectors)

…

ELABORATION OF FIGHTING PLAN

DURATION ESTIMATED OF THIS PLAN : 2 hours

N°	TYPE INDIRECT OU DIRECT	DESCRIPTION OF THE OPERATION AND THE MODE OF ACTION	RESOURCES USED	OBJECTIVE/S	POSITION (SECTOR, FRONT OR SIDE …)
1	direct	attack with water …	2 land staffs with fire engines	- Drive down the flames	- Eastern Sector, fire spots
2	direct	attack with bombs …	3 land staffs	- Ward off the fire spots	- Eastern Sector, fire spots
3	direct	attack with water …	4 land staffs with fire engines	- Drive down the flames and ward off the front	- Eastern Sector, front

…

OBSERVATIONS

The western sector is not accessible with the land resources.

Figure 2: Excerpts from an AEX2 form corresponding to the situation described in Figure 1

3 COLLECTING EXPERIENCE

We elaborated the AEX method as a variant of the debriefing and the REX (Malvache,1993) methods to help managers collect and reuse their experience. AEX proposes a general procedure which enables an organization to develop tools supporting the method.

In our example, the tool consists first, of a set of predefined and free forms (see section 3.3.1) for collecting experience and a guide to fill these forms, and second, of a software tool for reusing the collected experience (see section 4.1).

We now discuss the design and the main lines of the AEX method, how it has been initially used in Andalusia and factors that influenced its use.

3.1 AEX Design Framework

AEX design first took into account significant lessons learned from the use of previous experience-collection methods. For such a method to be actually used, it has to be understood and accepted by its intended users. Several technical, cognitive or social organizational factors have been identified that may lead users either to adopt the method or to leave it. Inhibiting factors (Ermine,2000) are, for example:

- *Lack and loss of motivation:* users do not understand why it is interesting to collect experience or they lose motivation.
- *Lack of a common language* to talk about experience.
- *Lack of consensus* about experience to be collected.
- *Lack of explanations or instruction* about, *e.g.*, the links between the collected experience and the resulting actions.
- *Fear of sanctions or self-questioning:* if experience collection is not anonymous, users may refuse collecting negative experience because they are afraid of penalty.

In our method we tried to prevent these inhibiting factors as much as possible.

AEX also follows a human-centered approach (Winograd,1997), (Ehn,1988) which relies on a deep analysis of how people work (individually, in groups, and in organizations) and of the actual demands of their domain. In designing AEX, we focussed on the actual activities of the users and of the organization, their real experience-collection needs, and their actual practice of experience collection. Our design approach was moreover participatory, *i.e.* representatives of fire managers were involved in the design process, as *co-developers of* the AEX method (with the knowledge engineer).

Though developed in the context of FFFM, AEX is a generic method that can be applied to various risk management contexts.

3.2 General Procedure

The general procedure we followed considers past experience as the major knowledge useful to improve an activity. The goal is to exploit experience for training purposes, as well as during risk management. Therefore, the first necessary step is experience collection. The usual procedures for learning from experience generally collect experience *after* the activity. Furthermore, they consider the collected experience as a whole and they derive *global* organizational actions from it. As a consequence, the connections between collected knowledge and resulting actions are not clear to the actors. In contrast to these procedures, we collect experience not only after the activity but also during it and we do not transform the collected experience.

The main points of our general procedure are detailed hereafter.

3.2.1 Two Types of Collection

In order to preserve the activity complexity (*e.g.,* FFFM) and to represent this activity as clearly as possible, the experience collection is divided into:
− **Collection during operational phase**: initial capitalization to capture the experience about decisions made during the revision of a plan (during intervention).
− **Collection during post-operational phase**: final capitalization to capture the experience that allows understanding the decisions.

3.2.2 Identification of Relevant Information

It is necessary to study the data warehouse in order to extract the relevant information and to identify the data flow among the different actors. This results in determining which information is relevant to the initial capitalization or to the final one. In addition, the actors who hold the information are identified.

3.2.3 Participation of Users in Tool Elaboration

Interactivity with users in an iterative process is a key point for the design of an appropriate tool, especially when experience is concerned. Our method recommends to consider the vocabulary, the opinions and the requirements of users from the very beginning of the design. It proves very constructive to define a common language using users' usual terminology. Thus, the new common language is very intuitive and easily accepted.

3.2.4 Elaboration Method and Tool Follow-Up

The elaboration method decomposes into three steps:
1. Understand the activity and propose a draft version of the tool,
2. Validate this draft version (by users) to obtain a working version,
3. Test the working version on real cases.

The draft version of the tool includes general requirements and usual terminology of users; it should reasonably represent the activity. It is a support to allow users to evaluate the tool.

The working version includes specific requirements and corresponds to all user tasks. This version provides a sound representation of the activity. This step also identifies the role and the task of each user with respect to the tool, *i.e.* who should do what? and where? in the capitalization process. The tool is ready to be used.

Finally, it is essential to make a last revision of the tool and to experiment it on real cases, to produce the final version.

The follow-up of the tool is necessary to a successful experience capitalization as a support activity to help and guide users during their first utilization of the tool.

3.3 FFFM Illustration of the Procedure

We have applied the general procedure to FFFM. The management tool was first realized by means of paper forms to initiate the experience collection. The form elaboration followed the three above-mentioned steps, during several sessions of meetings: 20 days of interviews and observations (first step). For some provinces, we have organized one session of 3 days for the second step and another one of 2 days for the third step.

The first step consists in understanding the activity of FFFM, how is it structured, how are the different tasks organized and what are the relations among the actors in this activity. To this end, the techniques used were: a) analysis of theoretical documents and existing organizational reports, b) interviews of managers from different centers of the organization (regional, provincial, sub-provincial levels and specific centers) and c) observations of different actors in real interventions. The first technique (a) is a means to acquire formal knowledge and thus to prepare interviews and observations (b & c). This is necessary to understand enough of the phenomenon to get relevant information. The interviews (b) made explicit the

tacit knowledge and the experience of actors. They result in the definition of the tasks and role of each actor involved in fighting management, and a list of fighting resources, as well as the identification of their potential of action. This leads to define the corpus of FFFM (operations and objectives). The observations (c) showed the coordination needs between actors and the different relations.

After studying the existing forms in Andalusian centers, it turns out that they do not represent the dynamics of fighting (*i.e.* distribution of fighting resources during a situation, operations carried out, objectives of resources, etc.) which is a key element of intervention. We therefore decided to set up new forms to represent missing information.

The result of the first step was a draft version of a new set of seven forms, which are our experience-capitalization tool for FFFM. These forms are complementary: each one contains specific information (even if duplication exists to obtain independent forms). The new set does not replace the existing one and is used differently. The work of filling out forms is dispatched among different persons from the organization. We identified the persons who hold the information suitable for the new forms. In addition, a guide to explain how to fill them out has been designed in collaboration with fire managers to ensure an appropriate style. The guide aims are:

− Answer questions of users (generally, those who did not participate in the form elaboration, e.g.: "which fires do we have to fill forms about?" or "how many forms must be filled out?"
− Clarify the mandatory nature of some forms (e.g., the AEX3 one must be filled out).

The second step was to fix the working version of the tool. Fire managers critically studied the forms in the light of their past experience and proposed improvements, like modifications of knowledge representation or of presentation. Thus, the draft version has been revised and the guide adapted accordingly. The working version has then been declared ready for use.

Finally, the third step was to test the working version on real cases, where the fire managers had to fill out the forms under real conditions. This leads to modifications, mainly on the operational aspect of the forms and their efficiency to capture the fighting dynamics. Furthermore, to detail a particular point that is worth noting, we introduced "free forms" on new sheets. It is an essential point of flexibility of the method. The final version of forms was over.

3.3.1 Results for FFFM Example

The new forms (see Figure 3) fall into two types, corresponding to two types of knowledge

acquisition. The first type is filled out during the FFFM and captures facts and experience about the fire and the fighting development that are relevant for re-planning purposes. This is the initial capitalization of the concrete experience "as is". The second type forms are filled out after the FFFM and allow managers to develop a critical point of view based on their experience, *i.e.* to justify their decisions or to propose alternatives. These forms provide understanding of the FFFM that has been made, they contain a valorization of the concrete experience, corresponding to the final capitalization. There exists one set of forms for each fire (one AEX1, as many AEX2 as situations, one AEX3, etc.). Some forms are not compulsory: for instance no AEX6 form is needed if no incident occurred. Additional documents of any kind (photographs, tapes, etc.) may be attached to the forms, as well as "free forms" for unforeseen records. Any person of the organization can fill out a free form.

The paper forms are intended to evolve towards a computer version, as described in the last section.

Name of the form: its title	Time of filling	Person who fills the form
AEX 1: Detection report	During the FFFM to capitalize experience in operational phase	Fire managers from provincial & sub-provincial centers
AEX 2: Situation report		Extinguishing technicians
AEX 3: First attack report	After the FFFM to capitalize experience in post-operational phase	Managers from provincial & sub-provincial centers & technicians
AEX 4: Report on an operation realized		Managers from provincial centers & technicians
AEX 5: Report on the distribution of fighting resources used		Managers from provincial centers & technicians
AEX 6: Report on an incident that occurred during the fighting		Fire managers from regional, provincial & sub-provincial centers, technicians
AEX 7: Report on an accident or a problem of resource that occurred		Fire managers from the sub-provincial centers

Figure 3: The set of new forms.

3.3.2 Tool Follow-up

The follow-up of the first capitalization for FFFM has been realized through meetings. Four meetings

have been organized in different centers of four provinces. Each one took two days and was divided into three parts:

− Explain the approach and the goal of AEX, to convince the persons who will fill out the forms of the interest of the approach;
− Provide support to fill out the forms on an example: explain different ways to fill out forms in order to extend their expression capacities and to ensure information usability (for instance by indicating the degree of precision of information, *i.e.* if it is the result of an estimation or a measure);
− Chair a discussion about already filled forms to improve their contents, in order to ensure a sufficient level of capitalized experience for reuse.

3.4 Discussion about the Uses of the AEX Method

An analysis of the uses of AEX confirmed the influence of the factors presented in section 3.1 on users' understanding and acceptance of a knowledge management method and revealed the influence of some other ones, like compliance to conventions (Norman,1999). These factors reflect the variety of the users (individuals and groups) and of the contexts of use of the method. Experience collection is distributed among several individuals and several groups; it is performed at different moments (during operational or post-operational phase), in different group configurations, etc.

We now discuss some of the individual and collective factors that we identified.

3.4.1 Common Language and Community Language

To rapidly get users adhesion, it is important not only to set up a *common language* among users, but also to start from the language used in the community (*community language*).

When users take part in the development of the method, it facilitates the agreement on the language. In our case, the guide was elaborated with the participation of fire managers and students to ensure an expression adapted to managers' practice.

The community of language of fire managers is based not only on words, but also on graphics (drawings, maps, symbols, tables, etc.). Our method promotes the use of graphic modes. Here again, we gave priority to community language, such as the usual symbols of the Andalusian fire fighting community (*e.g.,* symbols representing fighting resources).

3.4.2 Agreements and Negotiations

"Knowledge consensus" (Ermine,1999), *i.e.,* agreeing on the *kind of experience (to be) collected*, is an important factor of method use. To assess that the filling of forms concerning a fire was consensual, we compared two experience-collections performed by users at the same level of expertise. It was also necessary to explain the choices of the method and the procedure to follow to users who did not participate to the design of the method. Moreover, users should be allowed to suggest modifications in the method. For example, we adapted forms AEX1 and AEX2 so that fire managers from specific centers may give an account of their intervention.

Coming to an agreement doesn't necessarily mean to adopt one solution instead of alternatives, or a trade-off between alternatives. For example, managers used a color code to represent fighting resources that may appear inconsistent. The reason is that it refers to different categorizations of the resources: *e.g.,* land-resources *vs.* air-resources, own resources *vs.* shared resources, etc. Each categorization is relevant but depends on users' viewpoint.

3.4.3 Expressive and Flexible Representation Modes

The modes of representation of experience (text, photographs, drawings, etc.) must be carefully selected and agreed on.

A representation mode must be *expressive*: it must allow users to express as fully as possible what they want to express. In our case, a photograph allowed a user to infer the existence of a cliff close to the fire. This inference has been decisive for the choice of an action that would not have been possible using a textual representation.

A representation mode must also be *flexible*. Over-constrained modes are rejected by users. For example, we get rid of in the grid pattern provided in the old forms for drawing a sketch of the fire situation. Users can now draw freely and can also use a blank page when the pre-formatted forms do not suffice.

3.4.4 Roles and Task Distribution

Within an organizational context, we must take care of the distribution of roles between the different users of the method, *e.g.,* collecting roles (authors) and reusing roles (readers). Who will undertake the experience collection? Who will reuse the experience? Which are the relations between the various roles and the persons who hold these roles?

It is important to involve all people who have the experience needed by the organization. We took this factor into account by defining a network of collection and transmission of experience. This didn't change anything at the organizational level nor at the operational level, but only at the functional level.

3.4.5 Workload and Time Pressure

What differentiates AEX from other experience feedback methods is that it allows experience capture not only during the post-operational phase, but also during the operational phase. Some factors are more sensitive during this latter phase, e.g., workload or time pressure. For instance, by prompting users to capture experience in terms of fighting *situations* rather than in terms of fighting *resources* (as they previously did), the method contributes to decrease their workload.

Finally, for users to accept using a method, it is important to provide them with an operational tool or, in other words, to instrument the method. The first "paper and pencil" instrumentation described in the present section only concerned experience collection. It has been complemented with a computer instrumentation which integrates both experience collection and reuse.

4 COMPUTER INSTRUMENTATION

We aim at elaborating a decision support system to manage concrete experience. The computer tool (sketched in Figure 4.) that instruments the AEX method is organized around a structured corporate memory of experience *units* (decomposed into descriptions of problem, solution and results). To directly manage experience of past management without revision, we plan to use another type of memory units, in the form of contextual recommendations.

The communication among different centers of FFFM is realized by means of an Intranet but a central memory exists at regional level and local memories at provincial level: this provides flexibility but requires a good synchronization. The manager in charge of the collect during the operational phase is mobile thanks to a fire engine dedicated to the fight organization. This vehicle allows radio communication with the center at sub-provincial level and also with the fighting resources (land and air staffs).

The tool both facilitates the managers' work for collecting experience and the automatic exploitation
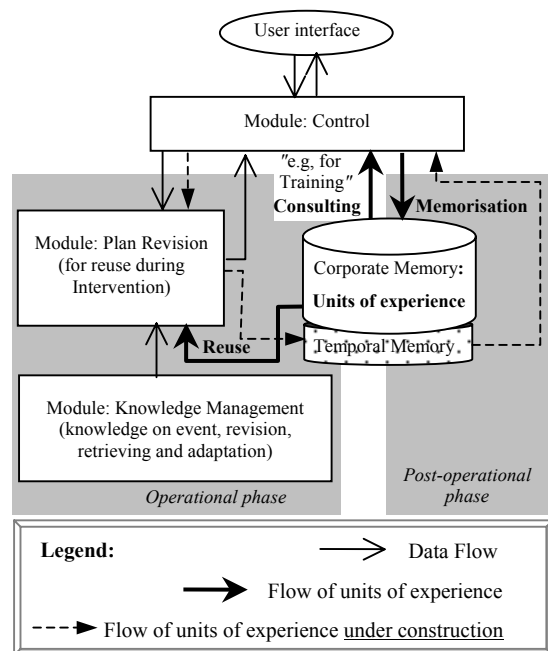

Figure 4: Simplified Architecture of the Computer Tool

(reuse) of the collected experience, as an aid during a fire or for training purposes.

4.1 Experience Collection

During *the operational phase*, the tool collects the necessary information to represent the emergency situation and stores it in the corporate memory. In the case of FFFM, from the organization point of view, computer forms constitute a good support for memorizing the management steps and provide long term storage to record the "history" of past interventions. From the managers' point of view the software facilitates and speeds up information collection:

– Computer forms avoid redundancy during experience collection: any information that should be repeated in the paper forms (because each form must be complete and consistent) is typed only once (e.g., information about the current situation is automatically repeated in every sector description form).

– The collection and the visualization of the units are realized by means of a Geographic Information System (GIS) and other graphic tools are available. It is hence easier for managers to draw surfaces, etc. Graphics are afterwards easy to understand by other managers and they convey a lot of information.

– The software provides a graphical users interface (Figure1 shows an example of screen), with predefined icons for operations and resources

(trucks, patrols,…) which can be dragged where necessary to describe a situation. Attached to icons are the corresponding possible operations, so the manager has only to click on a menu to choose one (instead of typing its name).

For these reasons the computer forms are quicker to fill, which is an advantage during crisis when time is limited.

During *the post-operational phase*, the collection tool is used to complement the information already stored.

The organization can then incrementally build a corporate memory containing past experience. Moreover, this memory is easy to scan for reporting and to compute for various kinds of statistics, which are often required by the general managers of the organization.

4.2 Reuse for Intervention and Training

The memory may afterward constitute a source of reference cases for both real-time help during intervention and training sessions. The system can easily recall previous experience corresponding to the current emergency situation and adapt past solutions to suggest solutions during intervention or display pedagogically interesting cases for analysis during training. To this end we rely on Case-Based Reasoning techniques to retrieve relevant past units and to adapt them to produce potential solutions (Delaitre,2000).

4.3 Generality and Evolutions

The specific formats of forms for FFFM have been decided in accordance with the application needs. But this is only one application of a general framework that can be customized to support another domain. Following the general procedure, this could be done without changing the underlying methodology nor the software that computes the information for reporting, training, etc.

Evolutions of the implementation, even in the same domain, are also straightforward. If *e.g.,* the FFFM terminology evolves or if new items are to be introduced in the forms the formats may be adjusted without great effort. This favors flexible representation modes.

4.4 Connection with Collecting Method

The structure of the computer objects mirrors the elements of experience that have been identified as important for the domain. This should be decided by interacting with users, as soon as in the prototype phase. In our case it is the result of the common language defined in accordance with our users, as described in section 3.4.1. As a consequence, both storing and retrieving of experience is easier for managers because the structures and formats are adapted to their practice.

The expected help from our system is well balanced compared to the required effort. The software system demands to fill out forms, but less than the paper version and in return it provides managers with quick retrieving procedure and readable displays of relevant information when necessary.

5 CONCLUSION AND PERSPECTIVES

We have presented a method for collecting and reusing risk management experience. What differentiates our method from most existing experience feedback methods is that:
- It allows experience collection and reuse not only during the post-operational phase, but also during the operational phase;
- It is computationally instrumented;
- Its design greatly benefits from close interactions with users and their organization.

The method focuses on *experience* and includes the collection of knowledge *practices* of individuals and groups.

The feasibility of our approach and of its computer instrumentation has been demonstrated (Delaitre,2000); the tool relies on case-based reasoning to reuse the corporate memory. An experimental interface using a GIS has also been tested.

Our approach first contributes to experience feedback research. The chosen architecture makes it possible to study a significant range of events, which is necessary to carry out a process of effective experience feedback in risk management (Amalberti,1999). Moreover, it relies on a wide range of knowledge (positive and negative knowledge, alternatives) to propose solutions during reuse. Concerning the cindynics domain, we achieve two major requirements in risk management: an operational tool to manage past experience

(Balducelli,2000) and an account of strategic, spatial and temporal aspects.

Computer instrumentation has several advantages. Firstly, it allows quick and easy searches of any information, according to different criteria. Secondly, it provides an organization with a structured support for the semantics of its know-how and with a formalization of it that is manageable by computer programs. Thirdly, it favors reusability of the method for different types of knowledge, even in the same organization.

It is also a first step towards Intranet communication among distant parts of the organization in a near future, which will favor sharing of experience and collective practice. It will provide regional managers, and other center managers, with a global real-time view of the fires. This may allow them to better take in charge difficult cases.

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