Improving Emergency Response through Business Process, Case Management, and Decision Models

Marco Polo Ruiz Herrera
Universitat Politècnica de València
marruih1@posgrado.upv.es

Juan Sánchez Díaz
Universitat Politècnica de València
jsanchez@dsic.upv.es

ABSTRACT

The emergency procedures contain a set of actions responsible for providing the necessary corrective measures to address an emergency. The relevance of contextual knowledge during emergency responses is of utmost importance since many decisions are made from the information gathered in real time that sometimes conflicts with the formal knowledge specified in the emergency plan. Consequently, tools that support the emergency plan mentioned must be sensitive to context and allow decision making at the time an emergency takes place. We demonstrate how Case Management Modeling Notation (CMMN) along with Decision Model and Notation (DMN) are very suitable approaches to obtain a flexible model adapted to the context-driven response processes.

Keywords

Emergency response, Knowledge-intensive business, Business Process Model and Notation, Case Management Model and Notation, Decision Model and Notation.

1.- INTRODUCTION

Emergency plans are a set of actions and measures aimed at preventing and controlling risks to people and their property in order to respond appropriately to the possible emergency situations to which an organization is exposed. Response procedures within self-protection plans, are actions told in natural language that are carried out immediately in light of the event of a disaster with the aim of preventing the loss of life, safeguarding goods and normalizing the situation as soon as possible (Sánchez et al., 2015); however, due to its nature and the variants that may occur, the self-protection plan must be executable, scalable, adaptable and, flexible.

The problems of nature classified as knowledge-intensive business models should be addressed with notation based on Adaptive Case Management (ACM) (Di Ciccio et al., 2014; Hofmann et al., 2015). Due to the increase in natural disasters that have occurred in the last decade, one of the fields of application with greater interest at present is emergency management. However, at the time of modeling solely with traditional process notations (e.g., Business Process Model and Notation (BPMN)) it is difficult to define beforehand possible scenarios (Van der Aalst et al., 2005). In addition, critical factors such as time, excessive information from the environment, poor structuring the unrepeatable and unpredictable flow must be considered (Jul, 2007; Kushnareva et al., 2015).

In May 2014, the Object Management Group (OMG) formalized the case management language (Case Management Model and Notation (CMMN)) in its version 1.0 (OMG, 2014), which allows to graphically represent flexible response procedures based on cases to respond to the emergencies. Even though in December 2016, OMG presented version 1.1 of CMMN (OMG, 2016) where it attended the technical details of the original version, some case workers consider it still immature and doubt that it is appropriate to apply it for critical domains in real-world such as the emergency management (Kurz, 2015). Although CMMN allows the ACM, not all response procedures keep the same classification during all stages. Therefore, there are tasks that can be automated to facilitate decision-making with DMN and give continuity to the flow of response with BPMN. This paper aims to integrate the BPMN, CMMN, and DMN specifications to build what we call the **ACM hybrid model**, which allows us to adequately represent the different characteristics of emergency response procedures and when executed, adequately manage the needs of the environment.

This paper is organized as follows: section 2 describes the related works that use modeling notations to provide attention to emergencies. Section 3 explains how the BPMN, CMMN, and DMN specifications can be integrated to represent a response process named the ACM hybrid model. Section 4, as a case study, analyzes the proposal to build an ACM hybrid model based on the fire response management procedure of the Hospital Universitario y Politécnico de La Fe in the city of Valencia, Spain. Section 5 shows the execution of the ACM hybrid model using the Camunda BPM environment. Finally, section 6 presents the key findings and possible future work.

2.- RELATED WORK

In the literature, there are several studies that consider the methodology of process modeling a viable alternative to represent the emergency response processes and provide adequate responsiveness. Hofmann et al. conducted a broad structured review of the literature to identify the different existing approaches that apply methods and tools of business process management (BPM) to the domain of Disaster Response Management (DRM), concluding that it is a promising approach because of the similarity between the general structure and the aims of both business processes and disaster response processes. In addition, as a result of the research work, they obtained an adequate classification of the requirements necessary for the development of business process solutions oriented to DRM (Hofmann et al., 2015).

In 2005, Van der Aalst et al. proposed an approach in which case management was used to support flexible business processes. They identified and classified the main entities of the system and built a meta-model as part of their conclusions and found that case management offered a balance between support and flexibility, however, this paradigm alone did not solve all the problems related to changes (Van der Aalst et al., 2005).

Zensen and Küster conducted a comparison between the BPMN language with an ad-hoc subprocess approach and the CMMN notation to represent the same case study. They aimed to identify advantages and disadvantages of each language and help choose which standard to use to model processes or part of processes that require flexible parts. They concluded that the BPMN ad hoc subprocess offered a certain degree of flexibility but that arbitrary jumps were difficult to model. Likewise, they recommend that in knowledge-intensive business problems, the data should be restricted to individual tasks that should not be shared with all participants of the process. CMMN offered a greater degree of work flexibility where tasks could be grouped in stages that had semantic similarity in execution and support a declarative approach. The disadvantage was the lack of outgoing communication events. In their conclusions, they suggested a combination of both to model highly structured and flexible processes (Zensen and Küster, 2018).

Nešković and Kirchner discussed in their work the main benefits of CMMN over BPMN when modeling knowledge-intensive business problems that require using context information to allow flexibility in runtime. The technical proposal was illustrated with an example in health domain. They concluded that CMMN was designed to model only a high level of business logic, while other details remain to be specified and developed at the level of specific applications. Therefore, they recommend developing an extension for CMMN that provides this support (Nešković and Kirchner, 2016).

Recently, Shahrah and Al-Mashari have shown how CMMN can be used to model an emergency response process. They used CMMN to build a template model for a generic emergency response process and indicated that the generic model can be easily expanded or exchanged between different modeling tools or existing execution platforms. Also, they presented a case study of a flood management process as an example of the use of CMMN in the modeling of the emergency response process. Finally, they concluded that the CMMN has great potential to model case-based processes such as emergency response (Shahrah and Al-Mashari, 2017).

As can be seen from the literature review described above, and as far as we know, we did not find a case study using hybrid ACM modeling, integrating the notations of BPMN, CMMN, and DMN to represent emergency response processes. Therefore, this paper attempts to help explain the implementation of a hybrid ACM model in the emergency response domain.

3.- AN INTRODUCTION TO CMMN AND DMN

Case management (CM) was introduced as a new paradigm for business process support systems (Van der Aalst et al., 2005) focusing on the data-centered process, knowledge-intensive, flexible and adaptable processes. As opposed to traditional business process management (BPM), based on control flow, where the order of execution of activities is determined by the execution of previous activities, CM allows the execution of weakly structured process, where the dynamic selection of activities to accomplish a business goal is based upon case worker skills and the evolution of case data. CM supports the ad-hoc, dynamic and unpredictable interactions between people, process fragments, data and, documents.

Emergency response procedures are typical examples of case management: interactions between different roles or independent agencies such as fire department, police, public transportation, etc. Also fragments of unstructured response activities ready to change their behavior at runtime.

The language CMMN (Case Management Modeling Notation) is a new standard for case management published by the OMG in 2014 (OMG, 2014). The case is the main concept, which lists all possible case roles and references the Case File Model and the Case Plan Model. The Case File holds all the data used in the case; the members of the Case File are Case File Items which can be any type of information ranging from a plain file (typically encoded in XML) to a folder hierarchy. Figure 1 shows the graphic representation of CMMN elements.

The Plan Model contains the behavioral aspects of the Case Model: events, tasks, stages, and milestones, called Plan Items. The events can be activated either manually by users (user event listener), by the system after an elapsed period of time (timer event listener) or by changes detected in the Case File model (anonymous event listener). Note that the Case File implicitly includes the context for throwing events to the Case Plan Model. A human task is a unit of work performed by a user of the Case. There are two types of human tasks: blocking task (tracked by the system) and non-blocking task (manual task). Additionally, there are two more task types: process task and case task. A process task calls an external process passing parameters as required. In the same way, a case task calls an external case, providing the necessary information when necessary.

Case Plan Model	**Case File Item**	**Stage**	**Task**	**Discretionary Task**
Blocking human task	**Non-blocking human task**	**Process Task**	**Case Task**	**Milestone**
		PROCESS	CASE	
Event listener	**Timer Event**	**User Event**	**Sentry: entry crite-rion**	**Sentry: exit crite-rion**

Figure 1. Elements of CMMN

A milestone represents a state reached during the case execution, which enables evaluation of case progress. The dependencies between elements of the case are modeled using event-condition pairs called Sentry, which can be of two types: entry criterion and exit criterion. The Sentry with entry criterion can be attached to case items as stages, tasks, and milestones. When the event of the Sentry occurs, and the conditions are evaluated as true the corresponding attached elements are enabled. Similarly, an exit criterion can be attached to tasks and stages. Upon task or stage completion the exit criterion terminates the attached plan item. A stage contains Plan Items and Sentry elements, to achieve one (or more) of the milestones owned by that stage.

Within the context of CMMN, a case has two distinct phases: design and execution. During the design phase, business analysts are engaged in modeling the case, which includes defining stages or tasks. During the execution phase, the case workers create and execute the plan, particularly by performing tasks as planned, while the plan may continuously evolve, due to the same or other case workers being engaged in planning and execution, i.e., adding so-called ‘discretionary plan-items’ (tasks and stages) to the plan of the case instance at run-time. This fundamental characteristic of case management, supported by CMMN, is referred to as ‘runtime flexibility’. It allows process participants to respond to challenges or new requirements that were not considered at the time of planning the business processes. This run-time planning is based on information that has become available to the case. Changing the case behavior means changing a case process.

Decision Modeling and Notation (DMN) is a new standard from OMG. The DMN notation has been designed to work alongside BPMN, providing a mechanism for modeling the decision-making represented in a task within a process model. DMN does not need to be used with BPMN but it is highly compatible. The DMN standard allows to model and describe decisions in a declarative way on two levels, the requirements level, and the decision logic level. The first level employs Decision Requirements Diagrams (DRD). These diagrams can contain several types of elements, decisions, input data, business knowledge models, and knowledge sources. A DRD diagram shows where the information required for the evaluation of decisions comes from. The second level uses a declarative language called Friendly Enough Expression Language (FEEL) to describe the decision logic or decision tables.

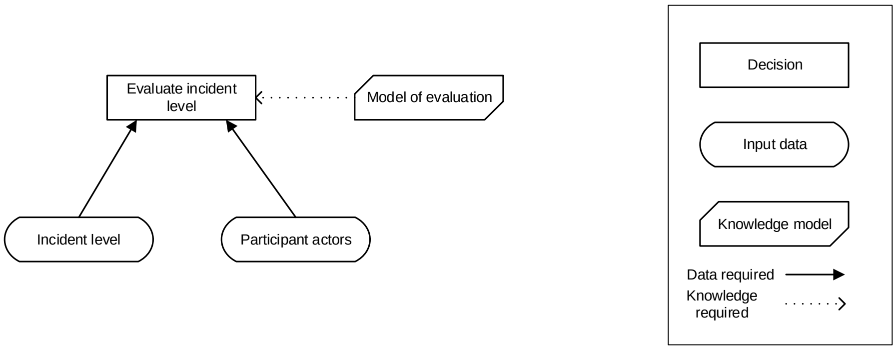

Figure 2. DRD diagram.

Figure 2 shows a decision requirement diagram with a top decision, two inputs data, and a knowledge model. The decision logic is implemented in Figure 5 using a decision table.

4.- CASE STUDY

In this section, we describe a case study of a specific emergency response process example. This case study aims to demonstrate how hybrid ACM modeling can be used appropriately to represent real situations in emergency management. The example of the case study to be used is the emergency response procedure of thin case of fire developed for the Hospital Universitario y Politécnico de La Fe located in the city of Valencia, Spain. This process was extracted from the self-protection plan that the institution provided us with and aims to define the sequence of actions to be developed for the initial control of a possible fire-type emergency, planning of the human performance, and the means available to the hospital. In essence, the hospital aims to avoid the partial or total evacuation of the center. If an evacuation in the hospital is needed, it will define the necessary guidelines so that it is carried out in the orderly, organized and easy way possible.

It is advisable that before reading the response procedures of the self-protection plan, the actors involved are identified. Likewise, they should be aware of its abbreviations, missions, functions to play and the activities to be carried out in each of the phases of the emergency. To facilitate the understanding of the emergency response procedure of the case study, Figure 3 shows the Action Diagram, which summarizes the possible sequences of action by each of the actors in the response procedure of the fire-type incident.

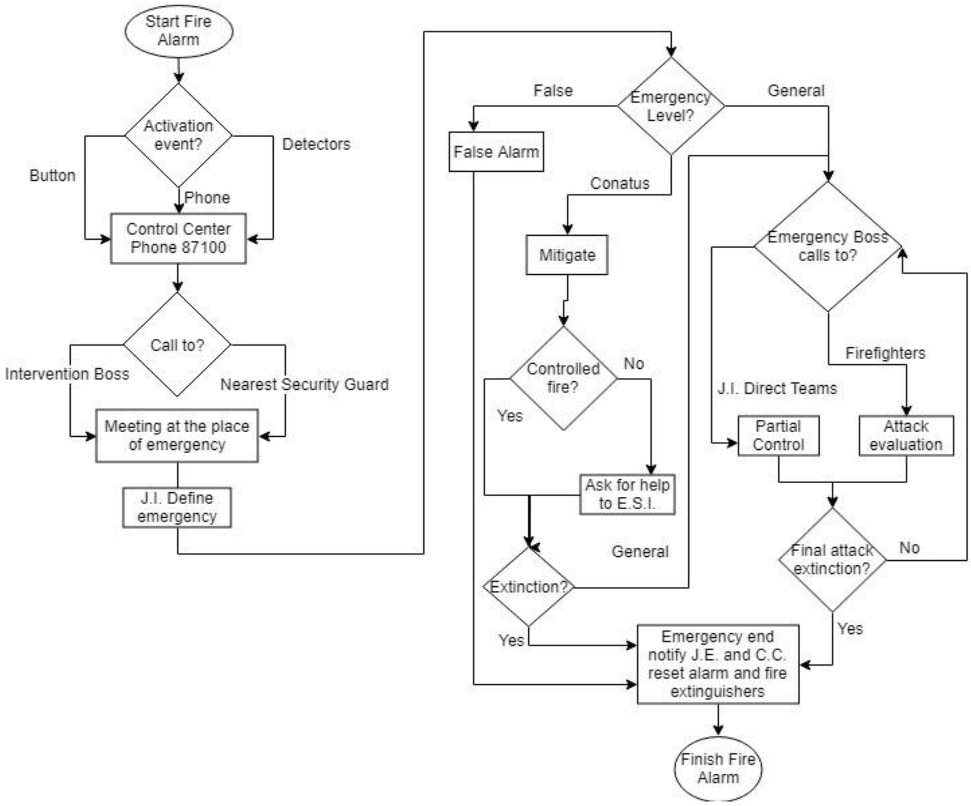

Figure 3. Action diagram of the fire-type incident response procedure.

The previous Action Diagram, facilitates the understanding of the emergency response procedure, However, there are activities that lack a clear sequence and the moment in which they must be performed, thus, this representation of the response procedure creates ambiguities and therefore, the sequence in the control flow is very unreliable when trying to make the response procedure executable in real time.

Once known and understood the content of the emergency response procedure, it is advisable to identify the key business elements and the relationship between them to facilitate the design of the hybrid ACM model.

Following the recommendations provided by the OMG standard to integrate the BPMN, DMN, and CMMN specifications as well as the content of the emergency response procedure of the case study, it is defined that the diagram in BPMN will be chosen as a base in order to potentiate the automation of the sequence. Therefore, the lanes of the pool will be the **Control Center**, **Security Guard,** and the **Emergency Boss**. With the help of the Camunda Modeler tool (Camunda Modeler, 2018), models and decision tables will be designed. It is important to note that in addition to the diagram, the digital object of each model contains in XML format the description of it, allowing the core of the BPM Camunda platform to interpret and execute the models (Camunda Engine, 2018).

Next, in Figure 4 is presented the model M0. Fire Management in BPMN, as a result of the fire-type emergency response process that was summarized in the Action Diagram of the Figure 3.

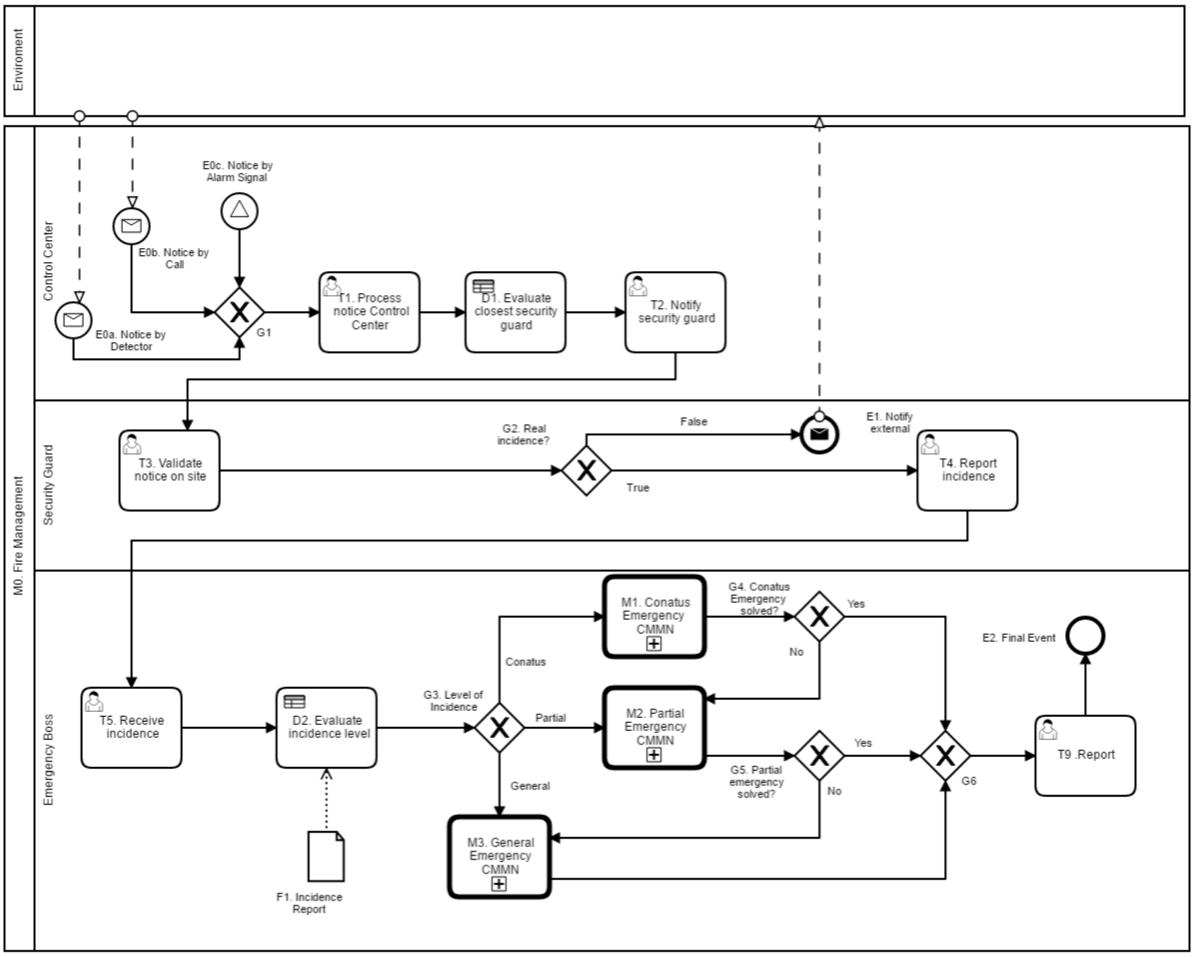

Figure 4. Model M0. Fire Management in BPMN of the Fire-type Incident

To start building the model in BPMN, it is identified in Figure 3 that the fire alarm can be activated by a telephone call, alarm signal or smoke detector, therefore, it is established that the initial events that can create an emergency instance will come from the Environment and are represented by circles. This is an example of how, based on the Action Diagram of Figure 3, the BPMN model of Figure 4 was built. Subsequently, the exclusive gateway G1 will be activated, and the information detailing the initial message will be notified in user task **T1. Process notice Control Center** and using the decision table task in DMN named **D1. Evaluate the closest security guard**, the security guard assigned to go to the incident area will be assigned to validate the emergency.

If the incidence is not real, the Environment is notified through the final event **E1. Notify externaly**; if the incidence is real, the security guard complements the **F1. Incidence Report** through task **T4. Report incidence**, this information allows the emergency boss to determine, through decision table **D2. Evaluate incidence level** in DMN, the incidence level and activate one of the ad-hoc sub-processes **M1. Conatus Emergency**, **M2. Partial Emergency,** or **M3. General Emergency** (ISGF, 2017); which are a call to the models that are in CMMN notation. Based on the output information of each of the ad-hoc sub-processes, the exclusive gateways G4, G5, and G6 bifurcate the workflow to activate another ad-hoc sub-process or reach the **T9. Report** task that when is completed, ends instance using the **E2. Final Event**.

Figure 5 shows the decision table **D2. Evaluate incidence level** in DMN to facilitate the emergency boss to evaluate which actors are going to intervene and the level of the incidence.

Model of Evaluation

DecisionIncidenceLevel

U	Input +		Output +
	Incident Level (incidenceLevel)	Actors Intervention (actors)	incidence
	string	string	string
1	"Simple"	"Local Staff"	Conatus
2	"Simple"	"Second Intervention"	Partial
3	"Simple","Limited"	"Local Staff","Second Intervention"	Partial
4	"Potential"	"Personal Local","Segunda Intervención","Públic Service"	General
+	-	-	-

Figure 5. Decision table: D2. Evaluate incidence level.

The Case Plan Model **M1. Conatus** in notation CMMN is illustrated in Figure 6, where the stage **M1S1. Mitigate Conatus Emergency** contains the user task **M1T1. Notify the intervention Chief** of manual activation, the task **M1T2. Mitigate Conatus Emergency** indicates to the hospital security personnel mitigate the fire with local resources. Last, through the task **M1T3. Evaluate the emergency** the user validates if the fire has been extinguished. The exit of the stage connects with the gateway **G4. Conatus Emergency Solved?** of general model **M0. Fire Management** in BPMN.

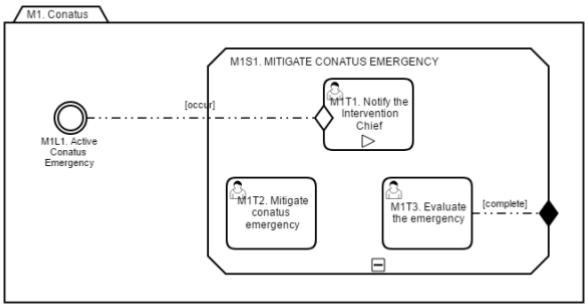

Figure 6. M1. Conatus Emergency Model in CMMN

In Figure 7, we represent the CMMN model **M2. Partial Emergency** where the stage **M2S1. Mitigate Partial Emergency** contains tasks such as **M2T1. Notify the Intervention Chief**, **M2T2. Active partial alarm signal**, **M2T3. Notify second intervention teams**, **M2T4. Evacuate visits from the area**, **M2T5. Evacuate area**, **M2T6. Mitigate fire,** and **M2T7. Evaluate partial situation**; likewise, a milestone **M2H1. Partial Emergency**. The exit in this stage connects with the gateway **G5. Partial Emergency Solved?** of general model **M0. Fire Management**.

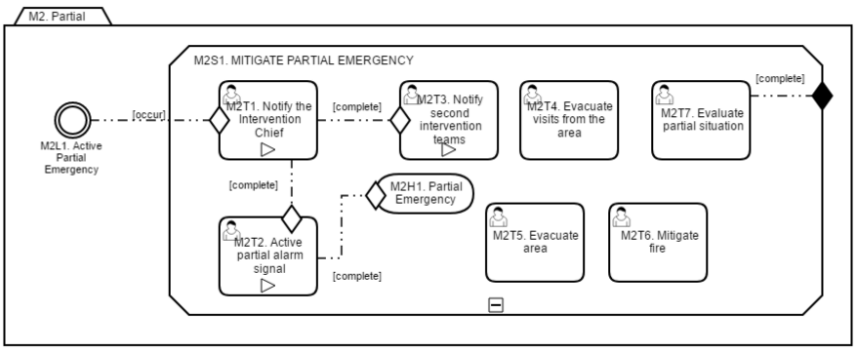

Figure 7. M2. Partial Emergency Model in CMMN

Finally, the model **M3. General Emergency** in CMMN notation (shown in Figure 8) includes the stage **M3S1. Pre-Evacuation** in which we have the tasks **M3T1. Notify firefighters**, **M3T2. Pre-evacuation procedure**, **M3T4. Receive external information** and the decision table **M3D1. Evaluate evacuation**. Furthermore, we have included the stage **M3S2. Evacuation** that connects the tasks **M3T5 Evacuation procedure**, **M3T6. Receive external information** and **M3T7. Evaluate general situation**. The exit of the model is linked with gateway **G6** of general model **M0. Fire Management**.

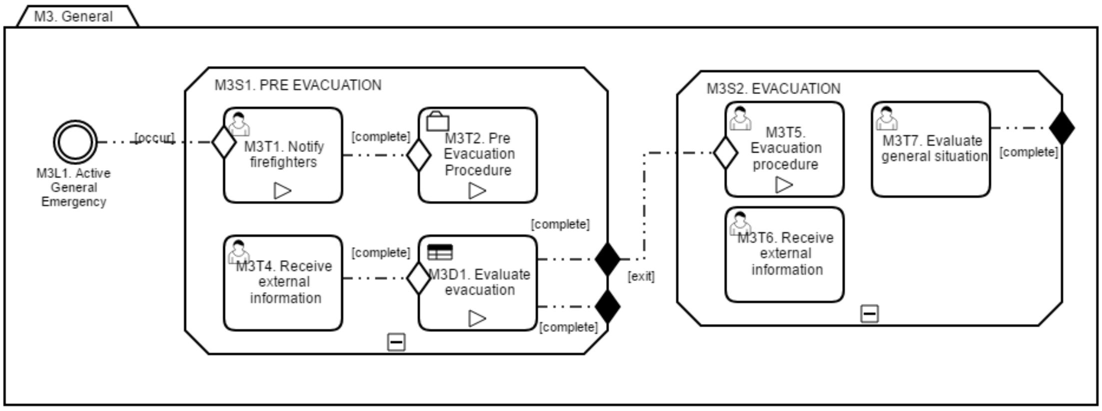

Figure 8. M3. General Emergency Model in CMMN

5.- EXECUTION ENVIRONMENT

Once we built the ACM hybrid model in the Camunda Modeler tool, we should use the BPM Camunda platform, which must be installed and configured together with the Eclipse Maven environment (Camunda Services, 2016). These settings allow one to execute the models and be able to perform simulations of various environments validating the behavior of the models with respect to variants and unrepeatable situations typical of emergency management. One of the benefits of Camunda BPM is the interoperability with other environments through web requests based on the Hypertext Transfer Protocol (HTTP), so it can be consumed through the Application Programming Interface service of the Representational State Transfer type known as the API REST. With the help of the Postman tool, we send a POST request method to simulate the activation of the fire alarm signal with the data shown in Figure 9 and with this create an execution instance.

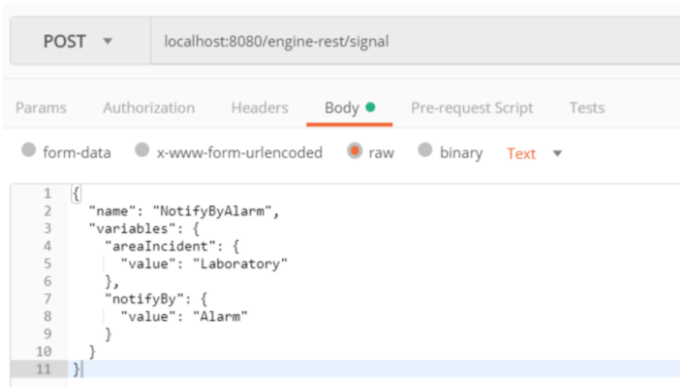

Figure 9. Activation of fire alarm signal via Postman

After this, we run the BPM Camunda platform and enter the TaskList application, finding in the option "My Task" the list of tasks of model **M0. Fire Management**. When we choose task **T1. Process notice Control Center**, we observe the data received from Postman.

On this occasion, to simplify the presentation of the paper, the fire at the **Conatus Emergency** level has been chosen as a sample, in order to validate one of the possible scenarios that may occur during the fire-type emergency in the hospital. In Figure 10, we represent the scenario of the conatus emergency using the orange color to indicate the instantiated items and in red the order of the workflow sequence in the model **M0. Fire Management**. In step 7 of the workflow, when the **T4. Report Incidence** task is activated, the security guard can complement the information for the **F1. Incidence Report** that is loaded in the **D2. Evaluate Incidence Level** and provides to the Emergency Boss, the decision making of the actors that will participate in the mitigation of the incident and establishes the level of the incident.

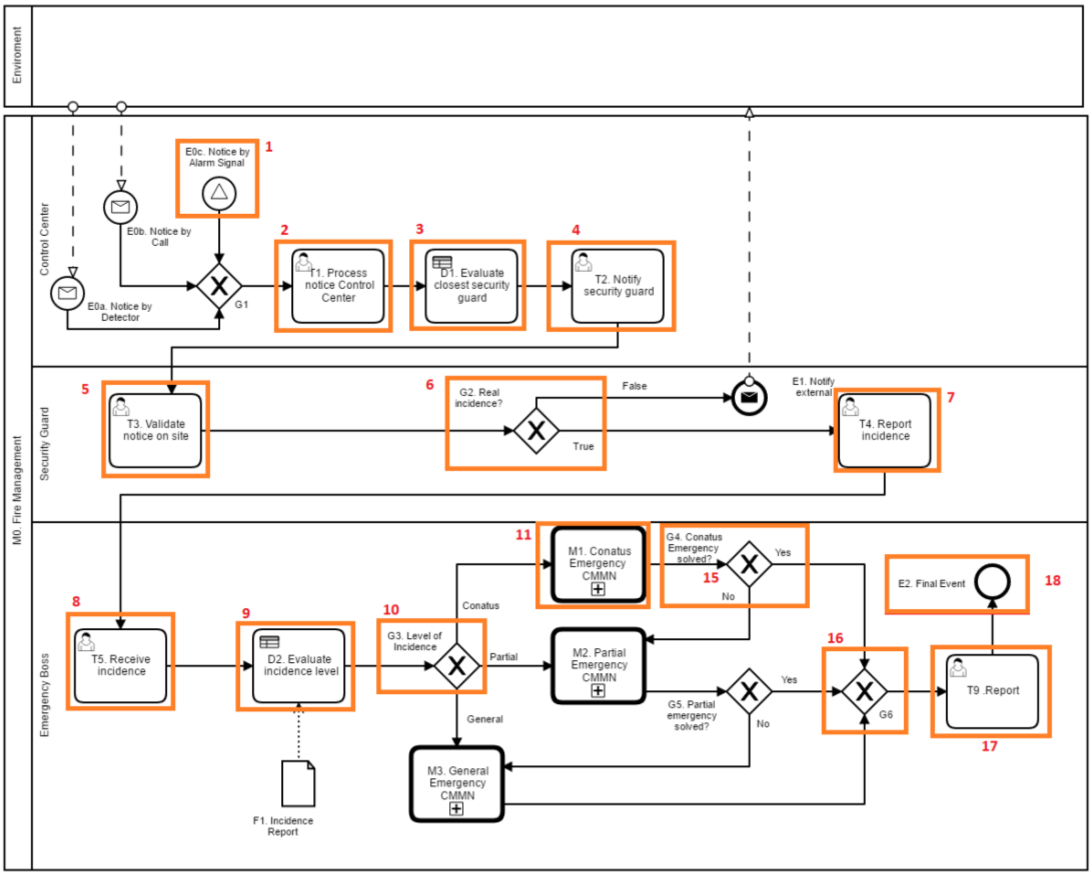

Figure 10. Representation of conatus emergency in model M0. Fire Management.

When the workflow in the simulation reaches **M1. Conatus Emergency**, a call is made to the model in CMMN notation, in Figure 11 we represent the continuation of the execution flow where the case worker intervenes to choose the tasks that will be activated.

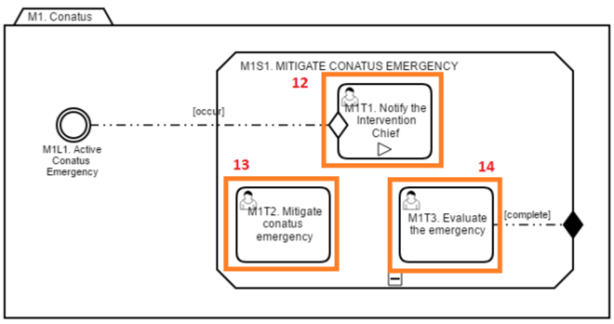

Figure 11. Representation of conatus emergency in model M1. Conatus Emergency.

With the help of the BPM Camunda platform and entering the variables of the environment via Postman for the activation of the instance, the emergency response procedure of fire type represented with the proposed ACM hybrid model has been implemented in a promising way for different scenarios.

However, we found that the web interface of the TaskList application of the BPM Camunda platform is not adequate for the interaction of the case worker during the emergency management. This was mainly because the tasks are presented as a list, which could lead to confusion when choosing the right element to instantiate. Although the Camunda BPM platform is a tool capable of executing models in BPMN, CMMN, and DMN, and its core can be consumed by API REST, the interface for a case worker is not adequate in emergency situations. Therefore, it is necessary to build a tool that maximizes the execution core's potential allowing to strengthen interoperability with other external systems and designing an appropriate interface to the case worker for emergency management. Likewise, the hybrid ACM model by integrating the BPMN, CMMN and DMN specifications would allow to create a library of processes, case definitions and business rules that facilitate the validation of new case studies.

6.- CONCLUSION AND FUTURE WORK

Emergency response procedures are characterized by being dynamic, highly knowledgeable and unstructured; therefore, they are classified as knowledge-intensive processes. Dealing with unrepeatable and unpredictable flows implies that the model must be flexible and adaptable. The Adapted Case Management appears as one of the most attractive and viable innovations in this context, thus, it has been decided to apply to the domain of emergency management. However, in most of the proposals, it is offered to choose between the modeling approach oriented to traditional processes such as BPMN or in case management as CMMN. With BPMN we find that its main benefit lies in the autonomy and agility of the execution because the pre-established conditions are the ones that guide the tasks that should be carried out in the workflow. With CMMN we obtain more flexibility, it relapses the direction of the flow in the events and the decisions taken by the case worker, the latter based on the experience of the case worker. As we can see, the greater the autonomy, the less flexibility.

Although CMMN allows attending for the adaptive case management, in emergency response procedures it is not possible to generalize that at all times the intervention of the case worker is required and to depend entirely on their experience for decision making. There are stages in which the execution can be accelerated by relying on traditional modeling approaches such as BPMN and DMN. By integrating the different approaches, we can obtain a flexible and agile model.

This document briefly presented the characteristics of the different process modeling approaches, including BPMN, DMN, and CMMN; it was demonstrated with the case study based on the of fire type incident of the Hospital Universitario y Politécnico de La Fe in the city of Valencia, Spain, how a hybrid ACM model can be built, where the BPMN, DMN and CMMN standards are integrated to represent artifacts and how they will interact with each other when a dynamic, unrepeatable and unpredictable scenario occurs. Likewise, it was shown, how the different standards converge.

ACM hybrid modeling is a promising proposal to provide support for emergency response processes and there are some modeling tools and execution platforms. Although this is the case, modeling and execution tools are still required to facilitate integration and interaction of different languages, to be adapted to an interface that provides the adequate support for emergency management.

Our future work will focus on implementing the proposal of the hybrid ACM modeling in other emergency response procedures to contrast with other cases of study. We will also focus on the development of a tool that facilitates the implementation of the proposed ACM hybrid models in an appropriate environment to the emergency management and the interoperability with external systems.

ACKNOWLEDGMENTS

The work of Marco Ruiz Herrera has been financed with the scholarship "CONACYT- GOBIERNO DEL ESTADO DE CHIAPAS" whose resources are contributed by the “Consejo Nacional de Ciencia y Tecnología” (CONACYT) of the Government of Mexico and the “Consejo de Ciencia y Tecnología del Estado de Chiapas” (COCYTECH). The work of Juan Sánchez Díaz is funded by the Spanish MINECO under grant CALPE (TIN2015-68608-R).

REFERENCES

Camunda Engine (2018) BPMN Workflow Engine, https://camunda.com/products/bpmn-engine/, accessed on 15 Dec 2018.

Camunda Modeler (2018) Design Workflows and Decisions, https://camunda.com/products/modeler/, accessed on 15 Dec 2018.

Camunda Services (2016) Get started with Camunda and CMMN 1.1, https://docs.camunda.org/get-started/cmmn11/, accessed on 15 Dec 2018.

Di Ciccio, C., Marrella, A., and Russo, A. (2014) Knowledge-intensive processes: characteristics, requirements and analysis of contemporary approaches, *Journal Data Semantics*, 4, 1, 29–57.

Hofmann, M., Betke, H., and Sackmann, S. (2015) Process-oriented disaster response management: a structured literature review, Bus. Process Manag. J., 21, 5, 966–987.

International Scout and Guide Fellowship (ISGF). (2017) Self Protection Handbook: Emergency Assistance, http://www.isgf.org/index.php/en/download/publications/our-kit/2817-8-emergency-2017/file, accessed on 28 Dec 2018.

Jul, S. (2007) Who's really on first? A domain-level user, task and context analysis for response technology, *In Proceedings of the 4th International Conference on Information Systems for Crisis Response and Management (ISCRAM) 2007*, 139-148.

Kurz, M., Schmidt, W., Fleischmann, A., et al. (2015) Leveraging CMMN for ACM: examining the applicability of a new OMG standard for adaptive case management. *In Proceedings of the 7th International Conference on Subject-Oriented Business Process Management*, 4.

Kushnareva, E., Rychkova, I., and Le Grand, B. (2015) Modeling business processes for automated crisis management support: lessons learned, *In Research Challenges in Information Science (RCIS), 2015 IEEE 9th International Conference on IEEE*, 388-399.

Nešković, S., and Kirchner, K. (2016) Using context information and CMMN to model knowledge-intensive business processes, *In Proceedings of the 6th International Conference on Information Society and Technology ICIST 2016*, 17-21.

Object Management Group (OMG). (2014) Case Management Model and Notation (CMMN) version 1.0, *https://www.omg.org/spec/CMMN/1.0/*, accessed on 10 Dec 2018.

Object Management Group (OMG). (2016) Case Management Model and Notation (CMMN) version 1.1, *https://www.omg.org/spec/CMMN/1.1/*, accessed on 11 Dec 2018.

Sánchez, J., Carsí J., y Penadés, M.C. (2015) Un entorno de gestión de casos para la resolución flexible de emergencias, ISSI-DSIIC, *Universidad Politécnica de Valencia*.

Shahrah, A. Y., & Al-Mashari, M. A. (2017) Modelling emergency response process using case management model and notation. *IET Software*, 11, 6, 301-308.

Van der Aalst, W. M. P., Weske, M., and Grünbauer, D. (2005) Case handling: A new paradigm for business process support, *Data & Knowledge Engineering*, vol. 53, 129-162.

Zensen, A., and Küster, J. (2018). A Comparison of Flexible BPMN and CMMN in Practice: A Case Study on Component Release Processes. *In 2018 IEEE 22nd International Enterprise Distributed Object Computing Conference (EDOC)*, 105-114.