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## A Framework for virtual training in a crisis context and a focus on the animation component: the gamemaster workshop

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### Abstract

*Critical infrastructures, historical places, and sensitive buildings are vulnerable to crises, from natural to man-made disasters. Public institutions and practitioners have to train, before the occurrence of a major event, to be prepared to respond to the crisis. These sites are difficult to vacate just to perform exercises. To propose training adapted to the needs the trainer have to create an exercise dedicated to the aimed skills. Stakeholders responding to high-risk situations are asking for new ways to train and compensate for the weaknesses of existing training approaches. The research work presented in this paper concerns the design of immersive environments that can be used to create, implement and simulate crisis scenarios to improve collaborative training.*

**Keywords:** Immersive training, Crisis, Virtual reality, Disaster Management, Multiplayer Environment, Simulation.

### 1. Introduction

Crises and disasters are situations defined as sudden and unpredictable disruptions (Lagadec, 1993). It is important to be able to respond and propose an optimal solution to alleviate the often-dramatic consequences. When facing a crisis, people are immersed in a profound loss of reference points and are subject to uncertainty. This uncertainty can be qualified organizationally at different levels so that anyone is likely to be concerned. Unfortunately, in addition to this element of surprise, the crisis evolves and can cause new complexity. It is, therefore,

necessary to adapt the response as the disaster evolves and consider as much information as possible.

When responding to a crisis, stakeholders involved in the crisis response have to coordinate their actions to prevent the risks and react to the incidents due to the ongoing natural, or man-caused disaster. William Wallace and Franck De Balogh were among the first to recognize four closely related phases in crisis management (Wallace & Balogh, 1985), that need to be addressed:

- **Preparation**, to prepare for a crisis by, for example, training response teams or preparing emergency plans; This is the phase we are interested in in this article.
- **Response**, to respond to an ongoing crisis. The response is dedicated to implementing the process and outcomes of the preparation phase. There, many stakeholders, each with their particularities, skills and tools, have to organise themselves and collaborate.
- **Recovery**, to return to a controlled situation where everyone takes notes of what has happened.
- **Mitigation or prevention**, to mitigate risks on a site and avoid future crises.

During the response, to find a solution to return to a stable state, crisis cells can be deployed. The crisis cell brings together people in charge to resolve the crisis and people able to communicate with the services involved in the crisis response. The crisis cells are essentially composed of tools that have evolved very little. Depending on the crisis, the room may only be composed of traditional paper plans with radios to communicate with people in the field. The emergency

managers must have as much information about the crisis as possible. But, to avoid drowning under information, they often only receive the required information. As an opportunity, they are asking for and are curious about the new management and learning tools (Engelbrecht et al., 2019). These tools must be able to adapt to all predictable and unpredictable developments. In addition, according to (Barr et al., 2010) there is also potential room for improvement in the field and the crisis cells, especially concerning information exchange between the stakeholders in a response to a crisis.

This paper focuses on the preparation phase. In France, Organizations, public administrations, services and institutions are compelled to carry out exercises to test their response to any type of crisis. The training sessions remind the stakeholders of good practices and help to detect and correct bad practices. Training takes place on-site, with the stakeholders playing their roles. This training, therefore, requires the mobilisation of key actors from different organisations, simultaneously, for half days, days or whole weeks. It is necessary to **mobilize all the trainees and stop on-site activities**, which can slow down the ambitions and the enthusiasm for the regularity of the exercise sessions (Mikušová & Horváthová, 2019). In addition, such training can take place on a critical site, which could be considered dangerous in the event of a disaster. This training can therefore be costly in terms of resources, time and safety. The financial costs increase rapidly depending on the number of actors to be moved or hosted, the site chosen, the complexity of the scenarios produced and the variety of tasks to be assessed. To limit the costs, exercises often **lack flexibility, complexity, realism and repeatability**.

For more repeatable, more realistic and less expensive training, it is possible to integrate Virtual Reality (Ricciardi & De Paolis, 2014) for immersive training (Bacon et al., 2013; Pons Lelardeux et al., 2017). Compare to traditional means, it offers freedom, repeatability and the possibility of distance training. Virtual reality is used to train actors in many key areas such as health, education and, crisis management.

We aim to provide crisis response training with a virtual reality environment to (i) gain repeatability and reduce costs through technology, and (ii) also gain flexibility, realism and complexity. What are the solutions to make training more flexible, realistic, immersive and complex? And are there tools which allow them to train as many times as needed, given the goals of the trainers, in a multiplayer, realistic and immersive environment, which allow them to collaborate and respond to a crisis scenario, in any

kind of site, whatever the nature of the crisis? **Can VR help significantly with on-site training for crisis response?**

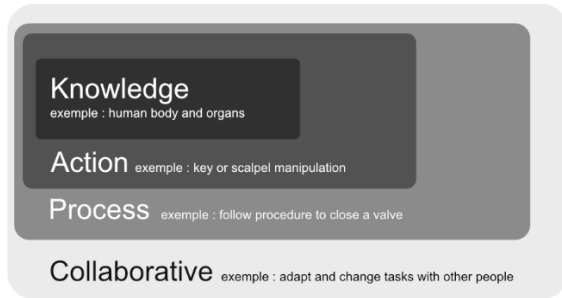
## 2. Related work

It is important to remember that part of the definition of a crisis is its dynamic and sometimes random aspect (Damos, 1995). In crisis management, immersive training often focuses on a specific case, with a pedagogy determined beforehand. There is no generalization to any kind of crisis, nor any kind of site. There are too few exercises that are open to sandbox scenarios. Most of the training is done through a scenario approach where the scenario is divided into branches. Tools can be found where the use cases are not flexible but sufficiently robust (Kabil et al., 2018)

More and more work is being done in generating immersive crisis training in virtual reality (Checa & Bustillo, 2020; Ricciardi & De Paolis, 2014). This kind of project proves the interest in providing effective training. Immersive Serious Games can improve the efficiency of training. Serious games enable to save time and repeat as many times as needed the exercises (Checa & Bustillo, 2020; Kretz et al., 2012). In addition, they allow adapted pedagogies. Nevertheless, it is difficult to find Serious Games, in the field of crisis response that allows testing an entire process, procedure, or an entire collaboration where procedures accumulate, sometimes with interference.

In this research work, we refer to four levels of learning levels (Figure 1) (Evain et al., 2021).:

- **Knowledge:** learning through theoretical knowledge on the crisis, the site, incidents, risks, actions to be performed, etc.
- **Action:** learning through action reproducing necessary operations to prevent risk, treat an incident or support another action
- **Process:** learning through a process where actions have to respect rules and a precise order
- **Collaborative:** learning through a collaborative process where multiple types of players have each to adapt to the other and synchronise their actions in the same environment.



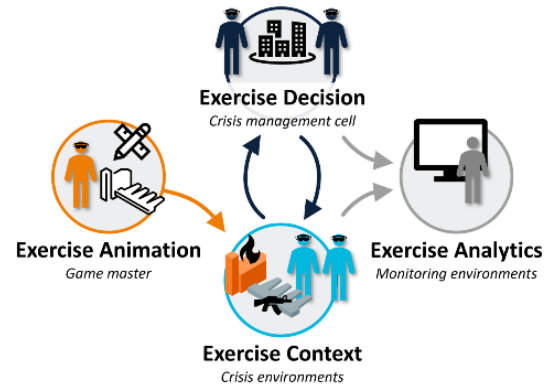
**Fig. 1. Decomposition of learning level in projects**

The flexibility, complexity and realism of training are limited to the number of branches prepared in advance, to adapt the scenario to the choice or success of the players. The more branches there are, the more preparation time is needed to develop the scenario. The scenario can also be very constrained, with specific actions worked on, but little large-scale collaboration. Even though many exercises end with good results, it is difficult to find the perfect training (Xi & Smith, 2014), especially for crisis response where the *knowledge, action and process learning levels* on a specific use case are not enough. Results are expected at the *collaborative level* with a sufficiently flexible, realistic and complex scenario to copy a future crisis.

To sum up, practitioners need an effective environment of repeatable training, where a multitude of possible scenarios can be triggered, while the time ticks and unpredictable dangers emerge to fit a real crisis as defined in (*Lagadec, Patrick. La Gestion Des Crises Outils De Réflexion à L'usage Des Décideurs. Nouvelle éd. ed. 1994. Print., 1994*). Therefore, this paper aims to answer this research question: **how to design and develop a tool to (i) help a trainer define a realistic crisis scenario, and its pedagogical goals, at the collaborative level, (ii) train a group of learners immersed inside an environment representing the crisis, and (iii) offer the possibility to the trainer to act on the ongoing scenario to copy the unpredictable nature of crises.**

Section 3 presents an overview of the RESEARCH project. In particular, it presents the contribution of this paper answering the research question: the addition of the Exercise Animation module and its role during the simulation. Section 4 presents three case studies: an incident in a fictional metro, a terrorist in a school and a fire in a cathedral. Section 5 discusses the first results and presents the first feedback.

### 3. The RESEARCH project



**Fig. 2. Overview of the RESEARCH project**

The RESEARCH project lasted from 2019 to 2022. As illustrated in Figure 2, it focuses on 4 modules, working in parallel, and based on an evolving simulation. Training, learning and decision-making are the three main contributions of this research project. All the modules are briefly presented below.

The *Exercise Context* (Conges et al., 2020) is the base of the simulation. It is an environment to simulate the crisis and train the learners. It allows immersed learners to navigate and perform actions and collaborative tasks related to the objectives. Exercise Context is generally the part that is used to train people on specific cases: where the actions are very technical and focus on specific manipulations and knowledge. As the goal is to create a more relevant training tool the training is more targeted according to needs. And can diversify the approach and have more free training cases to offer more personalised learning.

The *Exercise Animation* (Evain et al., 2021) adapts scenarios, before an exercise, and ongoing exercises to the will of the learners. It automatically adapts to the environment according to the actions of each trainee. The trainers can alter the environment at any time. The environment will react to any change. The *Exercise Animation* (the learners) works with and complements the *Exercise Context* (the crisis theatre). They form the *training part* of the research project.

The *Exercise Decision* (Conges et al., 2021; Fertier et al., 2018) chooses the intervention process and thus the actions to be taken in the field. It includes a crisis cell informed on the ongoing crisis through sensors and messages from the learners on the field. Conversely, learners on the field can receive instructions from the learners inside the crisis cell. It allows (i) the use of an external decision support

system to deduce a response process, (ii) the visualisation of the crisis through collaborative and immersive mapping, and (iii) the monitoring of the crisis response. The *Exercise Decision* (the crisis cells) works with and complements the *Exercise Context* (the crisis theatre).

The *Exercise Analytics* uses data coming from the three other modules. During a training session, it evaluates the learners and gives feedback to the trainers. It evaluates the performance of each trainee, or tool, and offers a visualization of their weaknesses and strengths. The *Exercise Analytics* works with the *Exercise Context* (the environment), the *Exercise Animation* (the trainers) and the *Exercise Decision* (the crisis cells).

Each module is presented in more detail in the sub-sections below.

### 3.1. Exercise Context

The *Exercise Context* aims to recreate crisis simulations. It can be adapted to any site, especially to sensitive areas that are not easily accessible or that cannot be easily closed. The site can thus be specifically adapted to the pedagogical goals of the exercise.

To answer the needs stated in the introduction this Exercise Context implements a multiplayer, realistic and immersive environment. It enables the collaboration of the learners during the exercise. The collaboration is controlled by the instructions sent by the Exercise Decision module.

The Exercise Context includes voice communication between the learners. Learners can communicate if the other learners are close or if they share a radio channel. Learners can choose their roles. Each role has specific skills that enable specific interactions with the virtual environment.

When it comes to training simulation using VR, having a good quality replica of the desired environment is important. The module follows the framework proposed by United BIM (Victor, 2017). It adapts the Level of Detail and Level of development to the intended users. The quality of our simulation is between *structural realism* and *functionality realism*. We define Structural realism as a faithfully representative environment: the same buildings, corridors, or stairs; the sensation sends to the user that it is indeed a replica of the real environment. We define Functionality realism as a convenient environment: intended dedicated to the pedagogical goals and not the realism of the scenario. It is therefore not necessary to fill the whole environment with any

furniture as long as all the rooms required for the scenario are represented.

Nevertheless, the simulation must be able to follow its course as real training and therefore the environment must offer the maximum variety of tools and features possible. The goal of the simulations is to have a collaboration between the facilities and the crisis cell.

The 3D models of the environments were designed from 3D scans and architectural plans with Blender, 3DsMax, and Maya to obtain a reliable and textured reconstruction. Sites have selected the need of the learners.

To create the simulation the Unity game engine allowed us to include stability while keeping a graphic rendering sufficiently realistic to have the immersion desired by the intervention services. Unity 2021.3 uses its URP system including more advanced fire and smoke particles. The size of the project's target locations requires increased stability and this is a significant technical constraint. An effort needs to be made to maintain maximum fluidity in environments, so users can navigate in virtual reality environments at over 50 frames per second. The interest is to avoid sensations similar to Motion Sickness and to be able to do long enough simulations without disturbing the user. By default, the usage of the occlusion culling technique is working satisfactorily but to increase fluid visualization the sites have to be separated in different scenes. Most of the 3D models must be in static meshes with lights calculated beforehand. Doors, badges, fire extinguishers, and coffee machines are quickly dissociated from the other part of the replica.

Non-Playable Characters (NPCs) have predefined behaviours and can either evolve normally in their environment or react to the crisis. To react to the crisis, they will look at the role they have been given and complete their course accordingly. An NPC can be a firefighter, a terrorist or a civilian. In the latter case, they will run away or wait for a trainee or another NPC to tell them to run away. If the NPC is a firefighter they will help solve the crisis and carry out the tasks the learners will ask him to do: this could be evacuating the artworks or civilians. If the NPC is marked as a terrorist they will either set up a hostage situation or walk a pre-determined route and injure or kill the civilian NPCs if they see them. There are 50 NPCs in the use case.

### 3.2. Exercise Decision

The crisis cell can see all information from the locations on a 3D map or through a web interface (Conges et al., 2021; Fertier et al., 2018; Salatgé et al., 2021). The response deduced from the crisis cell will be sent back by the task system to the learners on the

field. This network of functionality runs in parallel and can be deployed independently. The optimization of the decision taken by the crisis cell must be efficient enough to respond to the scenario.

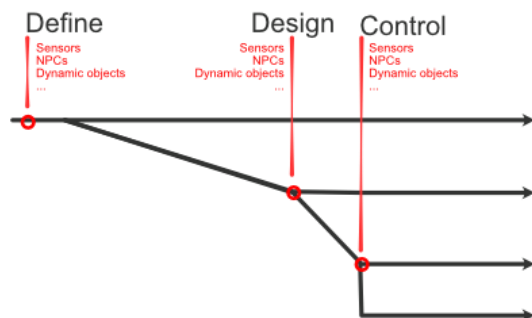
### 3.3. Exercise Analytics

For a simulation, a game report is created and visualized with indicators of acceptability threshold or comparison with other data. But also, communication allows the crisis cell to see which sensor is triggered and notifies the team that can adapt to how the crisis is managed.

All this information can be exchanged thanks to a work on the interoperability of the functionalities. The latter communicates the necessary information to related applications. These applications will provide a game report indicating the performances of the immersed learners and those in the crisis cell.

### 3.4. Exercise Animation: the Gamemaster

In the research work presented in this paper, we focus on this module. One of the main contributions of the *Exercise Animation* is to **turn the trainer into a gamemaster**. The game master encompasses several roles, which can be played by different users: the scenario designer, the trainer of practitioners training in the Exercise Context module and the disruptor. As illustrated in Figure 3, we aim to provide the possibility for the gamemaster to (i) *define* the environment in advance, (ii) *design* the scenario and (iii) *control* an ongoing scenario while ensuring the realism of the training. The 3 red lines represent the 3 phases: *define*, *design* and *control*. The 4 black arrows represent the tree diagram of the choices available for the gamemaster to design and control the scenario. The red legend represents information that the gamemaster has to define before the training and that they will be able to use during the design and control phases.

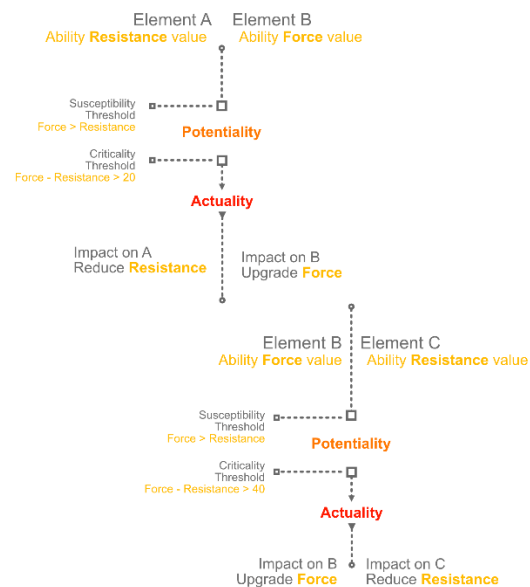


**Fig. 3. Integration, Design and Control Schema**

This solves and answers the question put forward in the introduction: users, trainers playing the game master, can *define*, *design* and *control* a replicable and

disruptible scenario. With this approach, learners will experience a real crisis.

During the *design* phase, when the gamemaster adds an element to the environment, such as a fire, the other elements in the environment react automatically thanks to a pre-established model (Benaben et al., 2021) representing all the causal chains and propagation conditions. This makes the simulation scalable and autonomous. The reactions depend on triggering *sensitivities*, such as “do fire” or “be inflamed” and *conditions*, such as “ $T > 500^{\circ}\text{C}$ ”. To define these parameters in a network, a model close to what has been developed by the causal and propagation chains is defined (Benaben et al., 2019; Ellis, 1994).



**Fig. 4. Example using the metamodel where the force value is more important than resistance**

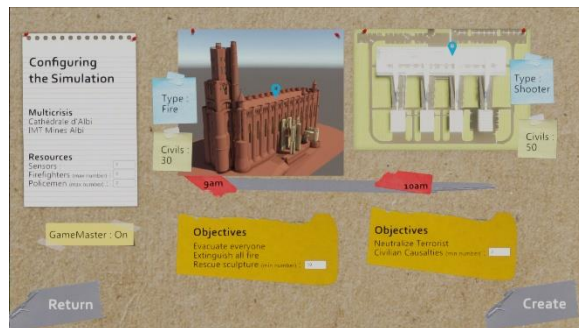
All the elements of the environment instantiate a metamodel made of three concepts: Element, Potentiality and Actuality. In Figure 4, the example shows the impact of one value of one element on the other elements. The Element B will impact A because it has a higher intensity than the resistance value of the same *sensitivity* shared by the two elements. Sensitivity can be described as *ability*. Each element has abilities that can either receive (resistance) or transmit (force). With this operation, elements can change if they meet conditions. These conditions can be distance or intensity thresholds. Once established, these relationships are managed automatically. This will automatically trigger a cascade effect to modify the values and cause a chain of consequences. By defining the elements and their actions, the possibility tree is generated in real-time. This tree enables a dynamic propagation of the effects added by the



gamemaster. The environment can thus handle a multitude of elements that will have a dedicated behaviour to the training. In our research work, this tree opens the possibility to work on multi-site crisis exercise, whatever their size or complexity.

The initial models, instantiating the metamodel, and causal chains are defined during the *define* phase. The more "generic" elements defined at this stage, the easier and faster the *design* phase will be. It could therefore benefit from interviews with practitioners, either from the chosen training location or familiar with the chosen crisis, to define as many of the relevant elements as possible in the *define* phase. This is a way to have an environment that is as close as possible to the training need and not to access a single scenario that might be too generic.

At the end of the *define* phase, before the start of the simulation when all learners join the training session, during the *control* phase, the gamemaster has a view of the available training locations (Figure 5). The gamemaster can first configure and choose the number of sensors that can be activated in the environment. Based on the various potentialities disseminated throughout the environment during the *define* phase, ideas of effects available to the gamemaster to add to the scenario are suggested.



**Fig. 5. The interface allows the gamemaster to configure the simulation before it starts.**

Training is effective if the objectives are met when the skills and methods are exercised in the right way. These data can be included in the *Exercise Analytics*. The interface for the gamemaster gives the possibility (i) to configure the objectives to be reached, such as the maximum time for evacuation or the maximum number of victims, (ii) to determine which components of the environment can be used during the simulation. The gamemaster can set which sensor may work, fail or even be missing during the exercise. The gamemaster can also change the number of resources available, such as decreasing the number of firefighters or having to enter through a specific door. The gamemaster can also choose a particular scenario which can make it easier to manage the training and only step in to make slight adjustments. This is a very

useful way to accurately compare results within the same scenario.

Multiple tests were performed to find the best set of movements. The gamemaster first navigated using the joysticks by walking, but it made users feel disorientated. The gameplay was simplified to avoid any discomfort. The gamemaster, and the learners, can now move using local teleportation, a VR technique commonly utilised for its light impact on the user's disorientation and VR-sickness. Unlike the learners, the gamemaster moves like a ghost and can pass through walls, fly or go back to the ground while being invisible to the learners. The user can go outside, go through another entrance, see the non-player characters doing their tasks and see the players performing their duties. The gamemaster has omniscient vision and can move without limit. This user can know what each player is doing and understand the current situation easily.



**Fig. 6. Gamemaster's view and its interface**

The gamemaster sees information placed in the environment according to what they look at or select but also according to what is activated. An interface dedicated to the possible actions to trigger is depicted in Figure 6. The gamemaster can aim and choose which *ability* they want to trigger from the element they selected. Its choices of events depend on what ability is activated. The user knows if they can trigger this or that change of state and whether they can add this or that asset from a pre-established library. This list gives him access to terrorist characters, a fire extinguisher, an explosion, a water leak, etc. At the beginning of the simulation and for the rest of the training, the gamemaster is free to dynamize the crisis.

It is necessary to be able to display a multitude of information for the gamemaster. This work is based on the deployment of a spatial and event-based User Interface. The interface has been designed according to the player's desire. The attention must not be disturbed and must leave the gamemaster free to interpret each piece of information. For the moment, while waiting for concrete feedback on our system, we have developed and tested several approaches. Interfaces for the gamemaster have been designed to

be in 2D, but it is possible to envisage it with a 3D appearance with the different elements represented symbolically. In that case, manipulations could still be handled by the same functionality as the 2D version. For this reason, the interfaces have been designed to be minimalist, each element being directly understandable and not giving off superfluous information. Work on augmented reality and ergonomic interface thresholds has influenced the approach to tools made available to users (Laviola et al., 2022). By experience, this user will be more used to selecting his component object and navigating the interface that is proposed to them but other approaches are possible. The gamemaster acts directly on the objects with interfaces generated according to the user's activity.

Once the simulation is established, the gamemaster proposes to the learners to place themselves in the available roles and launch the game. The *control* phase is still ongoing.

#### 4. Case study

The RESEARCH project offers a framework which answers our first research question: “**Does VR can help significantly on-site training for crisis response?**” and the gamemaster presented in section 3.4 answers our second research question: **how to design and develop a tool to (i) help a trainer to define a crisis scenario and its pedagogical goals, (ii) train a group of learners immersed inside an environment representing the crisis, and (iii) offer the possibility to the trainer to act on the ongoing scenario.** To evaluate the contribution of these two proposals, several implementations in virtual reality and evaluations were performed.

The first iteration aimed at resolving a crisis in a fictitious metro ((Conges et al., 2020) using only the *Exercise Context* module.

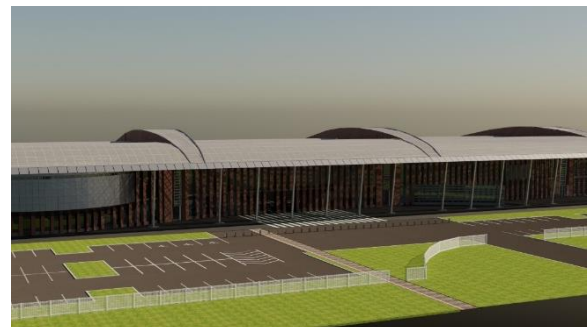
The second iteration concerned the evacuation of a real school caused by the spread of fire (IMT Mine Albi, France) It integrated a simple version of the *Exercise Animation* (Evain et al., 2021). At this point, it was possible to have a higher level of crisis management experience with the visualization of a 3D map (*Exercise Decision* module). The open source decision support system (Salatgé et al., 2021) was used to (i) inform and receive instructions from the *Exercise Decision* module and (ii) send instructions back to the learner's training inside the *Exercise Animation* module. The learners could also send feedback back to the external decision support system (Conges et al., 2021).

The last and third iteration takes place in two different locations: a new, more realistic, version of

the school from the second iteration and the Albi Cathedral (located in France). The simulation illustrates a multi-site terrorist event. The local fire brigade and the local councillors accompanied us during this process to define the scenario and evaluate the resulting pieces of training. In the scenario, a fire starts in the cathedral when and where the gamemaster decides it. The fire then automatically spread following the cascading effects implemented by the gamemaster, in the design phase of the exercise. A smoke sensor is automatically triggered because of the accumulation of smoke. This alerts the crisis cells and fire brigades.

Then 2 firemen, 1 civilian, and 1 policeman begin their training in the virtual environment. Each trainee can choose the role they want to play. Each role is more effective on specific tasks. A firefighter will be more effective against fire than a civilian, especially since the firefighter will generally be equipped with a set of accessories to shield him/her from fire.

The first site (the cathedral) has an area of more than 11,000m<sup>2</sup> and the school (Figure 7) about 8,000m<sup>2</sup>, so a consequent part had to be done on the size of the environments and concentrate on the parts needed for the scenario elements available. The topology of the 3D models was optimised until a replica of the school with 567,000 faces for 14,000 objects and the cathedral with 724,000 faces for 818 objects was obtained. Different versions exist to test the organization of the elements and the optimization of the imported models for Unity.



**Fig. 7. Picture of the digital replica of the school.**

In addition to the scripting of the crisis thanks to the gamemaster, there is also a crisis cell set up to orchestrate the response (*Exercise Decision* module). This team does not know the scenario and must adapt to provide a plan to resolve the crisis. This response is distributed to each trainee with their tasks thanks to a tablet near their left arm in the simulation.

After the beginning of the intervention, the gamemaster can go to the school and start to place a terrorist who will act as a shooter in the corridors. When the policeman is going to the second location,



the trainer is then expected to declare that the exercise is finished as reinforcements are on their way.

The *Exercise Analytics* module was also implemented to evaluate the learning given the data coming from R-IOSUITE and the Exercise Animation module.

At each iteration, the *Exercise Animation* module was evaluated during a demonstration (one per iteration) by a public made of firefighters, policemen, city officials, state officials, and national officials. At each iteration, their comments were considered to improve our two proposals (the RESEARCH framework and the *Exercise Animation* module). Their comments are discussed in Section 5. In addition, the change of sites and scenarios proves that our proposals answer to the need for an **effective** (thanks to an immersed serious game), **realist** (realist virtual environment) **flexible** (through the gamemaster), the **environment of repeatable training** (thanks to the VR) while the time ticks and unpredictable dangers emerge to fit a real crisis.

## 5. Results and Discussion

To evaluate the effectiveness of these applications with precise user feedback on each role and each functionality, we interviewed real practitioners. The demonstrations were experienced by more than thirty observers, all of whom had experience in disaster situations. The demonstration was made to last 25 minutes which can take a day to produce in real training with all the person intended. During one training session, one dozen of person has to accomplish different actions in parallel and in real-time. All the players had only a few pieces of training to help them understand the VR equipment and their roles. A large majority of practitioners confirmed their interest in this technology. Some of them recognise the need for their organisation to have this type of tool to train for crisis response. To better understand their comments, a questionnaire was provided after the last demonstration of the last iteration of this RESEARCH project. We performed a qualitative evaluation based on a few qualitative responses, including three from firefighters' colonels and commanders.

Feedback proves the contribution of the gamemaster. The appearance of the environments and the immersion of the players have impressed the observers. To the question "*how this project can help training*", firefighters answer: "*By the possibility of easily confronting professional crisis management scenarios and especially of being able to repeat them by modifying certain parameters to gain experience thanks to a credible field simulation*". Even with this positive feedback, it is important to understand what

makes it so encouraging. This proves that our research work answers some of their needs.

The live demonstration also highlighted some technical problems with the implementation of the environment. The 3D replicas had texture errors and lighting problems. The next version, more optimized and with new locations, will be integrated in the same way as the previous ones. With this framework, it is easy to imagine that any 3D model usable for VR can become a training sandbox.

It is important to point out that the work achieved by the players consists of simple tasks, combined in a collaborative process. Expert manipulations are not the objective of the simulation, but the collaboration between different people is. It is possible that for the continuation of the project and future tests, explanations on the handling of the virtual reality equipment as well as on the functioning of the navigation control and interactions could be set up. The level of acceptance of these technologies seems to be pleasantly high and even the most reluctant can project themselves on this use complementary to their training. To complete this feedback, it will be necessary to develop these answers with more in-depth questions. Indeed, the work focuses on four levels: *knowledge*, *action*, *process* and, above all, *collaboration*. The simulations created with this principle aim to reinforce this aspect of the training dedicated to crisis management. And that is why the combination of the gamemaster and its propagation mechanisms can be a strength for realistic training. Especially if the *Exercise Animation* combined, in addition to the *Exercise Context*, with the *Exercise Analytics*. This combination is the future of learning.

## 6. Conclusion

The project responds to a clear need for effective, realistic, flexible and repeatable training. To go further and propose more flexible training, would it be possible to have several gamemasters, with their own pedagogical goals, working with each other to disrupt and adapt a common training? Would it be possible to change the propagation rules during the simulation, without interfering with the training? Would it be possible to pre-affect propagation rules to objects accessible to the gamemaster through a predefined library of components? How would these additional elements facilitate crisis management training? A lot of exploration remains to be done on Exercise Animation, which has been identified as an important key for the future of crisis preparation. And these are

questions at the heart of our future research and experiments.

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