note n°05/11

Transatlantic Security Paper N.2
June 2011

FONDATION pour la RECHERCHE STRATÉGIQUE

CENTER FOR TRANSATLANTIC RELATIONS

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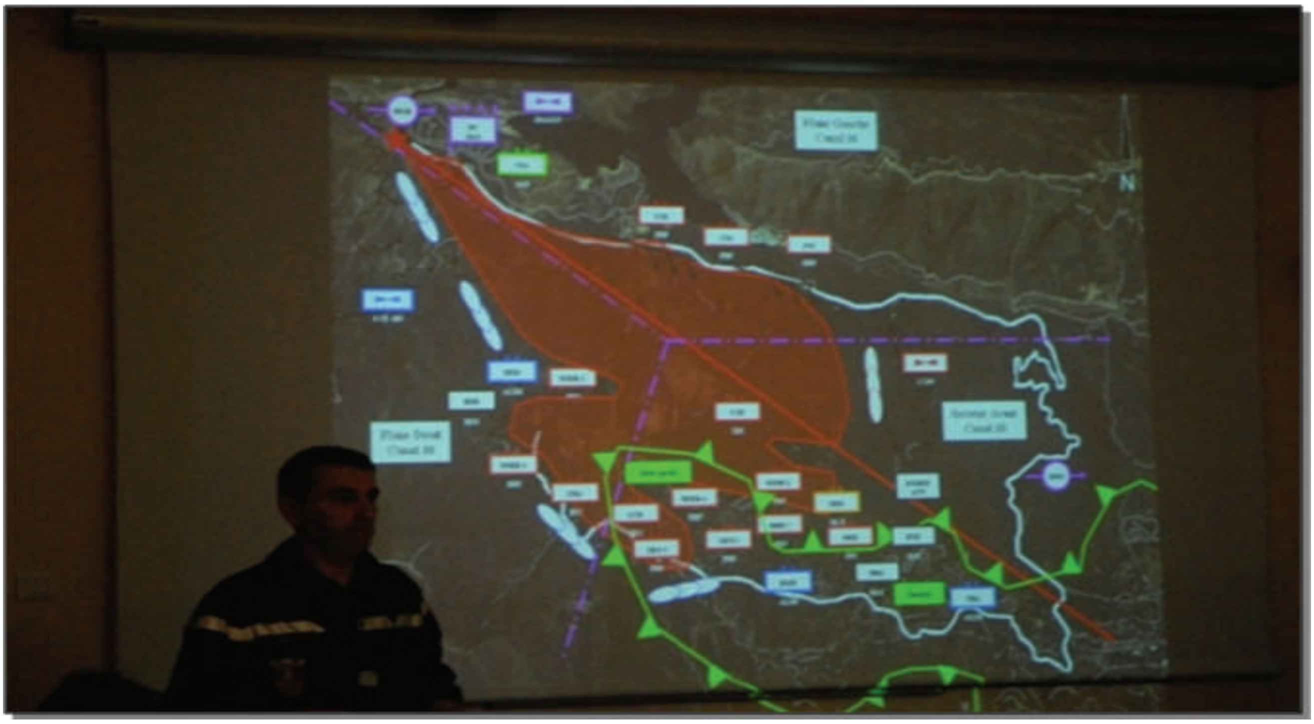
The next step after Japan?

(Virtual reality, training and crisis management)

Introduction

The recent crisis in Japan, which combined tsunami and technological events, shows that any crisis, especially those in developed and developing countries, is from here out a hybrid crisis, mixing natural factors and human/technological (NATECH). Faced with such dramatic events, which exceed any means available for emergency rescue service, it is necessary a) to remain prudent and b) to prepare. One of the means for preparing is unquestionably training. However, here, undoubtedly there are important constraints: How to train, for example, while reproducing vividly and realistically, an event? How to exceed the admittedly useful, although very limited, level of the table-top exercise? How also to avoid the unnecessary mobilization of dozens, even hundreds, of field and operation staffers to take part in an exercise which could lead to a disappointing outcome? A major crisis, a major exercise, in effect. The solution of virtual reality has emerged, in Europe and in the United States. It is also sometimes called "serious game".

Serious games, or "game-learning", are designed with the main purpose to train, investigate, or communicate. The term "serious game" is not new. Clark Abt discussed the idea and used the term in his 1970 book *Serious Games*[1]. In that book, his references were primarily to the use of board and card games. However, he gave a useful general definition which is still considered applicable in the computer age: "Reduced to its formal essence, a game is an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context. A more conventional definition would say that a



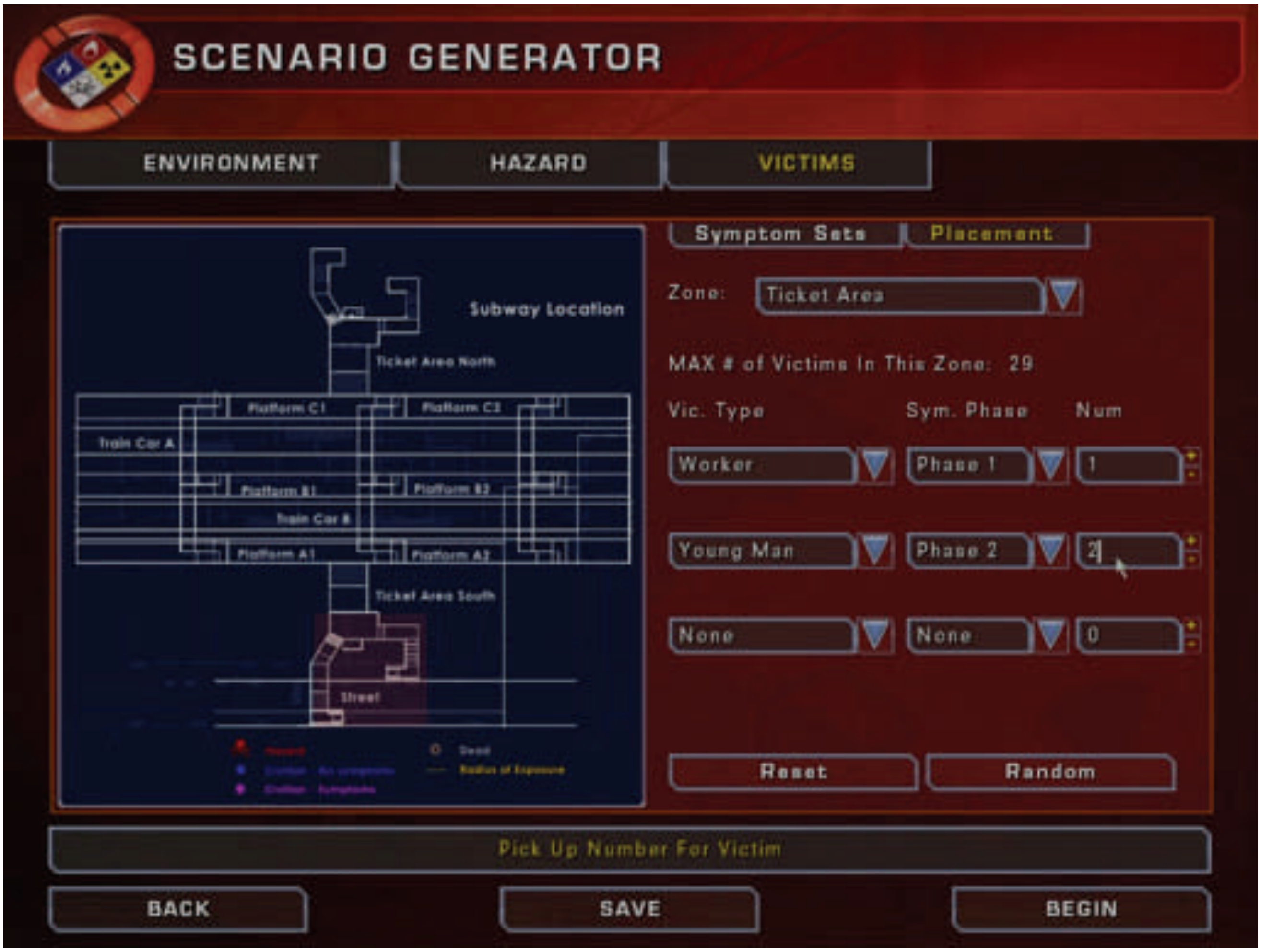
(© SDIS 13)[6]

game is a context with rules among adversaries trying to win objectives. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement." Earlier, officers have been using war games in order to train strategic skills for a long time (*Kriegspiel*). Mike Zyda provided an update and a logical approach to the term in his 2005 article in *IEEE Computer* entitled, "From Visual Simulation to Virtual Reality to Games". For him, serious Game is "a mental contest, played with a computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."[2]

When culture matters

Initiatives and other pilot programs have been developed for a number of years in Europe and in the US. Thus, the American and French fire fighting schools - Emmitsburg,[3] the US national fire school, ENSOSP[4] (which trains all French fire fighters) (*École Nationale Supérieure des Officiers de Sapeurs-Pompiers)* and ECASC[5] (ÉCole d'Application de Sécurité Civile de Valabre) (specializing in the fight against wildfires) each layout different types of serious game for firefighters. For the first time, a Franco-American exercise took place in France. On December 8, 2008, an American team from the NIMO TEAM, directed by Commander George Custer, took part in a Franco-American experimentation on a simulator of wildfires. In the end, the two teams adopted rather similar tactics, even if the positioning of the materials of rescue on the ground appears to have been a little different. But overall, a cultural difference in measure, according to the observers, came to light - the Americans looked to apply their rules of engagement to the crisis, while the French fire fighters sought to deduce their rules of engagement from the crisis itself.

It is true that the stakes are important: Emmitsburg has chosen techniques and teaching methods more founded on the standardization of practice, while ENSOSP seems to focus more on the adaptability of professional behavior to evolving situations. Another American product exists: *Hazmat: Hotzone*. It is an instructor-based simulation that uses video game technology to train first responders about how to respond to hazardous material emergencies. *Hazmat: Hotzone* is currently in development at the Entertainment Technology Center at University Carnegie Mellon in collaboration with the Fire Department of New York.[7] This software uses a scenario generator which makes it possible to configure and automate situations. A maximum exploitation of this approach is the configuration of decisional trees. This last approach, although it has some advantages (in particular, particular assessing the level of the players), also has several disadvantages: it cannot measure innovation, spontaneity or adaptability.



(Screenshot: *Hazmat: Hotzone*©)

Some technical definitions:

An *avatar* is a computer generated 3D character that represents the player, and that the player can move,

A *Non-player character* (NPC) is a 3D character controlled by the computer,

Terrain is the landscape that the characters move around in,

A *polygon* is a collection of pixels that forms a small plane surface; many polygons are combined to create a typical complex surface.[8]

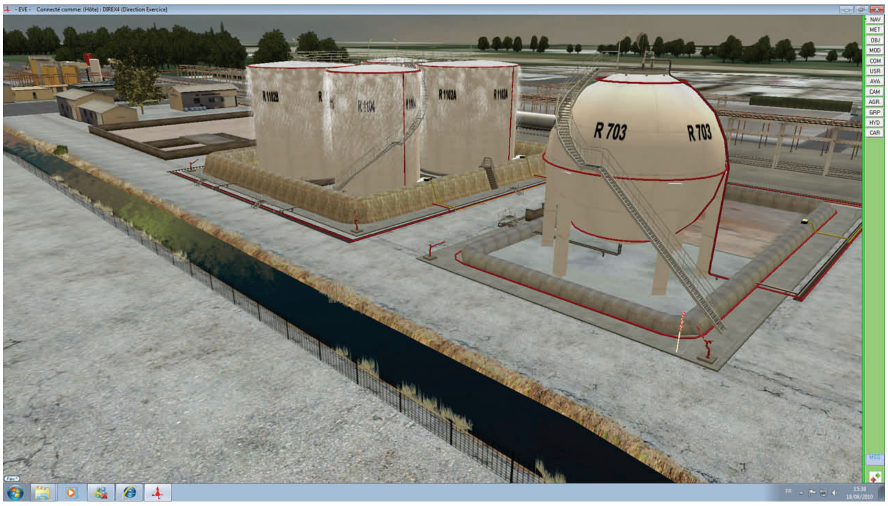
However, all in all, the objectives are the same ones:

Common Objectives

Decision makers training and communities of practice (CoPs)

Operational situations are often characterized by their kinetics and their magnitude (and by extension the severity of the effects). The more these two factors will be important, the more controlling events will be a serious challenge. Both a kinetic and large event, the radioactivity leaks in Japan have shown their short-term effects, including panic, even if the Japanese population seemed to be remarkably calm and rational. In the Japanese case and in general, first responders and decision makers, more particularly, deploy the following responses to impose control:

- Analysis of the situation to understand what has occurred and what may occur;
- Evaluation of the stakes to analyze what may be impacted;
- Definition of the objectives, the prioritization of action and not unnecessarily "dispersing" resources, which, by definition, are initially limited;
- Control of results obtained for adapting the plan;
- And generally, sequencing.



At the time of complex situations, these various phases require the implementation of decision-making support units involving several actors, even possibly different services, in order to offer a wide spectrum of competence and to be able to divide the tasks. A crisis is characterized, in particular, by the failure of the decision-making process. If the decisions taken are incoherent, unsuited, and consequently ineffective, the event will completely suffer from the decision makers by a very negative feedback loop. The avoidance of crisis consists in the prevention of ending within such an outcome, often arising from the magnitude and the complexity of the initial event. It is thus crucial to train decision makers while placing them at “the razor's edge”, managing all the organizational, technical, and especially, human aspects of difficult circumstances, which are characterized by a context that can be strongly degraded by stress and uncertainty.

Educational objectives repositioned on necessary competence

Too often, training in the public or private sector conducted for the intervention into accidental situations remains theoretical (centered on “knowledge”). Exercises or scenarios carried out that consider the technical difficulties of organization but lack the realism of threatening effects, consequences of actions taken by the trainees, and conventions of exercise, make it only partially possible to gain “know-how”. The lack of interactivity, relative to evolutions of a situation staged and defined in advance, does not allow working on a fundamental dimension relating to behavior, to capabilities of adaptation and initiative taking initiative. New methods for creating training scenarios that rely on virtual reality tools allow simultaneously activity on these three completely complementary dimensions. Virtual reality enables a total interactivity between the trainees and a realistic shared representation, in

real time. They can thus follow the evolution and measure the effectiveness of their strategies of reaction.

Different types of simulation and scenario

One can distinguish several types of exercise:

- Exercises of management which have the purpose to train, enhance or test the capabilities of the chain of command. It develops the strategic as well as the tactical level. Charged to analyze, decide and inform, managers must show reactivity, anticipation and adaptation in a complementary way;

- Practical exercises (or operations) which aim at training tactical operators. The perfect knowledge of the materials and equipment is essential. It is thus fundamental that the training permits a guaranteed control in the most realistic possible context (actual tools, site used and context adapted);

- Global exercises which involve the two types previously cited – managers and operators. This type of exercise faces the limitations of the requirement for personnel engaged in providing daily coverage (actions of rescue for firefighters, public safety for the police force or national police) to remain on “the streets” for the duration of an exercise. Moreover, the participants acting as the population and victims in general do not adopt the attitudes - in particular, panic and the temporary lack of social norms - which can be anticipated or feared in a real situation.

Virtual Operational Environments

To meet the specific needs of civil security and defense, simulation tools were developed and are currently used for training fire fighters. The simulation of virtual operational environments is a solution which is as of now operational and which holds many advantages. Let's be clear on “simulation”: it does not consist of a simulation in the military approach, the handling of divisional, regimental or infantry manpower, in a sophisticated counterpart of a “shoot and kill” video game, where the reflexes towards identifying targets are paramount. The such military simulation are costly and undoubtedly out of proportion for any actor in civil security. Useful simulation for actors in civil security is a technology that is both easy and less expensive and which is deployed on traditional computer platforms through networked computers, allowing accurate reproduction of the operational context (virtual reality) and the command and decision making process (command tools, transmissions) in a continuously evolving and interactive context: the concept of virtual operational environment. A virtual operational environment includes:

- A visually and auditory realistic depiction of the events, of the operational context, and their evolution in real time;

- Reproduction of the work environment (buildings, transmissions, decision making tools) usually present in a real context;

- A representation of the actions made or decided by the trainees, as well as the immediate impact of these decisions on the operational context

- A stage-management team which ensures the coordination and the coherence of the exercise (Play calls with trainees, telephone contacts, radio operator contacts…).

The framework of reality thus created is obtained by the presence of the actors involved in their own role in the midst of the action with accurate reproduction of events, which includes aspects of domino effects (fluid flows of weather geography, and physicochemical characteristics of subduing substances), etc. In other words, the simulation is used to address the following concerns:

- The operational ground, including the dimension of multi-agency;

- Complex event handling;

- And finally, the visualization of the actions and their effects in the operational context.

Virtual reality allows pushing operational realism further and makes it possible to confront participants with particularly credible and formative virtual technical environments.

By definition simulation helps to reproduce anything: refineries, plants (creating an obvious additional interest for companies, forests, transportation networks, public places, and critical infrastructures. The possibilities are by definition infinite, which is obviously not the case with exercises “in reality” which are “life size”. It ensures a reproducibility of operational situations to develop a common culture among many actors in bringing them into an identical experiment. The developed tools also contribute different operations each time thanks to the software engines which determine the evolution of the disaster in real-time in accordance to the actions carried out by the users (total real-time interactivity).

Different types of exercises

The system is used in various modes:

- Automatic: nothing is scripted, the system calculates in real-time and posts the visualization of all the effects of the disaster and the evolutions as a result of the countermeasures taken by the actors. It consists of a very interesting mode of function to ensure the training of seasoned teams or their evaluation at the end of the formation process: the system is the “Justice of the Peace” of the relevance/irrelevance of actions carried out in measuring the level of effectiveness in real-time;

- Semi-automatic: the system proposes situation assessments, which are validated or not by the trainers' committee according to the level of expertise of the trainees. It is the operating process used in phases of formation for consolidating competence;

- Manual: the trainers launch the visual representations according to a predefined initial stage. This operating mode is very useful for starting the training of new teams, and working on basic and systematic processes.

The advantages of a standard platform of “civil security” simulation are numerous:

- Opportunity (interactivity and realism);

- Reversibility of effects (adaptability of the level of difficulty and situation);

- A potentially infinite number of events (domino effect);

- Multilevel crisis management and experience feedback;

- Communication.

Simulation training can thus be adapted to many different levels of expertise. Application software adds further dimensions to the domino effect, which is calculated according to interfaces (for example, a leak on a chlorine tank will dynamically be reproduced according to the characteristics and proprieties of this product, the localization of the tank, or external factors/pressures such as the wind).

Set up of exercises

This consists in a mode of operation enabling the use of new tools. At first it is necessary to define the educational objectives in terms of adapted knowledge, know-how and behavioral skills (level of the trainees, initial formation or training), etc. The creation of an exercise forces the mastering of the first pedagogical constituent, but also in gaining sufficient expertise to develop operational topics and the various technical documents to be "as true as nature" as the trainees and the orchestrators will have need to use. This stage of design can be relatively significant in terms of time (counting ten to twenty hours of developing a four hour high level exercise). For example, an exercise for technical advisors lasting four hours:

- 0:30 hours of preliminary briefing for presenting the initial framework and conventions of the exercise;
- 2:30 hours of effective work with the virtual reality platform;
- 0:30 hours of debriefing by group;
- 0:30 hours of collective debriefing.

Platforms developed for civil security

In order to illustrate the subject, two examples will be developed hereafter:

The first relates to technological risks. It illustrates the capability to model and reproduce complex phenomena (explosions, fires, toxic clouds, effects of the thermal radiation, the flow of liquids...) and allows firefighters and industrials to work together by reproducing events of very great magnitude in relation to both industrial sites at risk and accidents in the transportation of hazardous materials;

The second is relative to formations for fighting wildfires because it illustrates the power these tools are capable of in reproducing the development of fire encompassing large areas (several departments) in a very realistic way by using true visual representations of the terrain while also making it possible to engage jointly methods from the air and ground.

It is advisable to mention that these platforms, located on two different sites are completely interoperable.

Technological risks and urban fires

In 2004, ENSOSP set up a technological risk simulator especially designed for the training of technical advisers in chemical risks. This development was carried out within the framework of a joint project supported by ENSOSP, and the US company Chevron-Oronite. Today, the Chevron safety executives and firefighters work on the same tool and take part in common exercises and trainings. This simulator is also used to play out more social or sensitive themes (strike, malevolent attack, terrorism).

This joint approach makes sense: The effectiveness of any action in extinguishing hydrocarbon

fires is largely conditioned by the coordination of the various resources of firefighting, (cannons and foam reserves) cannons and emulsifier reserves, etc. It is also associated with a good overview of the situation and phenomenon within its environment in order to prevent or minimize the risks of the domino effect. Virtual reality holds great educational richness for training actors about such complex scenarios.

Wildfires

ECASC originated the development of these new tools and since 2000 has been using a wildfire simulator to ensure the training of officers at the command of interventions of great magnitude. One of the most interesting aspects which have appeared is an increased interoperability between field responders and pilots, in the sense of an improved understanding of sometimes diverging and even contradicting perceptions and practices.

The complexity of a simulation can sometimes be increased in detail, such as for example crowd simulation.

Approaches on the crowd simulation for civil security

The problem of the collection of relevant information, i.e. usable by digital programming/ artificial intelligence, is banally tied to the definition which one gives to "crowd": When can we regard a "crowd" as a concentration of individuals? Are the behavioral actions of a crowd a) analyzable and b) quantifiable or measurable? The obvious corollary is this: up to what point is it relevant and acceptable to proceed with simplifications in the representations of a "crowd"? Certain computing researchers have brought solutions, which will probably seem "basic", even simplistic, to specialists on collective mobilization or sociologists, but which despite everything support some practical advances. The question here is not to provide the most perfect definition of "crowd", but to allow useful concretizations. An inevitable simplification is acceptable if it permits useful uses. As an example, McPhain defines a gathering as a form of collective action where more than 2 agents are engaged in one or more fundamental actions (vertical/horizontal locomotion, orientation, vocalization, verbalization gesticulation and/or handling of objects).[9] This approach appears adequate to us insofar as it is primarily functional. It does not seek to provide a typology of a crowd starting from its total description and/or its goal. In the same way, the formation of a group of individuals, their collective aggregation, is caused by a fundamental event. Schweingruber and McPhail propose criteria of classification based on four different states or levels of density - from unrestricted passage to a difficulty in clearing. This classification rests explicitly on the idea that a crowd is temporarily or permanently determined by the constraints of the environment where it is driven (if it is driven). It also seems to us that the observation of the field, in particular, the element "crowd control" justifies an approach of multiple interactions between actors who have different roles and interests, even divergent (police, media, passive passersby and observers), etc. It should be also admitted that a useful approach for civil security does not require regarding a crowd as a homogeneous whole, but to distinguish within it agents having an individual driving or gravitational behavior to other agents (for example, example the agent who would play an intermediary in the process of evacuation). Doing that, our approach is distinguished consequently from theoretical work on convergence, which postulates a crowd as a rational collective actor, with a defined common goal, etc.

It seems on reflection, that the technological choices (in particular, specific softwares and modules of artificial intelligence) are narrowly determined by the final use of the designed product. What does one want to find? Does one want to develop simulations of evacuations of very big crowds, the type of a football stadium, or simulations of professional and organized crowds, beyond behavioral degradation caused by stress - evacuation type of a production line at a factory site? It is certain that common points are potentially observable, for example, between the evacuation of an industrial site and the evacuation of an offshore oil platform (the same rational and normalized manner of evacuation/ reaction?). On the other hand, on examination, the problems of maintaining order and crowd control seem a very complex issue to work out for a product made for operational frameworks of an intermediate level, the type for commanders/operational/team leaders. The principal difficulties indeed appear to be the definition of behaviors and individual agents who are both sufficiently realistic and capable of having an involving or "aggregator" effect on semi-autonomous avatars. An additional difficulty would undoubtedly be the addition of culturally defined behavioral attitudes (for example, example the development of a Shia, German or Sub-Saharan African crowd), etc.

Many simulation models have been developed for evacuation management. They range from simple and procedural descriptive dimensions to complicated mathematical models. Moreover, some generate rather impressive detail, but only in direct proportion to the quantity of information, which is appropriate to collect for an optimal use of the model. The best is the enemy of the good in this case. The models of average complexity allow certain adaptability for its users, though they also are very demanding in regard to the collection of preliminary data. Southworth (1991) and Jamei (1984) carried out a systematic examination of the existing models:

Macro-Models of Evacuation

As an example, NETSIM (FHWA, 1995)[10] is famous for its robustness, its consistency and its reliability, but the quantity of data which it requires does not make it practical for a large population (about a few hundred). DYNEV (KLD, 1984)[11] is the model (deterministic) most known for evacuation exercises. It was conceived as a view to the evacuation of populations around a nuclear plant and can generate results which "begin" to have an operational interest. It is, in particular, possible to exploit certain exogenous variables of this software.

EVAC PLAN PACK Model is a model both probabilistic and dynamic[12]. In particular, it takes into account the congestion and obstruction of vehicles in a phase of evacuation.

Other models could be cited here: EMME/2[13], TRAFL[14], TRANSYT[15], or UTPS[16]. The majority use an approach based on simulation. These here offer undeniable advantages as measured examples of mass evacuation are rare. They also permit to test certain situations in terms of congestion, obstruction to flow, etc. In essence, models of dynamic management of traffic (Dynamic Traffic Management)[17] are of complementary interest, especially if they provide the following characteristics:

- Human/response factors of the evacuees to alert messages,

- Network topology, so that convoys and evacuees can "find" the best trajectories, or the shortest and least congested, etc.

However, not all these models appear to be able to be directly useful for fire fighters because the "focal range" is much too broad in regard to their needs.

BDI Software and Virtual Reality

More useful perspectives appear offered by software of the type BDI (*Belief-Desire-Intention*) intended for the programming of "intelligent agents", defined here as autonomous entities, which act/react and interact with the environment.[18] The BDI model, developed by Bratman[19], considers that intention and desire are active attitudes, but the intention is controlled by definition. The action is consequently, the difference between desire and intention, which leads to a temporal persistence of plans and/or the formation of subsequent plans/Phase +1.

Ideally, a computer BDI agent will react according to the following sequence:

Initial state

Repetition

Options: Generator of options (events queue)

1. *Selection of options: choice*
2. *Re-actualization of intentions (Options selected)*
3. *Execution*
4. *Arising of a new exterior event*
5. *Elimination of failed attitudes*
6. *Elimination of impossible attitudes*

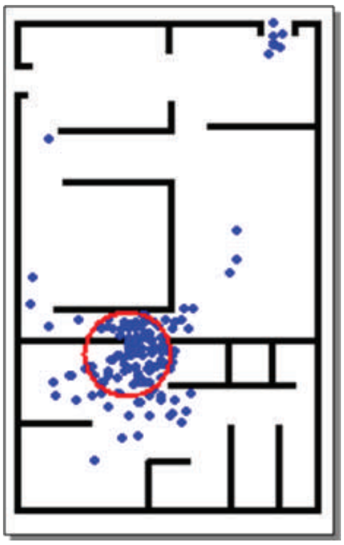
End, repetition –retroactive loop.

Apart from a moment of surprise or panic immediately following the occurrence of an event, an evacuating population is regarded as rather rational and involved[20]. The fundamental criteria are the degree of preparation of the crowd, i.e. its capability to respond in an effective way (to save lives, to evacuate, to escape, altruism) or "ineffective" (panic, egoistic behavior, etc). A crowd of professionals, the type of personnel of a chemical plant, will be more organized, altruistic and prepared than a civil crowd (standard attack on an area or in the subway). On the contrary, a "civil" or "by chance" crowd will be more inclined to spontaneously adopt reactive or instinctive reflexes of escape, verily from panic, without direction (at least initially), even for the individuals who approach personal practical strategies quickly.

Two levels can be distinguished here:

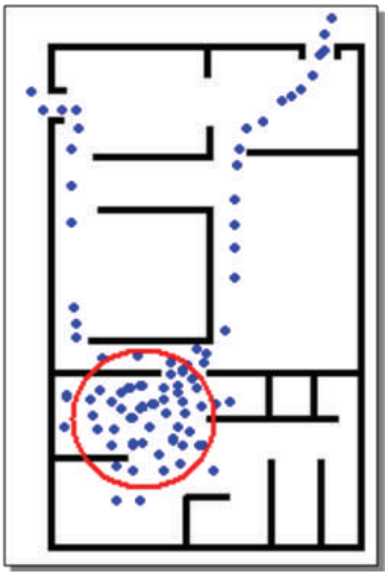
- The reactive level: quasi-immediate behavior in time which does not require reflection, a reflexive behavior (but complex as it is the result of education, culture, of the circumstances of the explosion and the terrain, etc.). By example: avoidance between people, emotional reactions (visible or not).

There appear to be three possibilities:
A competitive behavior is often observed in emergencies, when the individuals are in competition for their own chance of exiting (and of survival, if necessary):



The competitive behavior in general induces total or partial dysfunction, or unsuitable collective behaviors. Collective behavior of competition occurs when the individual units (a) go in a hazardous way until a goal is fixed, (b) seek a goal with a maximum rapidity and do not seek to negotiate with other agents, and (c) dos not seek to avoid collision (thus the individual cultural bubble is close to zero).

On the other hand, a behavior of creating a queue can emerge spontaneously when crowd aggregates (a) in front of an exit and (b) when it is formed/informed/prepared/trained with procedures of evacuation.



The behavior of creating a queue supports a fluid flow of the population. The formation of a queue largely appears a self-organized and conducted movement, not at congestion and very concentrated exit points, but at those with less congestion or most likely none at all. A behavior of creating a queue occurs when the individual units go randomly until a goal is found (a), search for a goal (b) and (c) if prevented by other individuals from evacuating, "negotiate" to create a queue or join with an existing queue. Looked at another way, it is rather close to the phenomenon of monitoring, as in ticket purchase or demonstration.

The fact of it is that it is often difficult to distinguish among the three levels of behavior.

Conclusion

In the end, we are witnessing a major change where firefighters are at the same time the main actors and recipients: simulations so that each day practiced makes it possible to work on large land-air scale scenarios (for wildfires, in particular), to improve multi-agency action/cooperation, to map out scenarios of events of great amplitude, to model past interventions, to place participants in the center of the action, to debrief stage by stage situations clearly in 3-D, and finally, to evaluate tactical reasoning, the procedures and the ideas of an operation.

The currently developed platforms make it possible to reach a determining stage of formation from high decisional levels to that of the first responder by completely immersing trainees in the middle of the events. They feel the effects (visual and aural), the stress and thus can prepare effectively. Technologies to share information remotely via the internet will also make it possible to plan the work of the trainees from different sites in order to minimize the logistical costs of displacement while preserving teaching aspects. The increase in exercises involving public actors, resulting from various operational and private services, is desirable in order to reinforce the synergy and quality of the preparations.

A transatlantic approach on this subject, even simply Franco-American, would have many and substantial advantages:

- Joint training on transatlantic exercises of large scale (type Japan, Chernobyl, Katrina),
- Evaluation of respective practices (Lessons learned),
- Creation of communities of practice on an international scale,
- Standardization or reciprocal knowledge of the operational procedures and doctrines,

In the short run, a transatlantic seminar on serious game and the civil security, associating experts, fire fighters and other potentially interested actors through education and training could allow the definition of the prospects and challenges in creating cooperation in this field.◊

Assertions and opinions in this paper are solely those of the author (s) and do not necessarily reflect the views of the Center for Transatlantic Relations or the Fondation pour la Recherche strategique.

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Presentation

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