CONSTRUCTIVE SIMULATIONS AS A COLLABORATIVE E-LEARNING TOOL FOR TRAINING OF EMERGENCY TEAMS

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Abstract: Modern armies have a mission to help citizens in different kinds of emergencies such as floods, earthquakes, nuclear and chemical accidents and pollution, as well as help in massive diseases. These tasks are very complex due to many organizations and social groups involved. If needed, they are forming emergency teams that act in challengeable conditions. Complex nature of emergencies requires advanced training methods. Simulation exercises provide researchers to vary conditions, to insert unpredictable events during simulation, to stop the exercise in any moment and to record course of actions for the later analysis and deriving of conclusions. Moreover, simulations are safe to evaluate the readiness of emergency teams and crisis staff for new situations, which have never happened before. The simulations obtain exercise dynamic and conditions closest to reality. This paper explains methodology, development of simulation exercise based on flooding scenario, the limitations, benefits and ways for use simulation exercises in the training plan and education curricula.

Keywords: constructive simulations, joint simulation exercises, emergency teams

INTRODUCTION

Today, constructive simulations are mainly used in military education and training. During the simulation, participants play different roles – as command staff members or act as unit commanders, responsible for fulfilling simulation objectives.

Modern armies have a mission to help citizens in different kinds of emergencies such as floods, earthquakes, nuclear and chemical accidents and pollution, as well as help in massive diseases. These tasks are very complex due to many organizations and social groups involved: governmental and non-governmental institutions, emergency services, rescue teams, voluntary groups and local people. They have different skills and knowledge. They are forming emergency teams and staff that act in very hard conditions – limited resources, short time, security risks, necessity for fast response, partially or full-destroyed traffic and communication infrastructure.

Complex nature of any kind of emergency directs us to simulation exercises as the only way to prepare emergency teams and staffs. These exercises invite all parties that should act during the disaster.

The next section is a short review of previous research work with the focus on constructive simulations. In addition, it gives the contemporary software products used for constructive simulations. The third section explains methodology for development of simulation scenario. The following section describes different aspects of exercise implementation by using flooding scenario. Finally, the conclusion part includes the experience related to concrete scenario, but also experience gathered during 10 years of practicing the simulation exercises in military training and education.

RELATED WORKS

Although there are different categorizations of simulations (Sulistio et Al., 2004), the most common for military training is division into three categories (Hodson, 2009): constructive, live and virtual simulations. Constructive simulations are the most complex category designed for training and education of staff and commanders of joint forces in order to fulfil complex long-term tasks. Different subject matter experts (i.e. different branches and services, such as engineers, artillery, infantry, armoured, reconnaissance, medical, transport, communication and many other types) are organized in expert teams in order to act as a whole. They need to learn from each other and to adapt their specific working procedures according to new tasks and organization. During the simulation, the participants play different roles – as command staff members or act as unit commanders, responsible for fulfilling simulation objectives. Beside computers and computer networks, they use maps, literature, and regulatory documents for fulfilling their tasks. Different mathematical and logical models are implemented in simulation software to emulate the dynamic of operations as realistic as possible (in different domains as spatial, time, etc.).

Constructive simulations are simulations based on computers and computer networks. These simulations use mathematical and logical models to show the dynamics of combat operations. The influence of the human factor in constructive simulations is limited to the use of people in the role of operators on simulation software, who during the simulation exercise must strictly apply tactical and management principles and use of assigned units (Chauhan, 2013). The logical and mathematical models used in the simulations were developed by experts in the field of the use of forces on the battlefield. The simulations show the dynamic behaviour of units, such as marching, performing various manoeuvres during combat operations, opening fire, supplying food and ammunition, repairing faulty equipment, medical evacuation of personnel and others (Dutta, 2010).

This type of simulation is a powerful tool for researching the characteristics of the existing systems and weapons, as well as for testing the possibilities of new combat systems considered for introducing the armed forces in different meteorological conditions and during the realization of different scenarios of force use. Moreover, simulations significantly reduce the cost of introducing new combat systems in use; also, the simulation can be repeated countless times, if necessary, from the beginning or from any point in the simulation time that needs to be realized again.

There are many constructive simulation software products. The most frequently cited are: JANUS, ROMULUS, SWORD, SOULT (France), JCATS, ONE SAF (USA), and GESI-SIRA (Canada & Germany). These products can be used for exercises of several levels of commands and units, from company to division (Simic, 2012).

METHODOLOGY AND DEVELOPMENT OF CONSTRUCTIVE SIMULATIONS

There are three phases for development of exercises for training of emergency teams by using constructive simulations: model preparation is the first, testing of simulation exercise phase is the second one and there is planification phase (CEISIM, 2009).

MODEL PREPARATION PHASE

Model preparation phase begins when the exercise creator (trainer, teacher) delivers the basic information about the exercise – the main goal, the exercise objectives and tasks, and the basic ideas for realization. This information also includes maps, human and technical resources planned to be involved in the exercise. Technical staff that is responsible for simulation exercise development arrange several meetings with subject matter experts (instructors, teachers), facing them with possibilities and limitations of simulation software, human and technical resources and time available for exercise. They together try to find an optimal solution. Model preparation phase lasts 4–7 weeks. Time is shorter if there are assets already prepared for some previous exercise (e.g. digital map, equipment, units) that can be reused in the new one. Each piece of equipment and each human (soldier or civilian) as well as each unit have to be transferred and represented with one artificial object (hereinafter *pion*) in the virtual environment. More precisely, technicians together with subject matter experts have to make particular models for endangered people and animals as well as for civilian authorities (e.g. local society institutions, police, medicals, emergency staffs, non-government organizations, humanitarians, etc.). This process is commonly known as *force generation* (military term).

One of the biggest challenges during this process is to make optimal solutions to adapt scenarios to the number of operators and working stations. Simulation software provides control of 1–50 pions by one operator. If the scenario implies more action of a particular pion, the operator is more engaged for its control. Technicians use specialized software tools for modelling of maps, pions and forces. They have to define parameters of logistical support for each pion (e.g. fuel for vehicles, equipment and health statuses for humans and animals, etc.). For instance, creation of new land/water/amphibian motor vehicles (crafts) includes defining vehicle speed in different conditions, fuel and lubricant consumption, load capacity, maintenance intervals and time consumption, but also some experiencing data as conditions and probability of failures during exploitation. After all parts of exercise scenario are completed by using different software tools (i.e. terrain editor and map generator, pion editor, force editor and force generator) they are saved in the appropriate formats. The technicians check everything with subject matter experts again and start the transfer process for loading of the scenario into the simulation server. This is the end of the model preparation phase.

TESTING THE SIMULATION EXERCISE PHASE

The purpose of testing the simulation exercise phase is to check correctness of digital map and pions behaviour in the virtual environment. They should be fully functional in accordance with the requests of concrete scenarios and exercise plan. This phase is commonly conducted seven days before the beginning of the exercise. The trial exercise is attended by the exercise director (heads of emergency teams), teachers (instructors of members of emergency teams), and technical staff and all operators participating in the exercise. One-day trial exercise seven days before the real exercise provides enough time to make minor changes of model and/or fix the bugs on map and pions. Moreover, the technicians use the trial exercise to conduct the training and preparation of operators for performing particular tasks during the exercise.

PLANIFICATION PHASE

Planification phase provides the initial set up of pions (humans, animals, vehicles, equipment etc.). Members of emergency teams, based on the concrete tasks, with the help of the operators, set the units on the digital terrain. Commonly, realization of this phase is one day before exercise and it lasts two to four hours. In exceptional cases, its realization can be immediately before (on the day) of exercise.

During this phase, the exercise director and teachers monitor the work of trainees (emergency team members) and coordinate with technicians to provide all necessary conditions and support. At the end of the planning phase, the exercise director controls the initial distribution of forces and finally, approves the initial constellation of forces for the exercise. In other words, the simulation model is finished. This is the end of planification phase. The saved model is reusable unlimited number of times and can be modified for further requests without need to repeat the development process from scratch.

IMPLEMENTATION

This section describes the simulation exercise in case of use of military forces in the operation to support civilian authorities in flood protection and rescue in the area of Mačva and Srem. The simulation exercise was performed by using constructive simulation software Janus FR-11. The simulation scenario included:

1. Growing of water level,
2. Land and air evacuation of endangered humans and animals from the areas affected by the flood,
3. Land and air evacuation of injured humans and animals from the areas affected by the flood and their disposal at the medical stations,
4. Extraction and repair of damaged technical and material means, and
5. Removal of landslides from blocked roads in the area affected by the flood.

The digital map of simulation exercise area includes realistic terrain of Morović, Bogatić, Crna Bara, Crnobarski Salaš, Badovinci, Dublje and Klenje. The next figure shows the initial positions of the engaged forces (blue objects on the maps below) in the area of Bogatić (LHS) and Morović (RHS) defined in the planification phase (Figure 1).

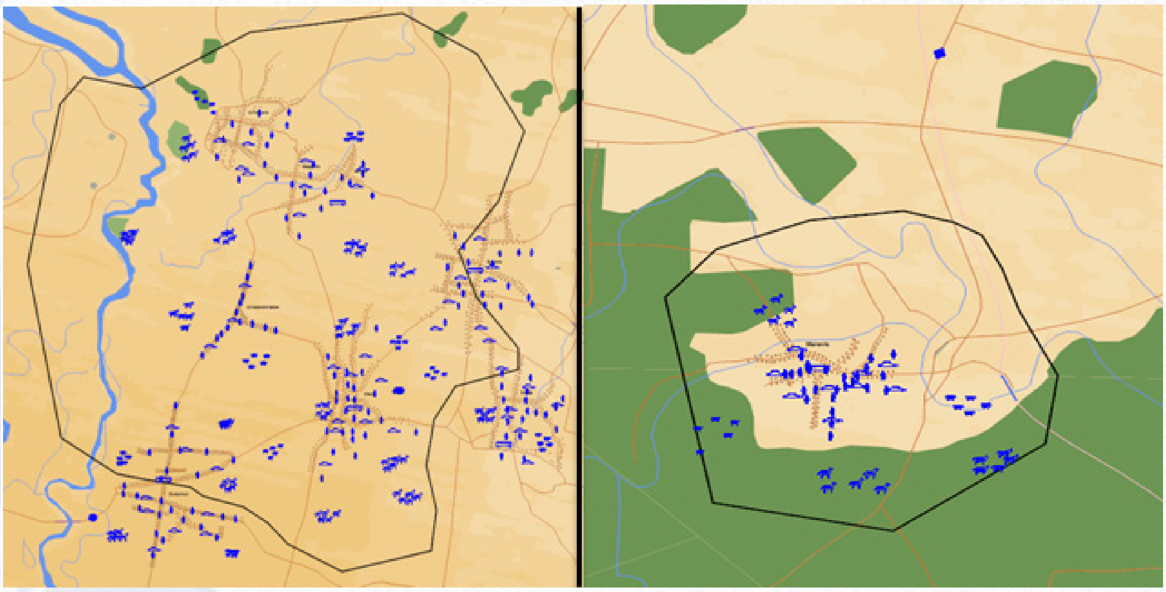

Figure 1 – *Planification of forces in the area of Bogatić and Morović*

Flooding Setup Phase

After planification and before beginning of the exercise, specifically for flooding simulations is that there is an intermediate phase for defining flooding parameters (Figure 2). It includes defining the centre and borders of the flooding area, water level at the beginning and end of exercise, *flooding resolution* and *updating frequency*.

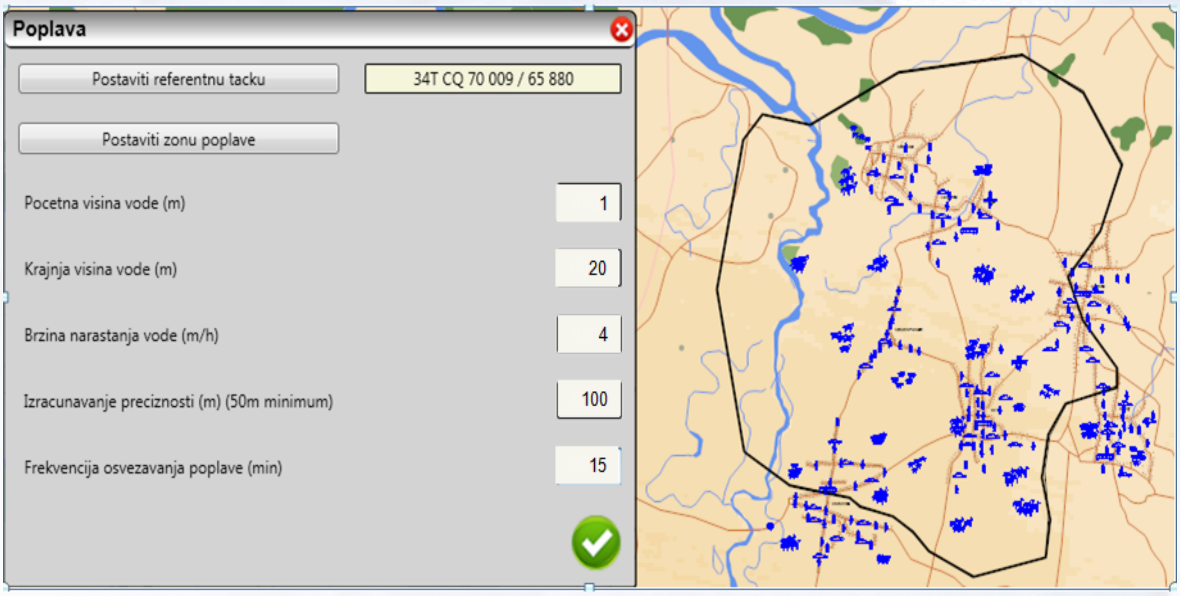

Figure 2: *Flooding setup in the area of Bogatić*

The centre of the flooding area (hereinafter CFA) represents the referential point as its coordinates and altitude defines a shape and a way in which the flooding area spreads. It means that zero water level is the altitude of this referential point. The starting water level is defined regarding the CFA. If the rivers or lakes cause the flooding, the CFA should be positioned on their surface. If the underground waters cause flooding (e.g. in some parts of Vojvodina), the CFA can be positioned on land, usually at the lowest point of the area endangered by flood.

FLOODING TEST PHASE

As mentioned above, flooding represents the specific scenario. Wrong setup of parameters *flooding resolution* and *updating frequency* can produce degradation of system performances due to more time the system needs to recalculate new flooding area shape after updating the water level. Practically, the system has to recalculate for each point on the map if it is under water or not and, if it is – how deep under water the point is. Therefore, the technicians practice the flooding test before the exercise starts. The next illustrations show the flooding dynamic during this phase (Figure 3 and 4). The technicians also test the spreading effects – if it happens in accordance with the characteristics of land shape and objects on the terrain (e.g. dams, embankments, etc.).

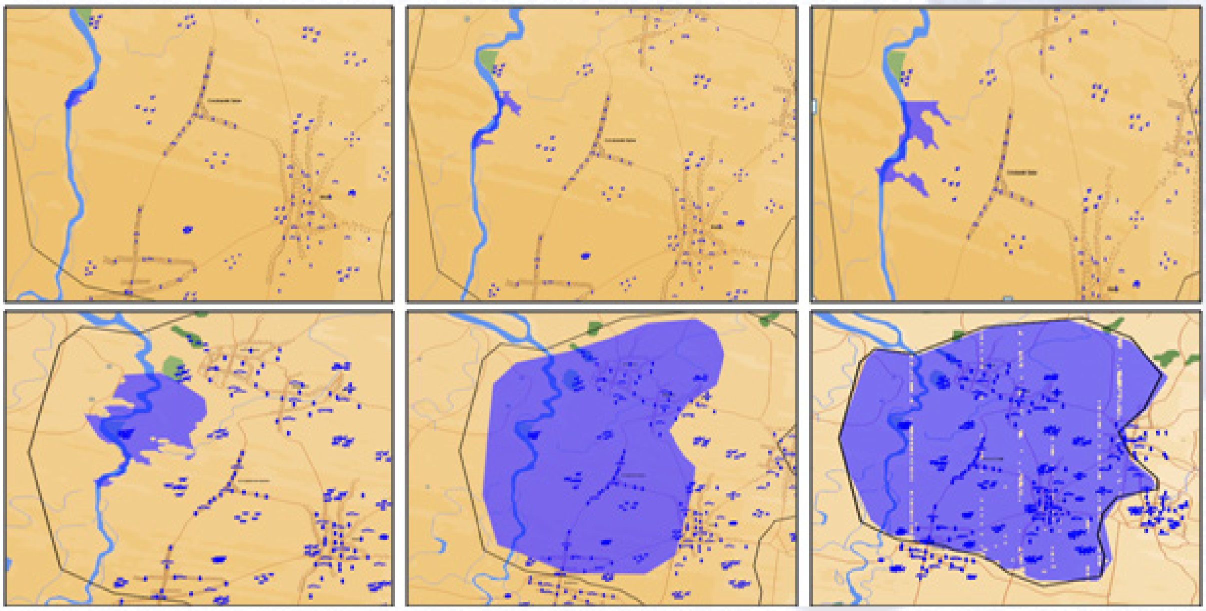

Figure 3: *Spreading of flood in the vicinity of Bogatić*

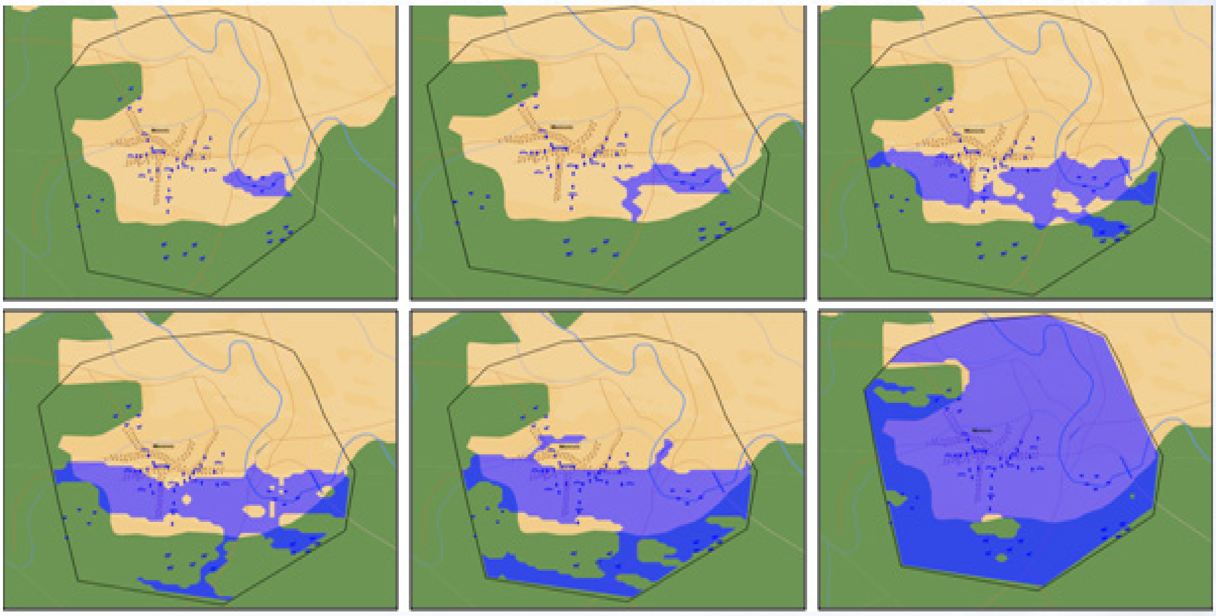

Figure 4: *Spreading of flood in the vicinity of Morović*

Flooding test also includes the testing of pions behaviour: endangered population and animals in the flooded areas, the ability of soldiers and combat and non-combat vehicles to assist the endangered populations in the flood zone.

SIMULATION EXERCISE BASED ON FLOODING SCENARIO

The members of the developed emergency staff represent the simulation exercise players. During the exercise, they are collecting the information, analysing it and making decisions about engagement of forces on different kinds of help they have to obtain in order to fulfil the exercise objectives. More precisely, they receive reports from the subordinates (they play the role of animators), analyse the situation, and make decisions of engagement. The next figure (Figure 5) illustrates evacuation of population by land. Upper left part shows the units with amphibian vehicles coming in the flooding area for rescuing. They search and find the population, and report the situation to the superiors (emergency staff members) (upper right part).

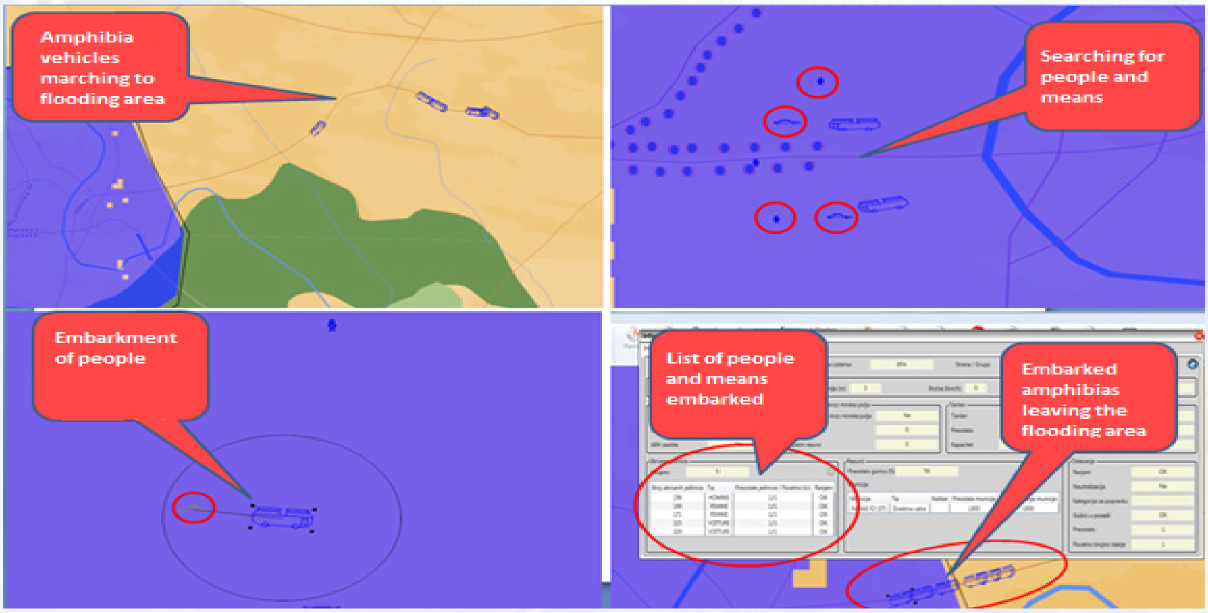

Figure 5: *Overview of rescuing and evacuation of the population by land*

Further, they receive orders and take actions in accordance with it. Bottom left part of Figure 6 shows the embarking of the endangered people on amphibian vehicles, while bottom right part shows the evacuation of this group of people from the flooding area.

The next figure demonstrates air evacuation of the population from the flooding areas (Figure 6). The scenario included the engagement of helicopter units for this purpose. After the reconnaissance mission, the air unit reported to crisis staff about the endangered population and received the order and guidance for the rescue mission. The upper left part of the figure shows the entrance of the rescue helicopter in the flooding area, the upper right part shows finding of the endangered people and their means and the bottom part shows the evacuation of people from the flooding area by helicopter.

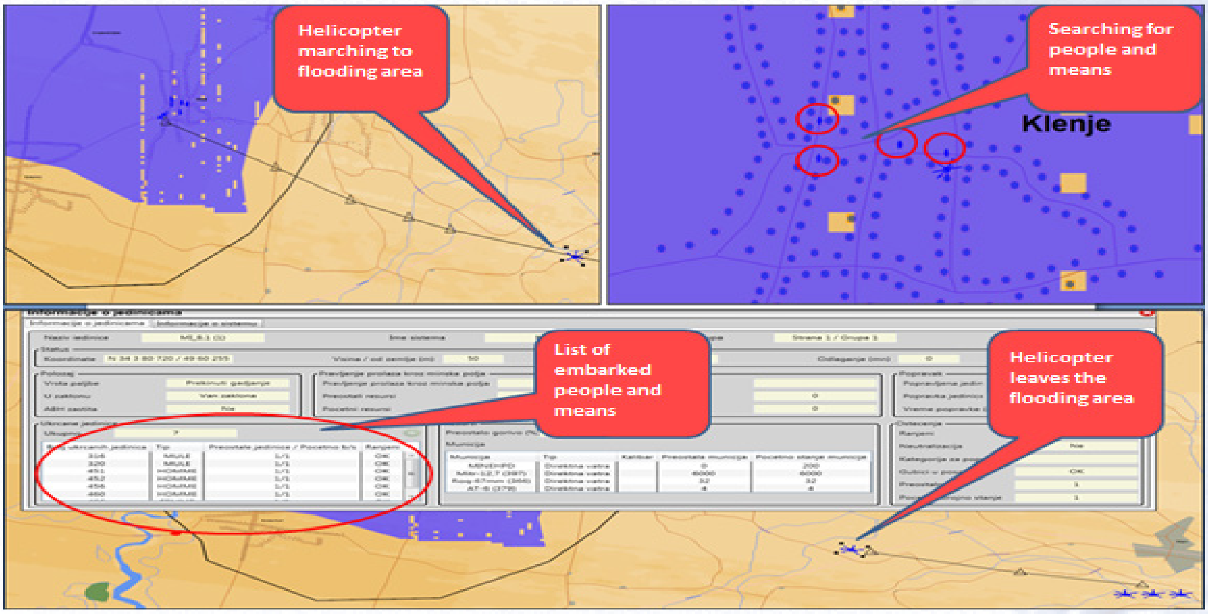

Figure 6: *Overview of rescuing and evacuation of the population by air*

Simulation system provides detailed information about the endangered populations and equipment. The next figure shows the system forms that provide this information for exercise participants (Figure 7). The upper part of the figure shows the information of defects on the vehicles endangered by water. The bottom part of the figure shows the status of the injured civilians. Such information are delivered to the members of crisis staff in order to challenge them to quickly make the right decision as needs are usually greater than the available resources. That means the players have to make priorities and to exploit units engaged in crisis scenarios in optimized way.

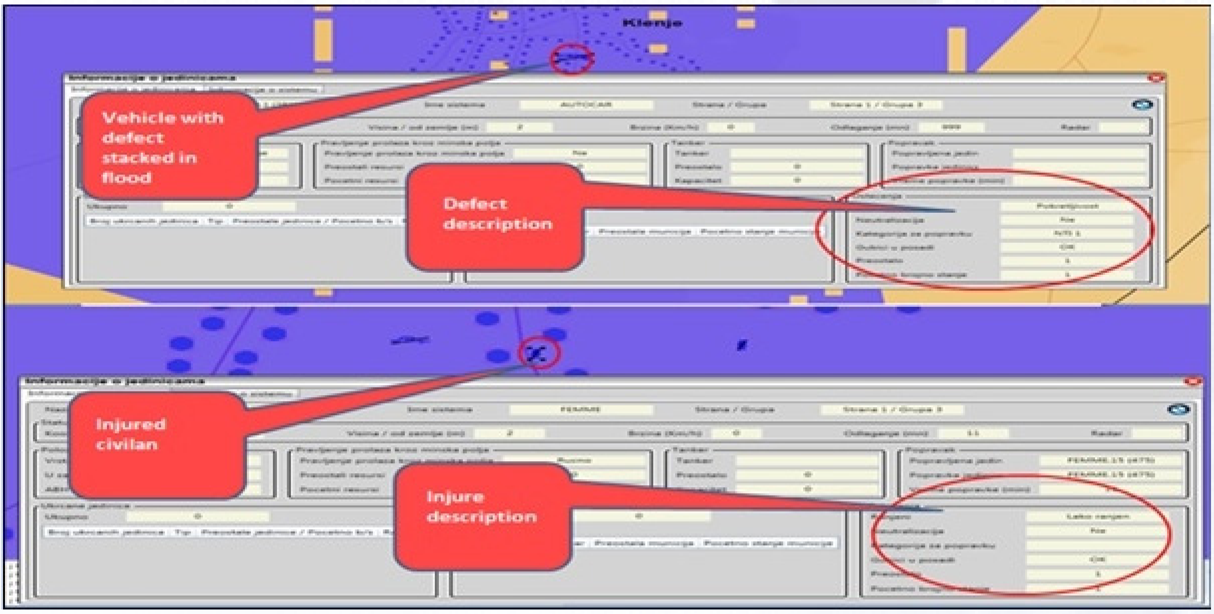

Figure 7: *System provides detailed information about the endangered population and means*

The next figure shows the air-medical evacuation of the injured civilians from the endangered areas (Figure 8). The upper left part shows helicopter guidance to the location of emergency. Helicopter operator then has to find the particular injured civilians on site, embark them one by one and evacuate to the specified medical station for further medical care.

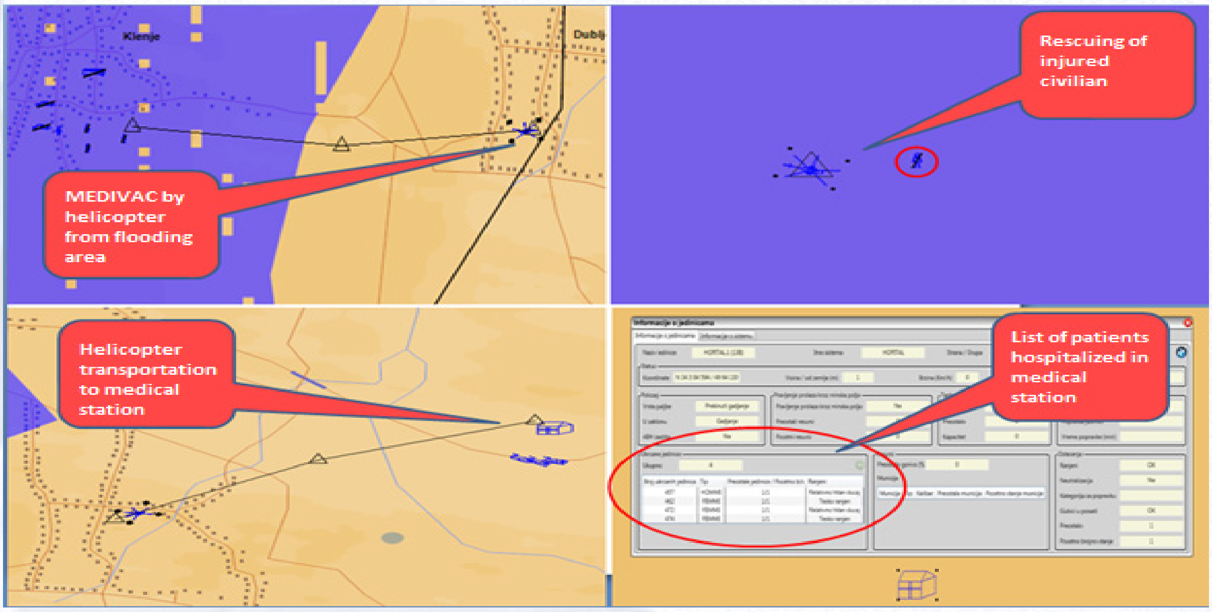

Figure 8: *Medical evacuation flooding area*

The next figure shows the technical support for vehicles and other means with defects located in the endangered areas (Figure 9). Crisis staff should deploy one or more mobile maintenance stations to perform this type of service. Similar to medical care, this kind of help has two phases. Firstly, the mean has to be drowned out of water and transported to the safety area – into the maintenance station. Simulation software offers parameters *out of function time* (hereinafter OFT) to emulate the repairing and maintaining processes. Minute [0 – 999] represents the measurement OFT unit. *Zero* OFT means that the vehicle is in fully functional state. On the other hand, 999 value means that vehicle is out of function and cannot be repaired. Other OFT values describe the time necessary for fixing the problem with the vehicle.

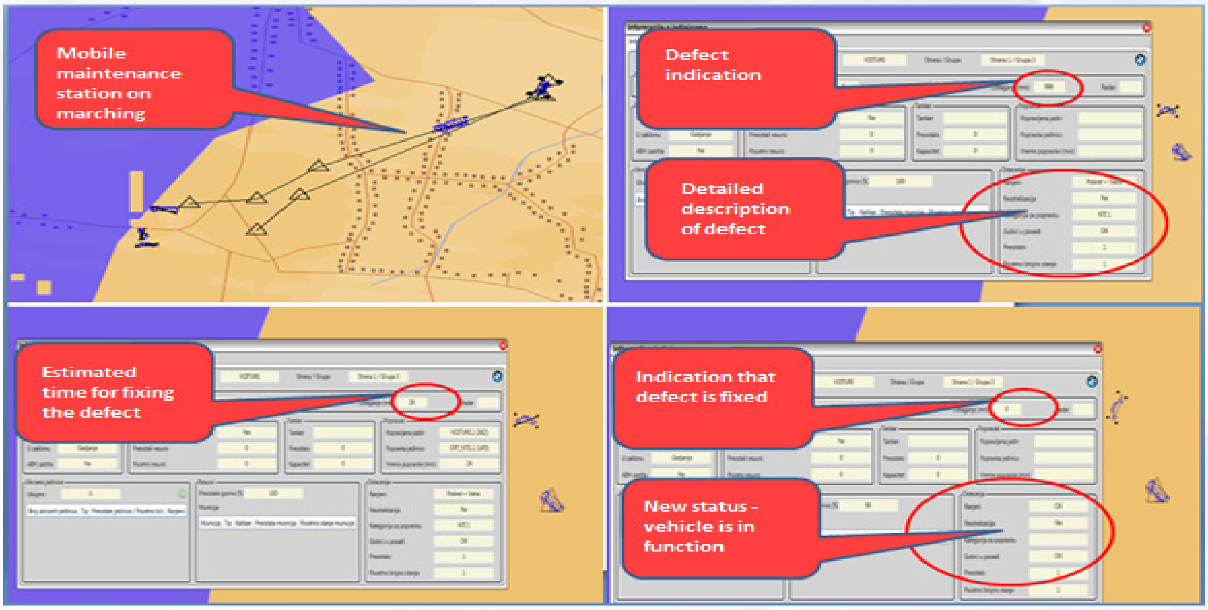

Figure 9: *Reparation of defected vehicles and other means*

As known, flood often causes road damages. Figure 10 shows the support for fixing this kind of problem. After reporting, the crisis staff has to make decisions about the engagement of road maintenance groups (hereinafter RMG). They order the RMG to go on a road damage site and to fix the problem. Simulation software includes the engineering norms used for this kind of simulated action. The figure shows the movement of RMG to the location (upper left part), deployment of resources (upper right part), and fixing the damage. After action, RMG reports to the staff, withdraw from the location and can be directed at the new one.

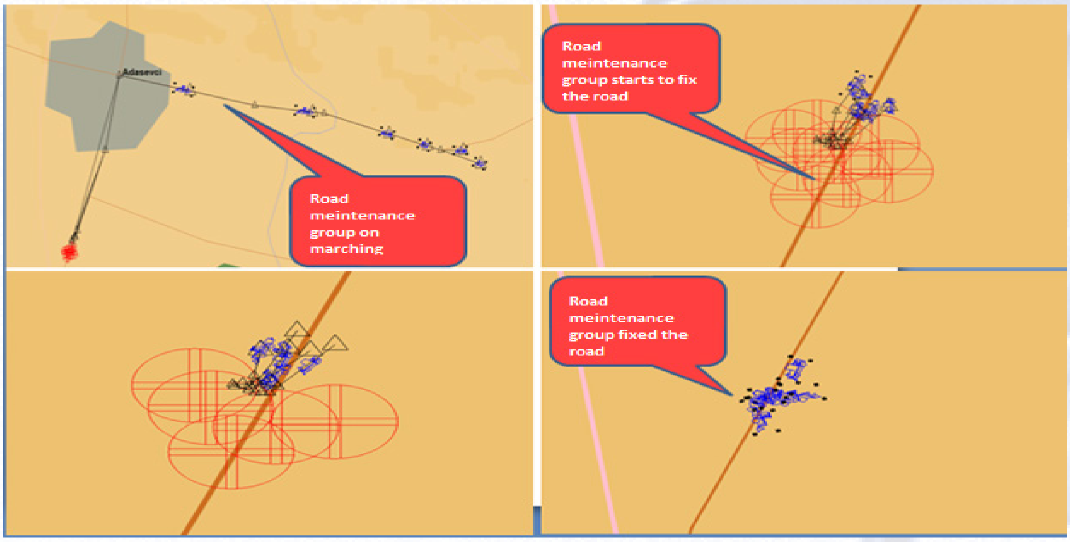

Figure 10: *Road maintenance group in fixing the road damage*

Simulation training also includes the regular use of communication means and procedures during the exercise. Like in realistic situations, the crisis staff members and other participants exchange a lot of information during the exercise. To avoid misunderstanding or missing complete important information, the players should be trained for proper use of communication resources. Command networks are formed on demand of exercise directors. Technicians create them by using VoIP server and radio-network stations. This way technicians record the communication for after action review and course of actions analysis.

CONCLUSIONS

Simulation exercises represent the efficient way for training emergency teams and crisis staff. Contemporary simulation software provides various possibilities in creation of scenarios to provide the training conditions close to realistic situations. Use of simulation is life and healthy safe, environmental safe, it is sparing the time, money and other means. Simulations offer a realistic dynamic of exercise, comprising the engagement of a lot of people simultaneously. Finally, it can be repeated as many times as is necessary for finding the most optimal solutions in a concrete scenario. Simulation exercises provide researchers to vary conditions, to insert the unpredictable events during simulation, to stop the exercise in any moment and to record the course of actions for the later analysis and deriving of conclusions. Moreover, simulations are safe to evaluate the readiness of emergency teams and crisis staff in new situations, which have never happened before. Climate changes and the latest COVID–19 experience directed us that everything is possible and we need to prepare ourselves for the future situations in order to minimize the damages of potential natural and artificial disasters.

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