Lessons from the first European Union tsunami simulation exercise

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Abstract

Disaster exercises (also called civil protection exercises or simulation exercises in Europe) are a highly effective method of testing emergency preparedness, evaluating and updating emergency plans, and training emergency responders. The European Union (EU) Civil Protection Mechanism facilitates cooperation in civil protection in major emergencies and disasters which require international assistance. With the objective to enhance the cooperation of all actors involved in operations under the EU Mechanism for Civil Protection, EU Simulation Exercises aim at establishing a common understanding of cooperation in civil protection assistance interventions and to accelerate the response to major emergencies.

These exercises are typically designed to simulate a scenario which overwhelms the response capabilities of the affected country, necessitating the involvement of the European Union Community Mechanism for Civil Protection. In this paper we present the design and outcomes of a tsunami disaster exercise in Greece. As opposed to earthquakes, which are over in a few minutes at worst, multiple tsunami waves may attack shorelines over a couple of hours, with little or no warning, making it difficult for search and rescue operations to know when it is safe to deploy and redeploy.

EU POSEIDON 2011 was the first ever tsunami disaster simulation exercise project in the European Union. The scenario was an earthquake on the Hellenic Arc, which would not only cause substantial structural damage to the island, but would also trigger a large tsunami that would hit most coastal areas of Crete. The scenario was planned so as to overwhelm local response capabilities and involved the triggering of assistance from the EU Civil Protection Mechanism. The simulation included a table top exercise, a command post exercise and a full-scale exercise.

We present the outcomes of the command post and full-scale exercise for the participating agencies and organizations. In addition, we highlight lessons learned by the participants of both exercises. Finally, we point out a number of implications for exercise design and conduct.

Keywords: disaster preparedness, disaster exercise, tsunami, exercise control

1. Introduction

Disaster exercises (also called civil protection exercises or simulation exercises in Europe) are a highly effective method of testing emergency preparedness, evaluating and updating emergency plans, and training emergency responders. While a number of approaches have been used to evaluate pre-incident emergency preparedness (Mileti, 1999; Perry & Lindell, 2006; Abrahamsson et al., 2010; Karagiannis et al., 2012), well planned and conducted exercises remain the most effective means of the overall evaluation of emergency preparedness, because they put emergency response systems to the test under realistic conditions and against set objectives (Wasserman, 1986; Smith, 1990; Perry & Lindell, 2003). A number of handbooks provide information and guidance on exercise design and conduct (DHS, 2007; FEMA, 2003; DSC, 2011; GSCP, 2009; EMA, 2004). Perry (2004), Erickson et al. (2004), Alexander (2005), and Carlstrom & Berlin (2008) highlight critical exercise outcomes for exercise participants and for relevant emergency response components.

The theoretical foundations of crisis management are still being explored and debated (Roux-Dufort & Lalonde, 2013). Just as in the physical and life sciences, where observations and experimentation eventually lead to useful abstractions through the formulation of conjectures and theories, disaster exercises provide useful data to help build confidence in inadvertent generalizations, as well as underscoring the limitations of current understanding. Compared to substantial advances in quantification of metrics that help projections in risk assessments, the science of disaster exercises is still emerging.

Here we present the design and conduct of a tsunami disaster exercise in Greece, undertaken in 2011. The exercise was designed to observe the emergency response during a disaster that overwhelms the capacity of the ''host'' country to address it, necessitating the involvement of European Union Community Mechanism for Civil Protection (also called European Union Civil Protection Mechanism – EUCPM). The logistics were complex, for the

host had to integrate foreign teams with different background skills and operational protocols, and overcome language barriers. The exercise was funded by the European Union (EU) Civil Protection Mechanism., which facilitates cooperation in civil protection in major emergencies and disasters which require international assistance. With the objective to enhance the cooperation of all actors involved in operations under the EU Civil Protection Mechanism, EU Simulation Exercises aim at establishing a common understanding of cooperation in civil protection assistance interventions and to accelerate the response to major emergencies. From 2002 to 2012, 36 exercises have been co-financed in this framework. Past exercise scenarios have included earthquakes, floods, and industrial accidents, Chemical-Biological-Radiological-Nuclear events and terrorist attacks (DG ECHO, 2012). Until 2011, there had been no exercises with tsunami events.

Tsunami disasters are arguably different than other emergencies. Hurricanes allow for several days of planning, as they propagate at speeds of a few tens of kilometers per hour over the ocean; in contrast tsunamis propagate at speeds up to ten times greater, at least until they reach shallow water. Riverine flooding may evolve over several hours, tsunamis over ten of minutes. As opposed to earthquakes, which are over in a few minutes at worst, multiple tsunami waves may attack shorelines over a couple of hours, with little or no warning, making it difficult for search and rescue operations to know when it is safe to deploy and redeploy. As opposed to most industrial accidents, large tsunamis affect very wide geographical areas and stretch even the most comprehensive national resources quite thin.

As opposed to Japan, where substantial know how exists at the local level and residents are as well informed as one can hope on what they need to do themselves to save lives, in most other nations emergency response relies on hierarchical operations, which, without a comprehensive exercise, will be tested for the first time in an actual emergency. On average, in the Solomon Islands tsunamis strike a few times every decade, in Japan and

Indonesia, about once a decade, in Chile every few decades, but elsewhere far less often, leading in most cases countries to rediscover their vulnerabilities, anew in every generation. However, historically about 10% of all world tsunamis occur in the Mediterranean region (Ambraseys & Synolakis, 2010). Mediterranean coastlines attract a substantial amount of seasonal visitors who may have little knowledge of local hazards; in this regard, planning is harder than in Japan, where even in summer months, beachgoers are well-informed of local hazards. Considering that 140 million people live in coastal areas around the Mediterranean Sea, the impact of a major tsunami could be catastrophic (IFRC, 2009).

Here we focus on the design and conduct of the exercise from the point of view of the exercise planning team. While the specific value of disaster exercises on the emergency management system remains a vexing research question (Carrel, 2006; Decker & Holtermann, 2009; Edwards et al., 2011b; Lindell, Prater & Perry, 2007; Morrison, 1985), the interest on the methodology of designing and conducting an exercise has been limited (Nunes, 1983; Johnson et al., 2009). Exercise planners rely on guidebooks and relevant training programs, including but not limited to the Master Exercise Practitioner Program, administered by the Federal Emergency Management Agency (FEMA, 2003). Our objective is to contribute to exercise design and implementation, by capturing lessons learned by planners of this first tsunami disaster exercise in Europe.

We note that a civil protection exercise is an experiment to help understand the behavior of the organizational structure during an actual emergency. Just like in a physical or social science experiment, there are numerous variables, and often some of them have to be kept constant to understand how the phenomenon depends on other variables of particular interest. In our case, while field teams were deployed in search and rescue operations in multiple sites, our objective was not to determine how adequate they were. A physical manifestation of the design scenario for the exercise will dwarf existing resources management. Our focus was to use the field teams as the means to provide information and

data, so as to train and test the communications of emergency services and their interactions with diverse teams and chains of authority.

Our presentation is structured in four sections. First, we present the exercise design and conduct, then, we highlight the exercise outcomes, with an emphasis on lessons learned for exercise planners, and then summarize our findings.

2. EU POSEIDON 2011 Full Scale Exercise

EU POSEIDON 2011 was a European Union disaster exercise that was planned and implemented to enhance civil protection preparedness in responding to a devastating earthquake and ensuing tsunami, through the cooperation of civil protection agencies at local, regional, national and European levels. The Civil Protection Directorate of the Decentralized Administration of Crete was the coordinating beneficiary and the consortium included seven Associated Beneficiaries, local emergency services (fire/rescue, emergency medical services, police, coast guard), and regional authorities, as listed and discussed in Saini et al. (2012).

The scenario of the exercise project was an earthquake on the Hellenic Arc, which would not only cause substantial structural damage to the island, but would also trigger a large tsunami that would hit most coastal areas of Crete. This scenario was similar to the event of 365AD (Shaw et al., 2008) as implemented by Flouri et al. (2013). Under this scenario, the two major cities of Crete (Heraklion and Chania) were primarily affected.

Specific objectives of the EU POSEIDON 2011 Exercise project were to:

- control and improve operations relating to preparedness and response to seismic events followed by tsunami, in terms of human and physical resources
- improve the coordination between the three international actors
- test novel early warning systems and communication applications and procedures for informing the public about emergency measures taken.

The EU Poseidon 2011 included a Table Top Exercise on May 30, 2010, a Command Post Exercise on October 4, 2011 and a Full Scale Exercise on October 24 and 25, 2011; all three were implemented in Crete.

2.1. Exercise design

EU POSEIDON 2011 aimed at establishing a learning environment for players to exercise emergency response plans, policies and procedures as they pertain to earthquakes and tsunamis (Saini et al., 2012). A full-scale exercise is the most complex civil protection exercise undertaking. Such exercises involve multiple services, agencies and organizations and validate many aspects of disaster preparedness. They implement and analyze existing plans, policies and procedures.

Full scale exercises are conducted in real time, and events are projected through a scripted exercise scenario with built-in flexibility. They include the mobilization and deployment of resources in the field, which act as if a real incident had occurred, except, of course, for invasive medical procedures. A full scale exercise also may include functional play from participants not located at the exercise incident response site, such as emergency operations centers. Controllers at the exercise control center simulate the activities performed by other agencies, for example search and rescue, by sending and receiving appropriate messages to and from corresponding emergency operations centers (DHS, 2007; FEMA, 2003).

The list of participants in the full scale exercise included 319 players at every level, 16 controllers, 2 evaluators, 41 observers, 89 actors and 30 support staff members. With a total of 498 participants, the EU POSEIDON 2011 Full Scale Exercise was the largest ever of this type that has been organized in Greece, when implemented.

2.2. Exercise Planning Team

The exercise planning team is responsible for exercise design, conduct, control and evaluation and established with membership from all participating agencies. Team members set up and operate the exercise site, plan and manage exercise play, and act the roles of individuals and agencies that are not physically playing in the exercise. They ensure that exercise objectives are tested so as to make evaluation possible, and that exercise activity level challenges the players. Controllers direct the pace of exercise play and are responsible for the overall exercise safety. They provide key data to players and may prompt or initiate certain player actions to ensure exercise continuity (DHS, 2007; FEMA, 2003).

2.3. Scenario overview

On a fall Saturday morning in October (the end of the tourist season), a Mw ~ 5,2 earthquake is felt in Crete, surprising both the locals and remaining tourists, who are mostly foreign nationals. No victims or major injuries are reported, and the offshore earthquake epicenter is located within minutes by international seismic observatories. While there no immediate reason for concern, the regional Emergency Operations Center (EOC) is activated. Minor seismic activity continues onto the following day.

On Monday morning, a Mw ~ 8.6 earthquake is widely felt across the island. Multiple incidents are reported all over Crete, and the EOC goes into full alert. Less than half an hour after the earthquake, a tsunami hits the north coast of the island of Crete (Flouri et al., 2010), disrupting all communications. The tsunami causes widespread inundation and damage. Numerous incidents are reported including collapsed residential, commercial and public buildings, coastal roads blocked by debris, and a marine oil spill when an oil tanker is swept off by the tsunami wave while unloading oil at the island's main power station at Ellinoperamata. The incident demands rapidly overwhelm the capacities of the local and

regional emergency and civil protection services. At the same time, massive information demands are placed upon local and regional elected officials.

Approximately one hour after the impact of the first tsunami wave, local and regional Fire and EMS Services request reinforcements from their respective national headquarters. However, reinforcements are unavailable as many resources have already been engaged in disaster response along the mainland. The General Secretariat for Civil Protection requests international assistance through the European Union Civil Protection Mechanism. Offers for assistance from two EU Member States are immediately accepted, while host nation support procedures are initiated for the reception of incoming relief teams. Incoming assistance includes two urban search and rescue (US&R) teams, one technical assistance and support team (TAST), one EU civil protection team (CPT), and one field telemedicine vehicle with satellite communications capabilities. The resources arrive progressively in Crete, on day one. By early afternoon, they receive their first operational and logistics briefing before being dispatched. For their first assignment, all foreign tactical resources are dispatched to a search and rescue mission in a river estuary outside Heraklion, where they are integrated into the local incident response system The EU CPT provides assistance to the regional EOC to coordinate incoming international relief.

Response operations continue on the following day. The foreign US&R, medical and technical assistance resources are dispatched to Chania to reinforce local Fire Service and EMS resources. They are first integrated in a search and rescue operation in a mass casualty incident in a river in the outskirts of Chania. Once this operation is completed, all tactical resources are redeployed to a structural fire and collapse operation in Chania General Hospital to relieve local teams. Meanwhile, the regional EOC keeps receiving continuing information requests for information, making the coordination of disaster response operations quite difficult. The exercise ends in the afternoon, with a simulated press conference, where exercise controllers impersonate journalists.

2.4. Earthquake and tsunami numerical simulation

A disaster exercise scenario inadvertently includes the description of the effects of the hazard on local communities. In this case, the exercise scenario was required to include an event that would overwhelm the capacities of the affected country. The 365 AD (Mw~8.6) earthquake and subsequent tsunami occurred in very close proximity to the modern-day cities of Chania and Heraklion (Shaw et al., 2008) and would likely overwhelm the capacities of Greece. Therefore, the exercise scenario was tailored to resemble the 365 AD earthquake and tsunami event. A detailed description of the earthquake and tsunami was developed to provide key information to emergency responders, including tsunami arrival times and maximum wave heights in Heraklion and Chania, tsunami inundation maps and earthquake ground shaking maps (Kaligeris et al., 2010; Alexandrakis et al., 2010).

Tsunami arrival times and inundation maps were produced using the extensively validated and benchmarked MOST (Method Of Splitting Tsunami, Titov and Synolakis, 1998) model for tsunami numerical modeling. Earthquake ground shaking maps were produced using an empirical attenuation relation suitable for the study region (Ambraseys et al., 2005). In both cases, the available historical evidence did not provide sufficient input for the simulation, and reasonable assumptions based on best available knowledge about the local geology had to be made. However, the purpose of the simulation was not to establish the details of the historical event, rather to illustrate a plausible scenario that can be used in a civil protection exercise (Kaligeris et al., 2010).

This meant that the disaster scenario description had to be developed with the end-users in mind. In this case, the end-users were going to be exercise planning team members and exercise players, all with limited or no knowledge of tsunami numerical modeling and earthquake shake maps. Therefore, the earthquake and tsunami event description final documentation included little or no technical parameters, yet incorporated useful information such as tsunami maximum wave height and tsunami arrival times for urban

areas in Crete. In addition, the documentation included a set of tsunami inundation maps and earthquake shake maps for Crete's top cities. Tsunami inundation maps presented the coastal zone that would be inundated should the tsunami occurred, while shake maps illustrated the estimated peak ground acceleration from the earthquake. Both sets of maps were superimposed on Google Earth satellite imagery for ease of reference. Moreover, a video animation was produced to illustrate the tsunami runup in the Old Harbor of Chania in real time.

Presenting the outcomes of the simulation in layman's terms was very effective. The exercise planning team used the information on the scenario description to develop the Master Scenario Events List (ref. section 3.4.2). Furthermore, exercise controllers (ref. section 3.4.1) used the tsunami inundation maps, the earthquake shake maps and the video animation to present the scenario to players and to add realism to the exercise. In addition, the tsunami inundation maps and shake maps were used by emergency managers and decision-makers at the Crisis Management Center (ref. section 3.1) to assess elements at risk, such as population, critical infrastructure or critical buildings, and to evaluate immediate needs (search and rescue, evacuation) and the potential for secondary hazards.

Although the documentation was very useful to both the exercise planning team members and the key players at the Crisis Management Center, a number of questions were raised regarding the modeling process, the sensitivity of the results and implications for the determination of disaster response priorities and the allocation of resources to the exercise incidents. Members of the scientific team that originally prepared the scenario numerical simulation joined the exercise planning team, while others were present during the exercise at the Crisis Management Center to respond to players' questions. This proved an effective practice that added realism to the scenario, improved the credibility of the exercise and helped streamline the exercise conduct.

3. Exercise conduct

3.1. Multi-agency cooperation structure

The standard Greek Civil Protection multi-agency cooperation system structure, illustrated on figure 1, was employed during this exercise. The Crete Crisis Management Center was the key information management and coordination node. It was staffed by top regional officials and top management from responding and supporting agencies. Their role was to provide for overall coordination and ensure agency reporting, prioritizing incidents, determining current and emerging resource requirements and availability. The Crisis Management Center was assisted by an Information Management Group, made up of representatives from key responding agencies and jurisdictions.

The Information Management Group was responsible for the collection, organization, analysis and display of information of field conditions. An International Cell was set up to facilitate coordination among the foreign response teams, the Monitoring and Information Center (MIC – now the Emergency Response Coordination Center or ERCC) of the European Union (EU) Directorate-General for Humanitarian Aid and Civil Protection (DG ECHO), the respective national civil protection operation centers, and the Crisis Management Center.

The Crisis Management Center was the key communications node among the Civil Protection Operations Center, the local and regional responding agency EOCs (Police, Fire Service, EMS, Coast Guard), the local jurisdiction EOCs and the foreign response and coordination teams. As foreign tactical resources became integrated into the existing local response system, lines of communication were established with both the local responding agency EOCs and the Crisis Management Center. Finally, those organizations and/or structures that did not participate physically in the exercise were modeled by the exercise simulation cell (SimCell).

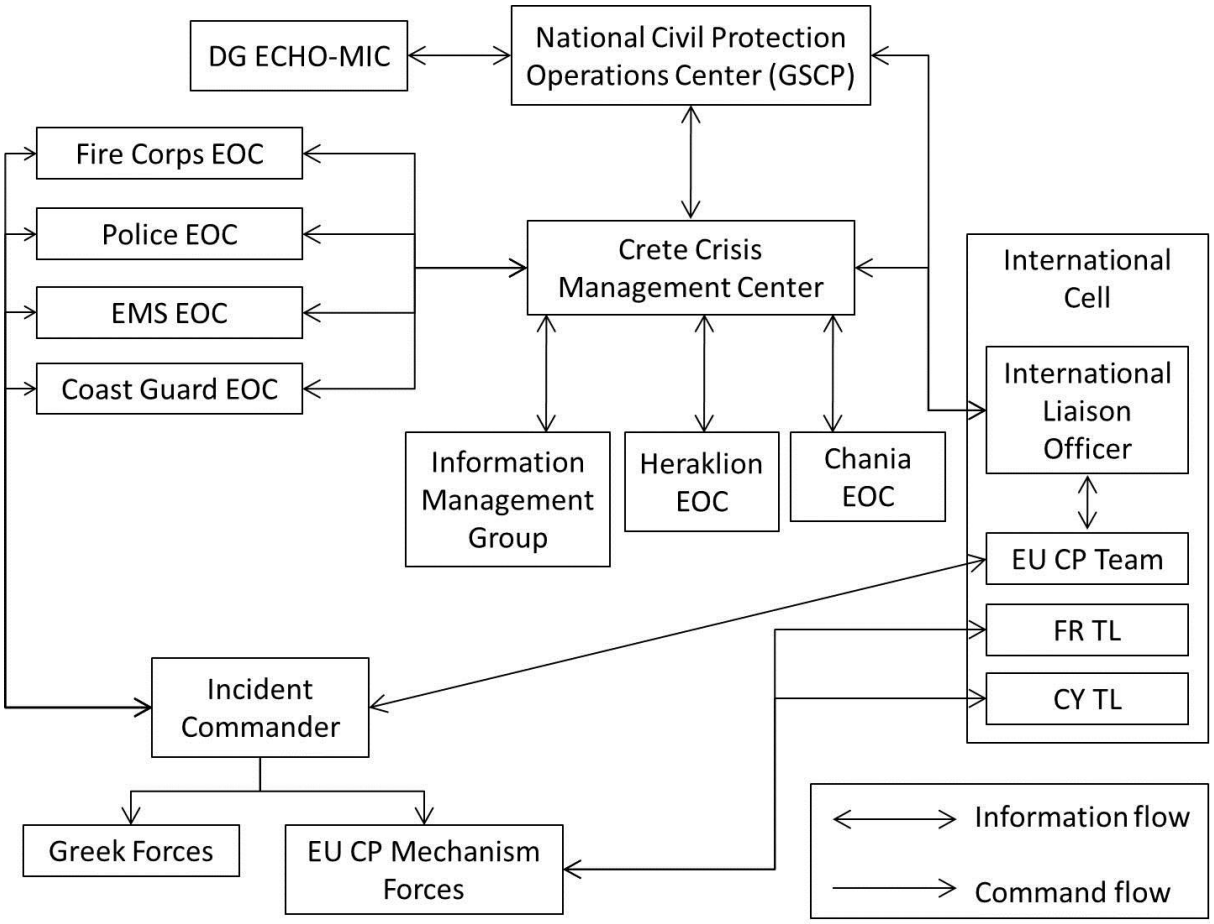

Figure 1: EU POSEIDON 2011 Full Scale Exercise information flowchart
(DG ECHO: Directorate-General for Humanitarian Aid and Civil Protection, GSCP: General Secretariat for Civil Protection, EOC: Emergency Operations Center, EMS: Emergency Medical Service, EU CP: European Union Civil Protection, TL: Team Leader, FR: France, CY: Cyprus)

3.2. Exercise organization

Key organizational issues were addressed in the Exercise Plan, which described the roles and responsibilities of exercise players, controllers, evaluators, actors, observers and support staff, and discussed the exercise implementation. Finally, the Exercise Plan detailed key assumptions and artificialities that were used during play; exercise artificialities could enhance or possibly detract from realism and were used to create the high pressure environment necessary for exercise conduct (DHS, 2007; FEMA, 2003; Saini et al., 2012). For example, a sudden announcement that the Heraklion airport had been closed because of

tsunami-carried debris, instead of enhancing the experience, resulted in top management arguing if this was indeed a realistic possibility in an actual emergency.

3.3. Exercise communications

Exercise players traditionally have used routine and existing communication systems. However, the need to maintain capability for a real emergency precluded the use of certain communication channels or systems that usually would otherwise be available (DHS, 2007; Saini et al., 2012). Measures were taken to ensure that exercise play did not interfere with real emergency communications and included the use of alternate radio frequencies increased use of e-mail and short message service texts.

3.4. Exercise control

3.4.1. Joint Exercise Control Group

The EU POSEIDON 2011 Joint Exercise Control Group (JECG) was a prototype in the history of the EU Civil Protection Mechanism Full Scale Exercise program. Its objectives were to provide a centralized control environment to present a synchronized and realistic exercise portrayal to the training audience, ensure that the simulation and scripted scenario events remain technically and operationally synchronized simulate the functions, actions, responses and decisions of the simulated organizations and agencies, and finally monitor and control the exercise play to ensure the accomplishment of the training objectives.

The diversity in the JECG was a challenge, as it brought together officials from local and regional jurisdictions, diverse responding agencies, volunteer organizations, and private firms. JECG members had varying degrees of familiarity with disaster management disciplines, exercise design, conduct and evaluation, and EU civil protection protocols. This diversity proved a creativity primer in the JECG and enhanced the Group's effectiveness.

3.4.2. Simulation Cell and Master Scenario Events List

The JEGG was physically set up in the Simulation Cell (SimCell) but was isolated from the Crisis Management Center and the Information Management Group. Access to the SimCell was restricted to controllers, Crisis Management Center evaluators and selected support staff. This setup proved useful as it allowed SimCell controllers to monitor the Crisis Management Center, but also provided them the necessary privacy to generate injects and receive player responses as required from the Master Scenario Events List (MSEL).

The MSEL was the key reference document for SimCell controllers. It outlined events and injects that drove exercise play, detailed realistic input to the exercise players, and provided information expected to be reported from non-participating simulated organizations. Every inject included time, intended recipient, responsible controller, and a short description of the event, and the expected player action (DHS, 2007; FEMA, 2003; Saini et al., 2012). Messages in the MSEL had been prepared in advance, reducing the time necessary to deliver messages while providing flexibility to quickly respond to unforeseen turns in exercise play that required contingency messages.

The participation of multiple agencies in the EU POSEIDON 2011 and the need to adjust the speed of exercise play according to the scenario often required the simultaneous delivery of multiple messages to multiple agencies by different means. To this end, exercise controllers used multiple means of communication, making use of existing technologies and off-the-shelf products, including internet short-message service, e-mail, mobile and landline telephones, voice over internet protocol and social media.

4. Full Scale Exercise outcomes

A number of textbooks (Mileti, 1999; Alexander, 2002; Perry & Lindell, 2006; Lindell, Prater & Perry, 2007) and official handbooks (FEMA, 2003; EMA, 2004; DHS, 2007; GSCP, 2009; DSC, 2011) advocate the benefits of disaster exercises to the community. In addition, previous research has highlighted the benefits of exercises to participating jurisdictions,

organizations and individuals (Morison, 1985; Peterson & Perry, 1999; Perry & Lindell, 2003; Alexander, 2003; Perry, 2004). In this section, we report the outcomes of the exercise for the community and individual participants, as they have been captured in the Full-Scale Exercise After Action Report (Saini et al., 2012). Our findings generally confirm the outcomes reported by previous authors (Peterson & Perry, 1999; Perry, 2004).

4.1. Outcomes for participating organizations and individuals

First, the exercise allowed inferential testing of the adequacy of relevant plans, including the Emergency Operations Plan of the Decentralized Administration of Crete and the EU Civil Protection Mechanism Activation Procedures. The Full-Scale Exercise After Action Report outlined a number of strengths and improvement opportunities identified during the exercise. For example, the exercise revealed that it takes approximately 8 minutes for the tsunami warning to be issued from the National Tsunami Warning Center in Athens and to be transmitted to the Crete Crisis Management Center through the National Civil Protection Operations Center. However, the Crisis Management Center took an additional 20 minutes to reach a decision whether to issue a tsunami warning using an experimental internet-based text message service (ref. §3.3.1). Overall, the tsunami warning dissemination time is disproportionately long compared with near-shore tsunami events arrival timeframes (Titov & Synolakis, 1998; Shaw et al., 2008; Flouri et al., 2010). It was therefore suggested that new technologies for disaster early warning be further investigated within the limitations of the Greek legal framework. In addition, the After Action Report provided a number of alternatives to improve warning times in tsunamis, including an appropriate delegation of authority for the dissemination of warnings and the increase of public education. Second, the exercise was a comprehensive test of personnel training. A number of plans and procedures were rehearsed during the exercise, including regional and local Emergency Operations Plans. In addition, the exercise provided an opportunity for emergency services

to practice structural collapse rescue skills and test their ability to function together in the field.

In addition, the full scale exercise was extensively publicized in the local and national media. More than 70 articles appeared in local and national media within a 10-day period before and after the exercise. Arguably, the exercise program enhanced the visibility of the various organizations and public services involved, increasing their public credibility, and helped to educate the public about the local government's level of preparedness. The exercise also provided an opportunity for a "hands-on" check of communications systems and equipment. For example, the exercise revealed that police, fire and EMS radio equipment did not support interagency communications. Emergency services have traditionally relied upon landline and mobile telephone networks for interagency communications. Both these systems may become inoperable in the immediate aftermath of the tsunami. The exercise After Action Report suggested that a Terrestrial Trunked Radio (TETRA) system be used to cover the entire island. This was actually implemented two years later and a TETRA network was established to ensure interoperable communications between emergency services and organizations. Finally, the exercise helped assess the viability of the emergency response network relative to a tsunami. For example, the Crisis Management Center was physically located in a public administration building inside the tsunami inundation zone. However, the jurisdiction Emergency Operations Plan did not include any arrangements for a backup site, should the primary location become inoperable. The exercise provided an opportunity for the Decentralized Administration of Crete to revise their Emergency Operations Plan and include a secondary Crisis Management Center location.

The analysis of Participant Feedback Forms helped identify the outcomes of this exercise for the participants themselves. Participant Feedback Forms are questionnaires designed by exercise planners with a view to capturing the participants' perception of the

exercise. They include a selection of open-ended and multiple choice questions and are usually given to all players, controllers, evaluators, actors and support staff at the end of an exercise (FEMA, 2003; DHS, 2007). The Participant Feedback Forms for EU POSEIDON 2011 Command Post Exercise and Full-Scale Exercise each included a number of questions that prompted participants to assign a mark (from 1 to 5, 5 being best) to specific aspects of the exercise organization and conduct.

The Command Post Exercise sample included 36 participants, mostly players who worked in the Crisis Management Center. 86 players in the Crisis Management Center and observers who had the chance to visit all exercise venues returned a Participant Feedback Form after the Full-Scale Exercise. The average score for the Command Post Exercise was 4,06 and rose to 4,11 for the Full-Scale Exercise (Saini et al., 2012; Kritsotakis et al., 2012).

Table 1 below provides the scores given by exercise participants to a selection of six questions in the Command Post Exercise and the Full-Scale Exercise Participant Feedback Forms. These questions provide insight to the perception of participants regarding the effectiveness of the coordination structure, their personal performance and the exercise organization. All six questions were common to the Command Post Exercise and Full-Scale Exercise Participant Feedback Forms.

Table 1: Average scores to selected questions form the Command Post Exercise and Full-Scale Exercise Participant Feedback Forms (Saini et al., 2012; Kritsotakis et al., 2012).

Question	Command Post Exercise	Full-Scale Exercise	Student's t-test p-value
Did the cooperation between the Crisis Management Center and the Information Management Team work well?	4,26	4,08	0,42

Were the responsibilities of the Crisis Management Center clear?	3,97	4,05	0,68
Did the participants manage their work under stress?	3,22	3,89	0,0023
Did the participants adapt their work to unexpected situations?	3,95	4,24	0,062
Was the exercise well-structured and organized?	4,03	3,94	0,54
The exercise scenario was realistic?	4,11	4,10	0,95

The first two questions refer to the perception of the participants regarding the coordination structure. The ratings indicate a clear role of the Crisis Management Center as a multi-agency disaster response coordination body and a good cooperation between the decision-making group and the Information Management Team in the Crisis Management Center. A Student's t-test places the p-value well above the 5th percentile, therefore the ratings change is statistically insignificant.

The next two questions are related to the performance of players during the exercise. The statistical significance of the change in the rating of the third question is unclear. Nevertheless, both ratings show an improvement of the players' capability to deal with the excessive physical and emotional demands placed on decision makers during disasters and crises. Since the bulk of the Command Post Exercise sample and most of the Full-Scale Exercise sample include Crisis Management Center staff, these scores reflect a positive change in the perceptions of players regarding their abilities and skills as a function of the exercise. Finally, the last two questions include an assessment of the exercise organization and design. The scores to both questions were consistently high on both the Command Post

and the Full-Scale Exercise. The average rating change between the Command Post and the Full-Scale Exercise remains statistically insignificant.

Overall, the exercise had positive outcomes for participating organizations, the community and the individual participants. A review of the Full-Scale Exercise After Action Report and an analysis of the Participant Feedback Forms generally confirms the findings of previous research in this field. The exercises allowed inferential testing of the adequacy of relevant plans, enhanced the visibility of participating agencies, provided an opportunity for a "hands-on" check of communications systems and equipment, and helped assess the viability of the emergency response network relative to a tsunami. Furthermore, the exercise improved the players' capability of with the physical and emotional demands of crisis management, as well as their perceptions of their abilities and skills. The next section highlights lessons learned for exercise planners.

4.2. Lessons learned

A large scale field exercise has many facets, simulating different aspects of emergency response during a disaster. In our presentation here we focused on the outcomes of the first tsunami disaster exercise in the European Union.

Large-scale exercises often focus on low-probability but high-impact events that warrant the activation of the entire emergency response system. As real-life occurrences of such events are limited, reports are scarce and there is little knowledge of the hazard. Therefore, exercise planners often have to resort to numerical simulations and computer models to estimate hazard characteristics to build the exercise scenario. In this project, a team of scientists and engineers produced a tsunami numerical simulation and earthquake shake maps for the exercise planning team and key players at the decision-making level of the multi-agency coordination system. Simulation results need to be presented in layman's terms to be useful for emergency managers and decision-makers who rarely have more than qualitative knowledge of the hazards involved. Nevertheless, the use of scientifically-backed

input to the scenario adds credibility to the exercise endeavor and can foster participation. In addition,

Although large-scale exercises (in this case, EU simulation exercises) are often designed to assess high-level international coordination functions (in this case, the activation of the EU Civil Protection Mechanism), they do have a national and local component. They allow inferential testing of local and national plans, help assess the local emergency response system viability and provide an opportunity to assess local communications systems and practice critical disaster response skills (e.g. search and rescue) under almost real-life conditions. Moreover, such exercises enhance the visibility of the local emergency management system and improve the credibility of local emergency management agencies with the public. Nevertheless, further research is needed on the specific value of large-scale disaster exercises on the emergency management system throughout the public administration continuum.

5. Conclusion

A civil protection exercise is an experiment to help understand the behavior of the organizational infrastructure during an actual emergency. In contrast to the physical sciences where scaling parameters are well established to help generalize conclusions in similar manifestations of widely different scales, there is no established theory to help scale our findings. In this regard, our presentation is but one experiment. Its value lies in underscoring unexpected difficulties even with such daily activities as multiple communications. In many ways, the state of the art remains similar to that of a gifted college student who tries out a real world problem. With a few repetitions, the student will eventually get it right.

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