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Interoperability in Disaster Medicine and Emergency Management

Interoperabilidade em Medicina de Desastres e Administração de Emergências

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ABSTRACT

Accurate and timely information is critical for health early warning and effective emergency management. Health Information Technology (HIT) standards address the challenge of integrating information from disparate healthcare resources e.g. devices, people, and information systems to support not only the effective handling of emergencies, but also their analysis for long-term resource planning. In the management of emergencies, co-operative use of standards facilitates effective sharing of information among the parties involved in search and rescue, continuous disaster assessment, and public awareness. This paper discusses the cooperative use of interoperability standards from Health Level Seven (HL7), the Organization for the Advancement of Structured Information Standards (OASIS), the European Committee for Standardization (CEN), and other Standards Developing Organizations to harness the power of Information and Communication Technologies (ICT) in emergency preparedness and response. The paper reports on the experience gained from the deployment of ICT in the Satellites for Epidemiology and health early warning (SAFE) civil protection exercise and interoperability considerations in technical solutions to be deployed in the "POSEIDON" exercise (earthquake followed by tsunami in the Mediterranean) still at the planning stage.

Descriptores: Planejamento de Desastres; Emergências; Incidentes desastre em massa; Gestão da Informação

RESUMO

Informações acuradas e na hora oportuna são essenciais para a emissão de alertas precoces de saúde e para a gestão eficaz de situações de calamidade pública. Os padrões de Tecnologia da Informação em Saúde objetivam resolver o desafio de integrar informações de diferentes recursos de saúde, como por exemplo dispositivos, pessoas e sistemas de informação para apoiar não só o tratamento eficaz nas situações de emergência, mas também na sua análise, para planejamento de recursos de longo prazo. Na gestão de emergências, o uso cooperativo de padrões facilita o compartilhamento eficaz de informações entre as partes envolvidas na busca e salvamento, de avaliação de desastres e conscientização pública. Este artigo discute o uso cooperativo de padrões de interoperabilidade do Health Level Seven (HL7), do Organização para o Avanço de Padrões de Informação Estruturados (OASIS), Comité Europeu de Normalização (CEN), e outras normas das organizações produtoras de padões para fortalecer o poder de Tecnologias de Informação e Comunicação (TICs) na preparação e resposta a emergências. O artigo relata a experiência adquirida com a utilização das TIC nos satélites de Epidemiologia e de alerta precoce de saúde (SAFE) exercício de protecção civil e os aspectos da interoperabilidade nas soluções técnicas a serem implantados no exercício "Poseidon" (terremoto seguido de tsunami no Mediterrâneo) ainda em fase de planejamento.

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INTRODUCTION

Time is a critical resource in managing emergencies that needs to be compensated by high aptitude, sharp judgment and timely information. Education activities and training within the scope of readiness exercises traditionally support the development of skills and the validation of plans and procedures. The role of ICT and interoperability standards further supports decision making and public awareness by delivering the right information to the right persons at the right time, in a predictable format that supplies the necessary context.

In the aftermath of a disaster everybody is looking for reliable and accurate information. People are looking for their loved ones. ICT can help them register to receive updates and note their latest recorded location. Systems like SAHANA used in South East Asia after the Tsunami disaster, as well as social media like facebook are receiving increasing attention[1-3]. Commanders on the field need to assess the scene of the disaster. They ask themselves: Is the area safe? How many victims are there? What is their location? How can the available resources assert the highest impact? The emergency operation center looks out for an overall assessment of the disaster, extending its own capacity through trained volunteers, location of response teams & ambulances, availability of healthcare facilities, and potentially external help. At the regional or national level, again assessment of the disaster is needed to understand the type of medical & other means, materials and human resources necessary to support the local population and visitors, transport patients, etc. In this level, decision makers need answers to questions like: What is the extent of the disaster? What is the extent of damage to infrastructures? What are the needs in medical assistance, food, shelter, support, etc. of the survivors? What is the status of the hospitals and other healthcare facilities? How many beds are available? Finally, there are also public health agencies concerned with health issues, such as: Is the water supply safe? How many people are in the shelter and what are their needs in food, beds, medication, etc.? Do we have indications for the outbreak of an epidemic? In all cases, a GIS system providing on a digital map summary information and real time updates would help quickly assess the situation and the development of the crisis.

In SAFE[4], a project co-funded by the European Space Agency[I], a civil protection exercise demonstrated the value of satellite-enabled applications in providing health early warning after an earthquake disaster. A local Wireless Fidelity (WiFi) network supported by a vehicle equipped with satellite communications provided Internet connectivity in the crisis zone and in an earthquake refugee camp. In the crisis zone, volunteers assisted in triage by entering information about victims on Personal Digital Assistants (PDAs) to be instantly accessed by the Emergency Coordination Center. In the earthquake settlement, the transfer of information from the Electronic Health Record (EHR) system to an epidemiological investigation system demonstrated the ability to provide early warning in public health at the onset of an epidemic. In this context, we experimented with the HL7 Clinical Document Architecture Release 2 (HL7 CDA R2)[5] using the International Classification of Diseases, 9th Edition/ Revision (ICD9[II]), International Classification of Primary Care (ICPC[III]) to code diseases, problems and symptoms. The resulting clinical documents were exchanged using web services in the frame of protocols accepted by the World Health Organization (WHO[IV]) and National Center for Disease Control in Greece (KEATINO[V]).

In POSEIDON, a follow-up civil protection exercise co-funded by the European Commission, the theme is severe earthquake following a tsunami in the Mediterranean. Its special focus is collaboration and coordination among the participating member states in the management of disaster and familiarization with the European Civil Protection (ECP) mechanism[VI]. The ECP mechanism was established by the European Council in 2001[6] to provide added-value to European civil protection assistance by making support available on request of the affected country to ensure protection primarily of people, their property, but also of the natural and cultural environment. The need to activate the mechanism may arise if the affected country's disaster preparedness is not sufficient to provide an adequate response in terms of available resources. The tools set in place for the ECP mechanism include the Monitor and Information Center (MIC), the Common Emergency Communication and Information System (CECIS), the ECP Training Program, and the Civil Protection Modules explained below.

MIC is the operational heart of the ECP mechanism, a one-stop-shop for civil protection means available amongst participating states through which all countries affected by a major disaster can make an appeal for assistance. MIC serves as the communication hub at headquarters level between participating states, the affected country, and dispatched field experts and provides useful and updated information on the actual status of an ongoing emergency.

CECIS is a reliable web-based alert and notification application created with the intention of facilitating emergency communication among the participating states.

[I] European Space Agency – ESA, http://www.esa.int

[II] WHO International Codification for diseases: http://www.who.int/whosis/icd10/

[III] International Classification for Primary Care: http://www.who.int/classifications/icd/adaptations/icpc2/en/index.html

[IV] World Health Organization: www.who.int

[V] National Center for Disease Control in Greece: http://www.keelpno.gr/en/

[VI] European Civil Protection Mechanism: http://ec.europa.eu/echo/civil_protection/civil/index.htm

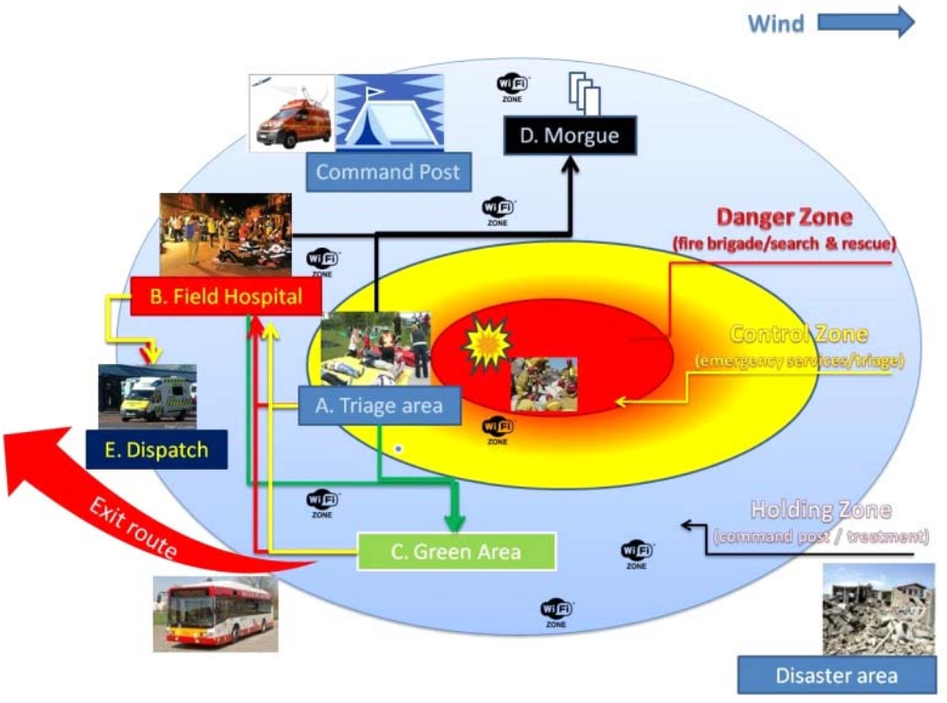


Figure 1 - Operating Zones in the disaster area for POSEIDON: role of ICT

The ECP Training Program is a program that aims to enhance the skills of experts involved in civil protection assistance operations by sharing best practices through training courses, organization of joint exercises, and a system of experts exchange and to ensure compatibility and complimentarity between the intervention teams from the participating member and associate states.

The Civil Protection Modules are made of national resources from multiple member states on a voluntary basis and constitute a contribution to the civil protection rapid response capability fostering organizational interoperability at the level of the intervention teams. So far thirteen modules have been specified, including water purification, urban search & rescue, field hospital, etc.[7].

POSEIDON will organize in October 2011 an operational civil protection exercise in the island of Crete that will engage forces from different European Union (EU) member states through the ECP mechanism. In the "POSEIDON" exercise, ICT needs to address the issue of interoperability standards and alarms in a global setting, whereas specific ICT applications to be deployed conform to these standards and aim at testing:

Activation of the European Civil Protection Mechanism: providing knowledge and wider awareness of the underlying processes and procedures.

Management of medical emergencies, triage: supporting the Emergency Medical Services in effective triage and treatment using innovative eHealth technologies in coordination with the regional health authority (see Figure 1 for an overview of the disaster area in POSEIDON as supported by ICT technologies).

Public alerts and warnings: assuring the provision of safety /evacuation tips to the Public across different media, and possibly attempt to reduce the anxiety of people by exploiting the power of social media,

Situational awareness: providing accurate information to decision makers & the public using standardized messages and exploring the possibility to visually assess the extent of the disaster presenting on the map update messages from the field as well as reports of incidents and available resources possibly including amongst other hospital beds, ambulances, and rescue teams.

In the next section, the relevant activities and standards from HL7[VII], OASIS[VIII], and CEN[IX] are presented as they are at the forefront of the emergency management and disaster medicine. Then, Section III presents in more detail the ICT applications used in SAFE and designed for POSEIDON focusing on interoperability and standardization aspects. Section IV discusses the main findings in SAFE and technical design considerations for POSEIDON. Finally, section V presents the conclusions.

RELATED STANDARDS

HL7 CDA and IHE Profiles

HL7 CDA R2 is an HIT standard modeled along the concept of Electronic Health Record (EHR) paper

[VII] Health Level Seven www.hl7.org
[VIII] Advancing Open Standards for the Information Society - OASIS, http://www.oasis-open.org/home/index.php
[IX] European Committee for Standardization: http://www.cen.eu

forms, useful in the exchange of medical documents among HIT systems. In disaster and emergency management, clinical documents need to be exchanged between Emergency Medical Services and the Emergency Department of the hospitals and their EHR systems if operational and interoperable, but also with public health agencies, regional health authorities and civil protection operation centers.

Integrating the Healthcare Enterprise (IHE[X]) has developed several profiles that relate to prehospital and emergency care. The *Emergency Management Services (EMS) Transfer of Care* (ETC) Profile supports the exchange of clinically relevant data between pre-hospital providers and hospital emergency departments[8]. The *Emergency Department Referral* (EDR) content profile allows clinicians to refer a patient to an emergency department providing a medical summary that includes besides the current health problem, past medical history, and medications, structures to provide information on the estimated time of arrival and method of transport. In addition, the *Emergency Department Encounter Record* (EDER) profile describes the content and format of records created during an emergency department visit. These profiles use clinical documents in HL7 CDA to exchange clinical information or EHR data.

The Emergency Responder Electronic Health Record Interoperability Specification by American National Standards Institute/Healthcare Information Technology Standards Panel (ANSI[XI]/HITSP[XII])[9] has selected specific standards and profiles to track and provide on-site information regarding an emergency episode/victim. These include the IHE profiles mentioned above, the OASIS Common Alerting Protocol (CAP[XIII])[10] examined in Section II, and several infrastructure standards that relate to identification and security. The National EMS Information System (NEMSIS[XIV]) is another effort to standardize and make sense of the emergency information collected across 50 states in the United States. Its data dictionary reflects more than 400 of the most common terms in the management of emergencies[11]. Table 1 shows elements of the EMS Transfer of Care IHE profile and their correspondence to widely used data dictionaries, such as Logical Observation Identifiers, Names, and Codes (LOINC[XV]) by the Regenstrief Institute, and Data Elements for Emergency Department Systems (DEEDS[XVI]) by the Center for Disease Control and Prevention (CDCX[XVII]).

Within HL7, besides the Structured Documents WG which works on clinical document specifications and implementation guides for CDA and the EHR WG that works on functional specification for different cases of EHR use, Emergency Care (EC)[XVIII] and Public Health and Emergency Response (PHER)[XIX] are Working Groups specifically looking into issues that relate to emergency management. The EC WG aims to *"bring the unique understandings and perspectives of prehospital care, emergency medicine, and emergency nursing to the HL7 standards process"*, focusing on the development of comprehensive EHRs. The PHER WG is focusing mostly on public health issues related to emergencies.

S. Renly et al. discuss in[12] the use of HL7 CDA in a cross-border setting in the Middle East. Schnürer and Oemig in[13] support that Aarden syntax, a standard produced by the relevant HL7 Aarden Syntax WG[XX], can be used along with terminology codes to trigger alerts and reminders to health practitioners in the presence of specific findings according to the epidemiological protocols defined by public health agencies.

OASIS-Emergency: Structured Information Standards

OASIS is a non-for-profit consortium for the advancement of Structured Information Standards founded in 1993 as Open Standard Generalized Markup Language (SGML Open). The objective of OASIS as it relates to emergency management is twofold. First is to accelerate the development, adoption, application, and implementation of emergency interoperability and communications standards. Second is to represent and serve the needs of all constituents, from practitioners to technology providers and national, international and multinational oversight agencies. The emergency interoperability member section of OASIS was formed in 2007 and consists of a steering committee and two affiliated technical committees: the Emergency Management Technical Committee (TC)[XXI] (2003) that creates standards and the Emergency Management Adoption[XXII] TC (2009) that addresses Education and Outreach. The emergency standards ratified or under development by OASIS-Emergency include the following:

- Common Alerting Protocol (CAP) v1.1, an International Telecommunications Union (ITU) Recommendation x.1303 in 2007[14]

- Emergency Data eXchange Language (EDXL) – Distribution Element (DE) (2006)[15]

[X] Integrating the Healthcare Enterprise www.ihe.net
[XI] American National Standards Institute – ANSI, www.ansi.org
[XII] Healthcare Information Technology Standards Panel – HISP, http://www.hitsp.org
[XIII] OASIS Common Alerting Protocol – CAP, http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html
[XIV] National EMS Information System- NEMSIS, http://www.nemsis.org/
[XV] Logical Observation Identifiers Names and Codes- LOINC, http://loinc.org
[XVI] Data Elements for Emergency Department Systems, http://www.cdc.gov/ncipc/pub-res/deedspage.htm
[XVII] Center for Disease Control, and Prevention, http://www.cdc.gov
[XVIII] HL7 Emergency Care Working Group, http://www.hl7.org/Special/committees/emergencycare
[XIX] HL7 Public Health and Emergency Response Working Group, http://www.hl7.org/Special/committees/pher
[XX] HL7 Aarden Syntax Working Group http://www.hl7.org/Special/Committees/arden/index.cfm
[XXI] OASIS Emergency Management Technical Committee, http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=emergency
[XXII] OASIS Emergency Management Adoption Technical Commitee http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=emergency-adopt

Table 1 - EMS Transfers of Care Data Element Index[8]

Data Element	pt	LOINC	DEEDS	NEMSIS
Emergency Contact Info	R2	Not available in LOINC	1.14 to 1.17 Emergency Contact	E07_18 to E07_26 Closest Relative
Chief Complaint	R	10154-3 CHIEF COMPLAINT	4.06 Chief Complaint	E09_05 Chief Complaint
Injury Incident Description	R	11374-6 INJURY INCIDENT DESCRIPTION	5.03 Injury Incident Description	E09 Situation E10 Situation/Trauma
History of Present Illness	R2	10164-2 HISTORY OF PRESENT ILLNESS	5.15 ED Clinical Finding	N/A NEMSIS
Acuity Assess	R2	11283-9 ACUITY ASSESSMENT	4.08 First ED Acuity Assessment	N/A NEMSIS
Active Problems	R2	11450-4 PROBLEM LIST	5.15 ED Clinical Finding	E12_10 Medical/Surgical History
Current Medications	R2	10160-0 CURRENT MEDICATIONS	5.09 Current Therapeutic Medication	E12_14 Current Medications
Allergies	R2	48765-2 ALLERGIES, ADVERSE REACTIONS, ALERTS	5.15 ED Clinical Finding	E12_08 Medication Allergies, E12_09 Environmental/Food Allergies
Immunizations	R2	11369-6 HISTORY OF IMMUNIZATIONS	5.15 ED Clinical Finding	E12_12 Immunization History
History of Past Illness	R2	11348-0 HISTORY OF PAST ILLNESS	5.15 ED Clinical Finding	E12_10 Medical/Surgical History
History of Pregnancies	R2	10162-6 HISTORY OF PREGNANCIES	5.15 ED Clinical Finding	E12_20 Pregnancy
Advance Directives	R2	42348-3 ADVANCE DIRECTIVES	5.15 ED Clinical Finding	E12_07 Advanced Directives
Family History	R2	10157-6 HISTORY OF FAMILY MEMBER DISEASES	5.15 ED Clinical Finding	E12_10 Medical/Surgical History
Social History	R2	29762-2 SOCIAL HISTORY	5.15 ED Clinical Finding	E12_10 Medical/Surgical History
Vital Signs	R	8716-3 VITAL SIGNS	5.15 ED Clinical Finding	E14 Assessment/ Vital Signs
Pertinent ROS	R	10187-3 REVIEW OF SYSTEMS	5.15 ED Clinical Finding	E09_13 Primary Symptom
Physical Examination	O	29545-1 PHYSICAL EXAMINATION	5.15 ED Clinical Finding	E16 Assessment/ Exam
Assessment	R	X-ASSESS ASSESSMENTS	8.30 Patient Problem Assessed	E09_15 Providers Primary Impression
Intravenous Fluids Administered	R	X-IVFLU INTRAVENOUS FLUID DMINISTERED	6.02 ED Procedure	D04_04 E18_04 Medications Given Route, 4205 Intravenous
Medications Administered	R	18610-6 MEDICATION ADMINISTERED (COMPOSITE)	7.04 ED Medication	E18_03 Medication Given
Procedures	R	X-PROC	6.02 ED Procedure	E19_03 Procedure

- EDXL – Resource Messaging (RM) (2009)[16]
- EDXL – Hospital Availability (HAVE) (2009)[17]
- EDXL – Situation Reporting (SitRep) work in progress[18-19]
- EDXL – Tracking of Emergency Patients (TEP), analysis phase[XXIII]

[XXIII] OASIS Tracking of Emergency Patients http://www.evotecinc.com/TEP/

- EDXL – Tracking of Emergency Clients (TEC), analysis phase
- The CAP v1.2 Integrated Public Alert and Warning System (IPAWS) Profile v1.0 was approved as a Committee Specification in 2009. The Department of Homeland Security's Federal Emergency Management Agency (FEMA) has decided to adopt an alerting protocol in line with CAP 1.1 as the standard for Public Alerts and Warnings[20].

The OASIS EDXL standards today provide the capability to support Alerts and Warnings, seamless routing of information, hospital availability to know where to route patients, and to request, commit, track, status and return resources. Important standards under development are those for Situation Reporting about any incident and its response (SitReps), to track patients (TEP), and extension of TEP to track any person displaced, evacuated, sheltering in place, expired, and/or requiring medical attention in the context of any scale incident (TEC). EDXL-SitReps aims to standardize the operational picture of the incident namely information about the situation and cross agency/jurisdiction response between responders, government officials, coordinating entities and the public[21].

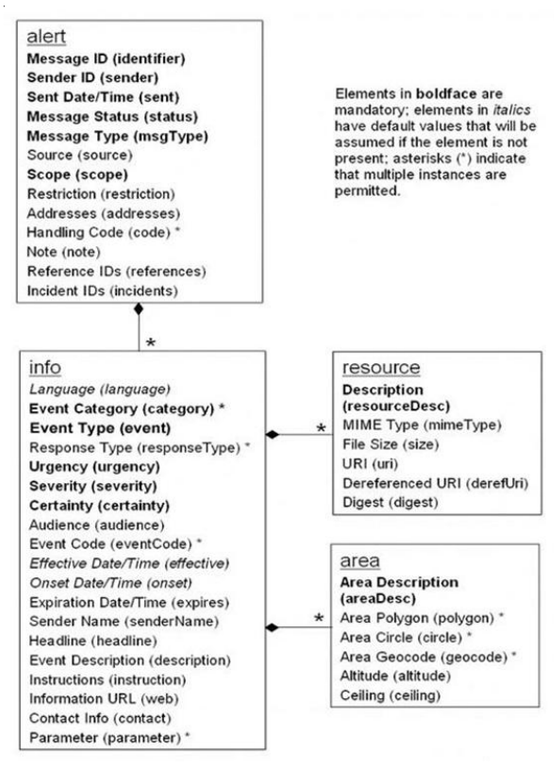


Figure 2 - Basic entities of the Common Alerting Protocol[10,14].

In Europe, CAP (Figure 2) has been used along with the Tactical Situation Object (TSO) developed in the EU co-funded Open Advanced System for Disaster and Emergency Management (OASIS project[XXIV]), in Reaction to Emergency Alerts using voice and Clustering Technologies (REACT project[XXV]), a follow-up EU project to facilitate effective electronic communications among operation centers using standards[22]. TSO is the result of CEN Workshop Agreement led by the OASIS project to facilitate the exchange information in disaster and emergency management. TSO consists of message syntax and a dictionary[23] and provides information regarding an emergency episode comprising of context, event, resources, and associated missions (see Figure 3). Different types of events, the resources engaged in the operation, and the tasks in progress are reflected in TSO terms (i.e. Context, Event, Resource, and Mission). The REACT project used CAP with the TSO dictionary and its successful approach was adopted by the Italian Firecorps[24].

HIT IN THE MANAGEMENT OF EMERGENCIES

Experience from SAFE

The Satellites for Epidemiology and health early warning project (SAFE[XXVI]), set out to demonstrate the value of satellite-enabled applications in the acute phase of the disaster as well in a settlement of earthquake victims. A vehicle equipped with satellite & local WiFi communications accompanied by a mobile biochemical laboratory provided the supporting infrastructure on the field within 30 mins of arrival, while a number of satellite terminals provided auxiliary telecommunication capabilities to key locations including the Operations Center of Civil Protection, a regional Hospital, and the Emergency Coordination Center. Dedicated power generators provided autonomy to each of these sites and a WiFi network provided the mobile teams with a live connection to the civil protection operation center, independent of the conventional telecommunications infrastructure,

[XXIV] OASIS EU project: Open Advanced System for Disaster and Emergency Management, http://www.oasis-fp6.org/
[XXV] REACT EU project: Reaction to Emergency Alerts using voice and Clustering Technologies, http://www.react-ist.net/
[XXVI] SAFE - Satellites for Epidemiology and health early warning project: http://www.medes.fr/home_fr/telemedecine/teleepidemiologie/safe.html

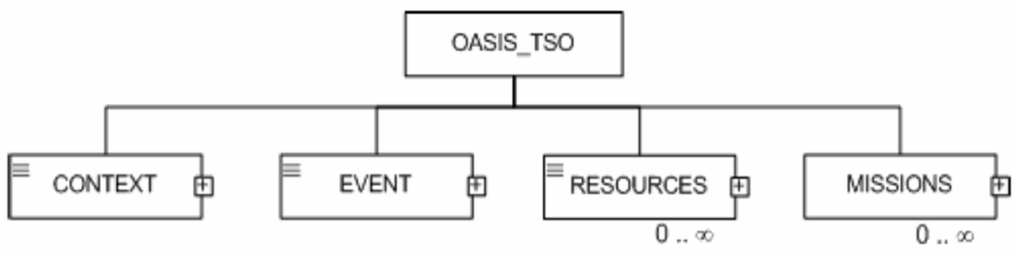


Figure 3 - Components of TSO object used in the REACT project[23].

which may be damaged or severely overloaded by the disaster. Thus, despite the disaster each of these sites was able to communicate through the Internet along horizontal and vertical lines of command.

Figure 4 - Triage application used by Red Cross volunteers in SAFE.

In the acute phase of the disaster volunteers with PDAs entered triage information (Figure 4) that was immediately conveyed to the Emergency Coordination Center through the Satellite/WiFi network.

In the emergency ward of the hospital, a screen listed the emergency episodes transferred in ambulances en route to the hospital (Figure 5). In the earthquake settlement, a group of volunteers with PDAs supported the management of the camp by recording the health needs of the population, facilitating the creation of reports on the status of the settlement and requesting medication, and other needs. The use of open standards was limited, since both applications were dedicated clients to the legacy emergency information system. The use of non-standard unstructured reports via email worked at the local level, but overall scalability was limited in relation to the exchange of information with third-party systems, a capability that was not exploited in SAFE.

In the medical office of the earthquake settlement an EHR system was deployed, and was extended to support selected protocols of the National Center for Disease Control. The symptoms (in ICPC) and diseases (in ICD9) that were recorded during the patient visit to the office, triggered an alert to report the incident, by presenting the appropriate form with selected fields were automatically retrieved from the EHR. After the physician digitally signed the form, the latter could be submitted through a web service, in HL7 CDA format to the epidemiological surveillance system. Additional reports from the mobile clinical laboratory were linked to the original report based on a unique id. The HL7 CDA implementation guides used in this context have been adapted from ones developed for the US realm[25].

POSEIDON: Resilient & Robust Interoperable Systems

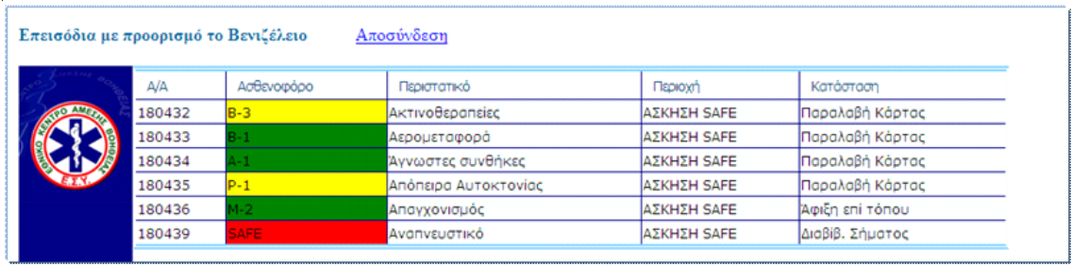
Building on the experience gained in SAFE, efforts concentrated on creating open resilient and robust applications that address the information needs of different groups including decision makers, civil protection teams, emergency workers, and the public targeting the efficiency of the underlying processes. In particular, application focus areas that were selected to be supported with appropriate interoperability standards were:

- Situational Awareness for civil protection agencies and informed decision about the activation of the ECP mechanism
- Management of Emergencies, Triage, and Telemedicine
- Alerts and Warnings to the Public.

Each of these areas is described in the paragraphs below.

Supporting Situational Awareness

Situational awareness is a process rather than a state where people are aware of emergency situations, and pending risks, and take measures to address them (Figure 6). Recent advances in ICT can support situational awareness by providing up-to-date information to collaborating civil protection agencies on the unfolding emergency incidents. Digital maps showing with clear marks information on the severity of incidents, the status of the infrastructure and the allocation of resources would facilitate not only decision making, but also horizontal and vertical coordination and communication. SmartPhones with Global Positioning System (GPS) and Geographical Information System (GIS) support will provide



Α/Α	Ασθενοφόρο	Περιστατικό	Περιοχή	Κατάσταση
180432	B-3	Ακτινοθεραπείες	ΑΣΚΗΣΗ SAFE	Παραλαβή Κάρτας
180433	B-1	Αερομετακομιδή	ΑΣΚΗΣΗ SAFE	Παραλαβή Κάρτας
180434	A-1	Άγνωστες συνθήκες	ΑΣΚΗΣΗ SAFE	Παραλαβή Κάρτας
180435	P-1	Απόπειρα Αυτοκτονίας	ΑΣΚΗΣΗ SAFE	Παραλαβή Κάρτας
180436	M-2	Απαγχονισμός	ΑΣΚΗΣΗ SAFE	Άφιξη επί τόπου
180439	SAFE	Αναπνευστικό	ΑΣΚΗΣΗ SAFE	Διαβίβ. Σήματος

Figure 5 - An application in the Emergency Department providing advance information on the episodes about to arrive.

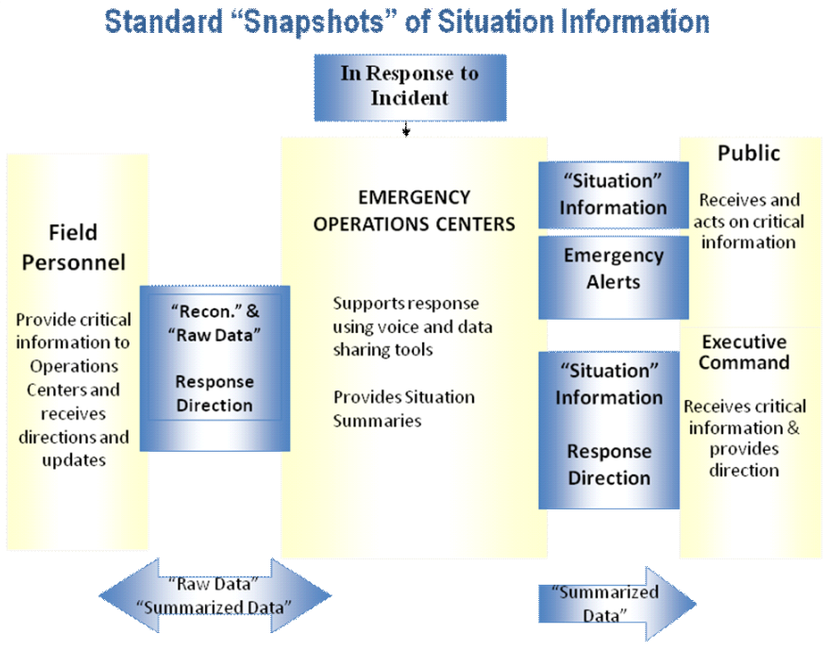


Figure 6 - Types of Situation Information from in EDXL-Sitops[18].

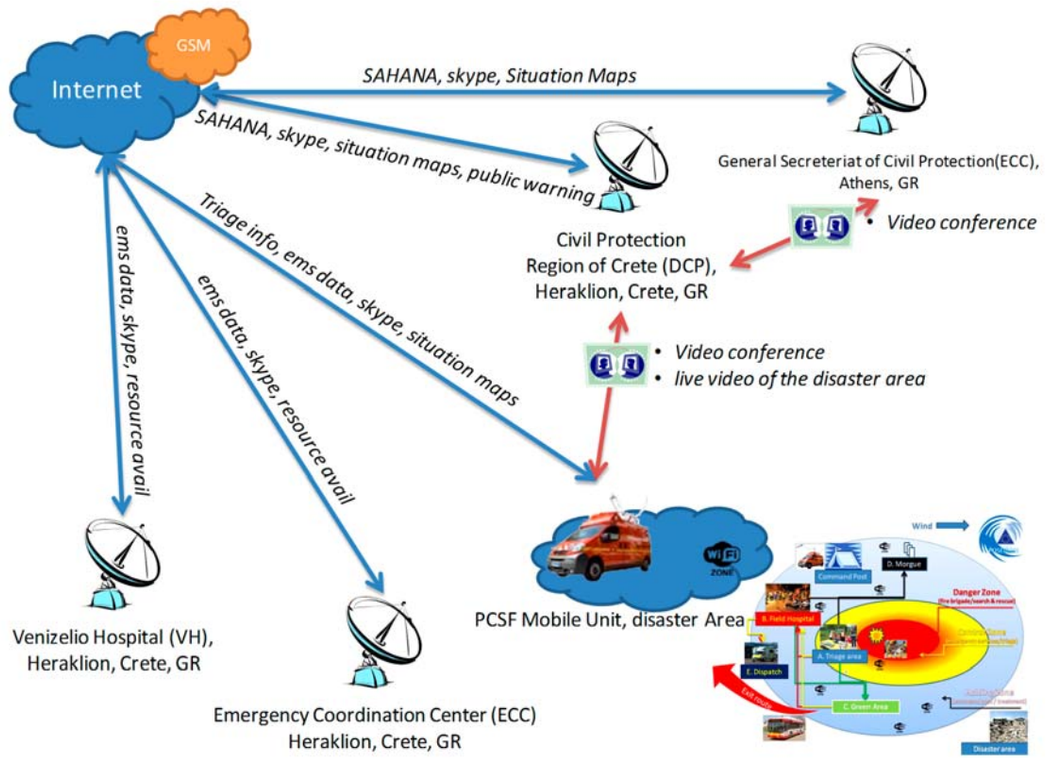


Figure 7 - Emergency Network infrastructure in the field area supported by satellite and wireless communication.

updates to commanders over the hybrid emergency satellite/WiFi network. In POSEIDON the CAP protocol will be evaluated as the message format. However, specification of the data dictionary is pending as TSO, EDXL-SitOps, RM, TEP are analyzed together with relevant medical dictionaries in the specific POSEIDON context. The REACT project used the TSO dictionary together with CAP to communicate information on the status of the crisis in different languages. In POSEIDON we need to use custom codes in Greek, which need to be translated in English and French to support intervention teams from other EU member states. Recent developments in OASIS-Emergency for EDXL standards as SitOps,

as well as HL7 Domain Analysis Models and IHE profiles for emergency are quite promising and of potential use to POSEIDON that addresses the specific use case dealing with Earthquake and Tsunami.

Management of Emergencies – Triage-Telemedicine

Significant part of the data feeding situational awareness is provided by the actual emergency workers on the field, doing triage, engaging in emergency treatment, or transferring victims to a healthcare facility or a shelter. The transfer of information on the number, type, and severity of emergency episodes from the crisis area to the Operation Center of the Civil Protection, the Emergency coordination center and the receiving hospitals can help take important decisions about the management of resources and possibly the request for external assistance. Additional issues related to the use of interoperability standards at the site of the crisis concern information on hospital resources and the use of telemedicine services to support emergency health workers in field hospitals. Interoperability is quite important if the EHR is perceived to evolve as the central repository for all citizen related health data. Figure 7 shows a supporting auxiliary rapidly deployable network infrastructure based on Satellite communication (a satellite equipped van), a local WiFi network, and optionally sensing devices and actuators equipped with Radio Frequency Identification (RFID) designed for POSEIDON. What is particularly important in this emergency setting is that each of these telecommunication links does not constitute a single point of failure. Global System for Mobile Communication (GSM) & Satellite communications, RFID and traditional PDAs/ Smartphones should work interchangeably to provide robust services facilitated communication and coordination among decision makers and emergency response teams.

The form shown in Figure 8 has been designed by emergency management personnel to be used during secondary triage-treatment in the field hospital area and upon arrival to the hospital (area indicated by box). If standardized and widely adopted not only for

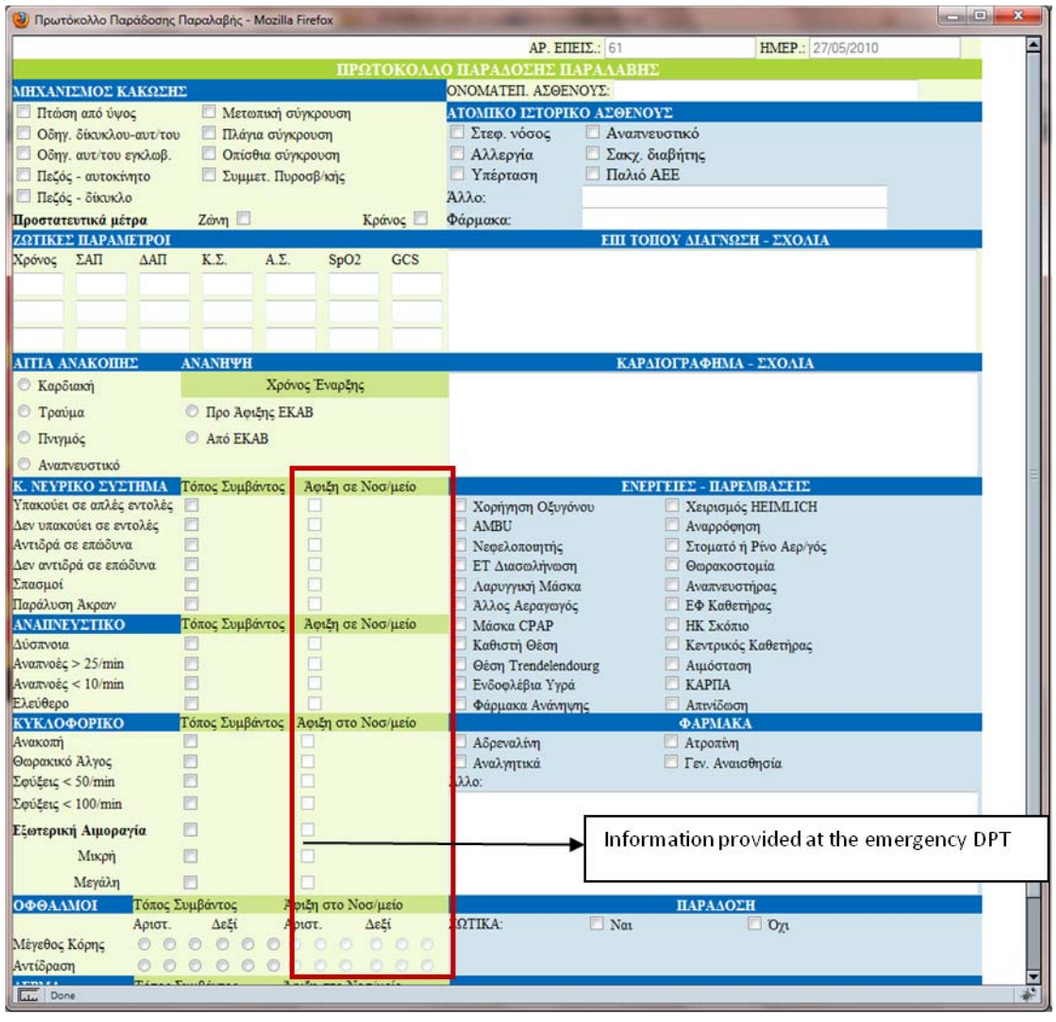


Figure 8 - Form provided upon delivery of episode to the hospital Emergency Department by EMS ambulance personnel.

disasters but also daily practice, it could improve to accountability, resource management, and eventually patient outcome.

An area where the HL7 CDA seems to be particularly useful is the exchange of data between the Emergency Coordination Center and the Emergency Department component of the hospital information system. The IHE ETC content profile has been analyzed to examine whether it suffices to accommodate the information. In addition to IHE profiles elements of the ongoing work on EDXL TEP need to be taken into account.

If the ability to evacuate the patients is limited, telemedicine could be a viable alternative, in the absence of specialized health professionals. From a standards perspective, clinical documents in HL7 CDA based on different templates could form parts of a teleconsultation folder, presenting an overview of an episode to be shared with experts. Additionally, patient-connected health monitoring devices can provide volunteers with important insight on their progress, while they can also support telemedicine.

Another important aspect of our work relates to the EDXL- HAVE standard[17], which specifies an XML document format that allows communicating the status of a hospital, its services, and its resources. These include bed capacity and availability, emergency department status, available service coverage, and status of a hospital's facilities & resources (Figure 9).

Alerts, Warnings and Guidance to the public

Alerts and Warnings for the public traditionally use different media, e.g. sirens, loudspeakers, radio, internet, television, short messages. In addition, customized maps may provide evacuation routes and concentration areas. As far as standards are concerned, CAP provides the right standardization framework. However, the actual message format and content need to be analyzed, confirmed with, and endorsed by the national civil protection authorities for limited experimental use and evaluation by exercise participants. Currently in Greece, there is no legal framework for the use of electronic communication in alerting the Public on the occasion of pending natural disasters such as tsunamis. Thus, the evaluation results of this public alert service in the POSEIDON exercise will be reported to relevant authorities.

In the USA, National Oceanic and Atmospheric Administration (NOAA), already produces tsunami alerts using CAP on the Internet (Figure 11). In Europe, a tsunami alert service is provided on subscription basis

```
<have:HospitalBedCapacityStatus>
<have:BedCapacity>
 <have:BedType> AdultICU </have:BedType>
 <have:Capacity>
  <have:CapacityStatus> Available
</have:CapacityStatus>
 </have:Capacity>
 <have:SubCategoryBedType> Surgery
</have:SubCategoryBedType>
 <have:Capacity>
  <have:CapacityStatus> Vacant/Available
</have:CapacityStatus>
  <have:AvailableCount> 40 </have:AvailableCount>
 </have:Capacity>
 <have:SubCategoryBedType> General
</have:SubCategoryBedType>
 <have:Capacity>
  <have:CapacityStatus> Vacant/Available
</have:CapacityStatus>
  <have:AvailableCount> 20 </have:AvailableCount>
 </have:Capacity>
</have:BedCapacity>
```

Figure 9 - EDXL-HAVE message example[17]

Figure 10 - Map showing graphically the tsunami alert, shelters, and evacuation routes. The map will be automatically updated to reflect updates from the field and facilitate communication and coordination.

Figure 11 - NOAA is using CAP in tsunami alerts

to interested individuals (http://www.tsunami-alarm-system.com). The CHORIST[27] project is another effort supported by the European commission to develop modules for risk assessment, public warning, and a rapidly deployable telecommunications system that is using TSO and CAP. As already mentioned CAP is an XML-based data format for exchanging public warnings and emergencies between alerting technologies. CAP allows a warning message to be consistently disseminated simultaneously over many warning systems and media including internet, radio, SMS, TV, etc. Thus, CAP increases warning effectiveness and simplifies the task of activating a warning.

RESULTS - DISCUSSION

The "SAFE" exercise demonstrated the value of ICT in the management of disasters. However, in a larger European or global context, interoperability issues turn out to be quite critical in providing timely information to decision makers, emergency workers, and the public.

ICT applications built for emergencies need to be primarily usable, robust, and resilient. In SAFE, despite support for disconnected operation, security and privacy provisions were deemed quite unfriendly to users with PDAs that were facing repeated disruptions of network connectivity. The high overhead of security and privacy mechanisms has to be weighed against usability and productivity in the backdrop of fluctuating network infrastructure. Moreover, while delivering integrated services is helpful, a reliable and robust solution requires redundancy so that occasionally unavailable service components do not hinder emergency communications. Disconnected operation is quite important, while flexibility and alternative ways of use are keys to an effective ICT-enabled communication and coordination mechanism. Finally, the availability of HL7 CDA implementation guides available at the HL7 portal, were very helpful in the process of creating the specific clinical document templates for a predefined standards-compliant way of communicating accurate health data.

For POSEIDON, the challenges are higher as we try to bring ICT applications to work much closer to standards from HL7, OASIS and other relevant SDOs, while addressing the interoperability issues present both at the technical and the organizational levels. Information that flows in from different sources has to be cross-checked and leveraged based on standard procedures. This is a quite challenging task as information and messages should be developed in Greek and translated in English and French. Moreover, the legal framework needs to be reexamined reflecting on the experience gained and the evaluation results of the POSEIDON exercise.

Although selection of applications and configuration in POSEIDON is still in the adaptation stage, early

indications show that cooperative use of standards through predefined protocols and guidelines appropriate to the disaster scenario considered is feasible. However more work lays ahead: bridging gaps and harmonizing partly overlapping standards in emergency management and health information technology would certainly improve our capacity for rapid situation assessment and emergency response.

CONCLUSIONS

Situational awareness, resource availability, and timely response are the most critical parameters for effective disaster management. The grand challenge for engineers in service design and implementation is to cooperative deploy standards from different organizations to create robust, resilient and flexible integrated services, and leverage information from different sources to support decision making. The pressing need for HL7 International and other Standards Development Organizations (SDOs), interoperability initiatives and consortia is to work together to cultivate a spirit of cooperation and collaboration that will bring out effective robust and usable services built on global agreed standards to advance interoperability not only at the technical but more importantly at the organizational level leading to more effective and informed Disaster Management and Emergency Response.

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