Deliverable reference:	Date:	Responsible partner:
D13.3	12 August 2015	RAKOS

Bridging Resources and Agencies in Large-Scale Emergency Management

BRIDGE is a collaborative project co-funded by the European Union's Seventh Framework Programme for research, technological development and demonstration (FP7-SEC-2010-1)
SEC-2010.4.2-1: Interoperability of data, systems, tools and equipment
Grant Agreement No.: 261817
Duration: 1 April 2011 – 31 March 2015

www.bridgeproject.eu

Title:

End-User Involvement Report

Editor(s):	Approved by:
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	Classification: Public

Abstract / Executive summary:

The major issues researched in this report are: *How are the end users' perspectives integrated in the BRIDGE project, and which adaptive measures to end users' capabilities and challenges have been emphasised during the project execution?* It is a criterion that the project should provide *significant* improvements to the emergency response. Expert judgements in disaster risk reduction could be applied to frame information about emerging crises in "the real world", for making assumptions and communicating recommendations to researchers and technology developers in the BRIDGE consortium. It is the joint performance of experts as a group that guided the construction of the End-User Advisory Board (EUAB). We always need a combination of experts (phenomenological expert, communication expert, social relations, technological equipment, psychology etc.), of which our conception is a load-response model. Knowledge about the load (scenario, energy, toxicity, malicious intentions etc.) and the associated first responses (psychology, sociology, technology and culture of human-system interrelationships) are linked to the expert skills. This document presents an analysis of the end-users' involvements provided by interactions between the researchers in the consortium developing technologies, the social scientist, crisis management researchers and professional end-users, of which the EUAB played an important role.

The end-users were thought to become challenged with; Requirements, Specifications, Development and Validation. In order to meet these challenges the contents of end user involvement have changed according to the level of maturity of the products produced in BRIDGE. End-users were involved in EUAB meetings, workshops, conferences, participation in demonstrations, evaluations, attending ValEDation Days, and testing concept cases.

The end user involvement as part of the Participatory Design Methodology has been extensive and continuous spanning from informal contacts to structured evaluations of demonstrations. The technology developers have had a humble approach to the disaster response domain, being observant and sensitive to input from end users. The achievements presented through the eight concept cases and the underlying Middleware are developed through a process with continuous feed-back and adaptation to end-users' needs and challenges.

We consider the design of the BRIDGE project's active use of participatory trial research as promising and a basis for further development in future EU projects in the disaster risk reduction domain.

Document URL:
http://www.sec-bridge.eu/deliverables/...

ISBN number:
-

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Version History

Version	Description	Date	Who
1	First version, creating document structure and some text contributions	13.04.2015	Eivind L. Rake and Ove Njå
2	Second, preliminary, version	10.05.2015	Ove Njå and Eivind L. Rake
3	Third version	10.06.2015	Ove Njå and Eivind L. Rake
4	Review version	26.06.2015	Eivind L. Rake and Ove Njå
5	Final version	14.07.2015	Ove Njå and Eivind L. Rake

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List of Abbreviations

3D	Three dimentional
ASA	Advanced Situation Awareness
ATS	Air Traffic Service
AZF	French initialism for AZote Fertilisant, i.e. nitrogen fertiliser
BRIDGE	Bridging resources and agencies in large-scale emergency management
C2	Command and control
CC	Concept Case
COTS	Commercial Of The Shelf
CTAS	Crisis Training AS
DEMO	Demonstration
DKKV	Deutsches Komitee für Katastrophenvorsorge e.V (German Committee for Disaster reduction)
Dr.	Doctor
EDXL	Emergency Data Exchange Language standard
ELSI	Ethical, Legal and Social Implications
EMCC	Emergency Medical Communication Center
eTriage	Electronic triage system
EU	European Union
EUAB	End – user Advisory Board
EUI	End – user involvement
FIT	Fraunhofer-Institut für Angewandte Informationstechnik
FRITS	First Responders Integrated Training System
GCS	Glasgow Coma Scale
GPS	Global Positioning System
ICT	Information and communications technology
ID	Identification
JIRA	A proprietary issue tracking system used in BRIDGE for project management functions

JRRC	Joint Rescue Coordination Centre
LED	Light emitting diode
LNG	Liquefied natural gas
LRS	Local Rescues Sub-centre
LTE	Long term evaluation
MHA	Master of health administration
MSB	Myndigheten för samhällsskydd och beredskap (Swedish Civil Contingencies Agency)
NKI	Name of a school of engineering
PhD	Philosophiae doctor
PLUS	The Paris Lodron University of Salzburg
PPR	Project Delivery report
RAKOS	Regionalt Akuttmeidisnsk Kompetanse Senter (The Regional Centre for Emergency Medical Research and Development)
RCC	Robust and Resilient Communication
SAMU	Service d'Aide Médicale Urgente (Urgent Medical Aid Service)
SINTEF	A company name
SOS	Urgent distress call
SUH	Stavanger University Hospital
SWARM	Situation aWare Resource Management
TCC	Technical Coordination Committee
TEMIS	A company name
THW	The Bundesanstalt Technisches Hilfswerk (German Federal Agency for Technical Relief)
UAV	Unmanned Aerial Vehicle
UIISC	Intervention and Guidance Units for Civil Protection
WFGM	Work Flow Generation and Management
WHO	World Health Organization
WP	Work packages

1 Introduction

Rescuers respond to emergency situations that are unique. Decision making on scene an accident is context bound, embedded in ever changing environments. Thus, decisions in action sometimes involve huge uncertainty. In order to ensure self-protection and to optimise the outcomes of life saving and damage mitigation activities, the rescuers' competences must span from automatic skill-based behaviour to problem solving knowledge based behaviour (Rasmussen, 1983). The crisis command system orchestrates the entire response effort, maintaining the hierarchical command structure on scene.

1.1 Major issue regarding end-users' involvement

How can technology provide positive influences in the most critical phases of an emerging crisis? How can technology within complex emergency response systems enhance performance in situations, for example when the crisis is in its early stage? In such cases the consequences may be unclear, different authorities may be involved, and many actors may be involved in the on scene crisis combatting. The media may be paying particular attention to the crisis, seeking commentary from many quarters, which may lead to mis-reporting of circumstances and future actions. Incident commanders in neither the police service, the ambulance service nor fire brigades have substantial experience from large/major incidents, thus novelty is an important feature. The questions are numerous and uncertainties large, especially since the BRIDGE project assume large scale crises. Such crises presuppose that the pre-crisis phases have emerged, in which the contextual conditions will vary substantially and similarly the working conditions for the first responders. The end user advisors assigned to the BRIDGE-project therefore played an important part as experienced and reflective professionals, able to address the concept cases and systems of systems to "real world" contexts.

The overall goal of BRIDGE has been to increase the safety of citizens by developing technical and organisational solutions that significantly improve crisis and emergency management. BRIDGE is building a system to support interoperability – both technical and social – in large scale emergency management. The system serves as a 'bridge' between multiple first responder organisations, contributing to an effective and efficient response to a variety of events such as natural catastrophes, technological disasters, and large scale terrorist attacks. The key to this is to ensure interoperability, harmonisation and cooperation among stakeholders at a technical and organisational level.

The major issues researched in this report are: *How are the end users' perspectives integrated in the BRIDGE project, and which adaptive measures to end users' capabilities and challenges have been emphasised during the project execution?*

The issues prerequisite an in-depth knowledge about crisis scenarios, characteristics of interactive response systems, patterns of weaknesses and strengths, and various organisational, institutional and national barriers to integrate advanced human/computer interaction techniques. Furthermore knowledge about the working practices and underlying understandings as well as disaster management strategies are vital to the analysis of the issues presented above.

1.2 The BRIDGE project

The BRIDGE project was planned with a significant involvement from end users, and RAKOS was given the task to coordinate the End-User Advisory Board (EUAB) and contribute with end user perspectives throughout the project. Figure 1 illustrates the project's working packages and the major End User Involvement (EUI) activities.

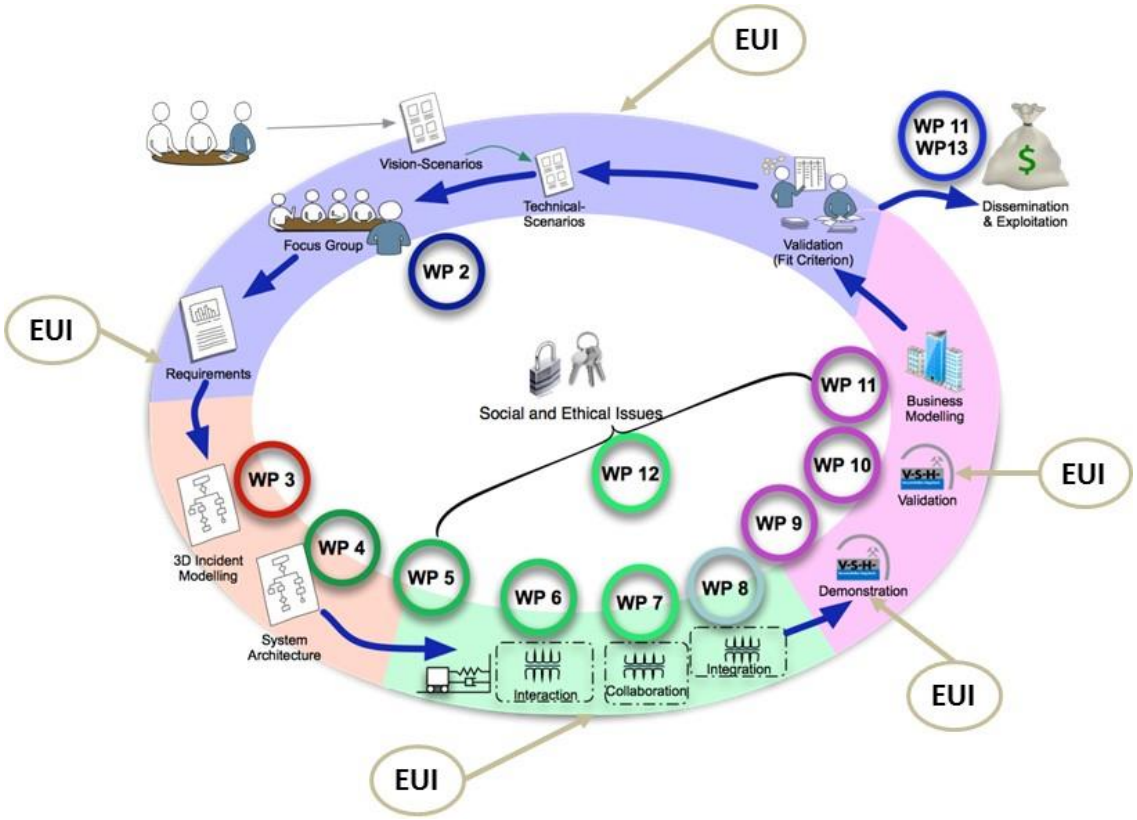

Figure 1 Work packages, connections and end-user involvement (EUI)

WP 2 was dedicated activities for domain analysis with the purpose to reveal characteristics of the crisis management field that could be useful for requirements and the development of technical solutions throughout the project. The researchers used a large set of social science methodologies to collect, analyse and transform data into useful interactions between concept case owners and end users.

WP 3 encompassed the development of tools for a computer-based 3D graphics model based on available information and scenarios about targeted critical infrastructures. Software components for running 3D simulation in real-time during training and in case of an emergency has been developed, and also deploying 3D simulations to relevant parties using ad-hoc network and technology.

The work in WP 4 yielded gathering and analysing services, standards, systems and applications, delivering the technologies for middleware, integration and interoperability. The work identified core functionalities and described the system through manageable, ordered, logical blocks and components, in order to specify a detailed system architecture and deployment strategy. The major goal was to specify and design the architectural components and integration strategy required for multimedia data.

WP5 (Network and interoperability) developed the BRIDGE Interoperability Platform comprising solutions for providing stable network infrastructures and interoperability among network nodes in BRIDGE networks, such as; MESH as overlay ad-hoc network; opportunistic systems (Help Beacons, Local Cloud); and combined MANET (mobile ad hoc networking)/DTN (delay tolerant network) routing. The work developed new and enhanced middleware functionalities, and it provided visualisation tools for changing networks.

WP6 (Interaction design) dealt with design and user-interaction techniques especially suited for command posts (whether in the field or not) and mobile devices. The work comprised development of a set of common user interface components that presents information pulled and fused from the given situation and related events. The user interface is able to facilitate multi-agency planning, scheduling, and situation awareness in time-critical settings. Furthermore, the user interface is scalable, so it can accommodate different leaders at different levels in a hierarchy, therefore it can accommodate people with different cultural, ethical and professional backgrounds. The user interface is able to integrate information from a variety of sources, including services and sensors in a flexible manner both at design and run time. The work has also included exploration of novel stationary and mobile user interaction techniques supporting crisis and emergency management (including the responding services, victims, bystanders and technical resources).

WP7 (Collaboration technologies) established methods and tools that support run-time inter-agency and inter-agent collaboration. In this work a model based automated (collaborative) support system in combination with scenario-based multidisciplinary training sessions was developed. The work also comprised development of an agent based workflow composition and communication support system, introducing design scenarios, training and (development) exercises with focus on experience based learning in social contexts.

The integration was organised in WP8 and was a continued integration of all the parts of the BRIDGE system as well as the technical testing of its functionality. BRIDGE is a system of systems, with no single fixed BRIDGE system configuration; it changes over time and services come and go. A particular BRIDGE system configuration depends on the situation (e.g. emergent interoperability). The test formalised a set of actions including any procedure, process, equipment, material, activity or system that helped to understand whether the system performances met the required specifications and quality attributes. The BRIDGE platform is a foundation for the system of systems, and the integration is based on loosely coupled components and standardised messaging and service interfaces.

WP9 was the demonstration work package aimed at showing tangible results created during the project phases. The work included four demonstrations (Flums 1, Stavanger 1 and 2, and the final demonstration in Flums), which showed the progress of the work. Closely connected with WP 9 was the WP10 Validation-package. Validation and evaluation consisted of performance testing and general assessment of usability and sustainability of the system compared to the established functional requirements from the JIRA database.

WP12 (Social, legal and ethical aspects) facilitated constructive deep integration of multi-dimensional social, legal, ethical analysis into ambitious interdisciplinary user-led socio-technical innovation. It combined the expertise of social experts to provide integrated design oriented analysis. The work included an inventory of privacy issues in large scale crisis management systems, and it developed possible strategies for handling potential privacy (personal data) infringements and other risks. Exploration of a ‘living lab’ approach was focused to also contribute to academic and public debates about social, ethical and legal issues.

In the WP13 (Dissemination and standardisation) two main components were addressed: Internal and external dissemination strategies as well as implementation of the developed

system elements. Work was also carried out to support further exploitation (based on business plans developed in WP 11 Business modelling and exploitation), with the ultimate goal of standardising the support resources used in multinational crisis response.

Increasing the efficiency of multinational crisis response by the enhancement of new technology processes and organisation has been one of the most important issues in the BRIDGE project. Aspects of efficiency due to innovative technological and operational solutions have been considered in order to achieve the desired integrated system approach. Thereby, the solutions developed have had the aim of harmonised interfaces between the different users. An End User Advisory Board (EUAB) was formed to strengthen the end user involvement.

1.3 The End-User Advisory Board (EUAB)

The EUAB was assigned to reflect the BRIDGE objectives and achievements from the first responder's point of view, in particular with regard to requirements definition and specification, review of intermediate and final results. The end user involvement activities have been most prominent in the domain analyses phases, the development of functional requirements (Rake, 2012), discussing concept cases and systems of systems during its developments, setting up demonstrations, evaluate and assess experiments and conducting end user validations. The BRIDGE project established an End User Advisory Board (EUAB) consisting of an independent group of end-user experts in the fields of disaster management and emergency responses. A representative of RAKOS chaired the EUAB. The EUAB did not make any decisions on behalf of the project, but made recommendations to the Technical Coordination Committee. The EUAB;

- ensured that the project remained aligned with end user needs and technology trend during the course of its execution,
- ensured that the project results were always aligned with the newest end user trends,
- supported and facilitated the organisational top down perspective on the whole complex of disaster management,
- Secured a bottom up perspective, in which the end user considerations were included in the development process,
- addressed collective high level requirements within various emergency organisations,
- facilitated evaluations and discussions throughout the project and about the achievements in the BRIDGE project.

The EUAB consisted of seven members and a chair, representing the police service, the ambulance service, the fire department, the civil defence and technology development environment from different European countries. Below we present the members of the EUAB:

Eivind L Rake, Chairman EUAB, fire department/ambulance service.
PhD in crisis management.
Project leader, Stavanger University Hospital, RAKOS (2011-2015).
Deputy fire chief, Fire Department South Rogaland (2004-2012).
Deputy fire chief and fire chief, Sandnes Fire Department (1984-2004).
Researcher and teacher, NKI-technical college (1979-1984).

Christian van de Voorde, Fire department.
Kolonel, directeur Projecten Brandweerzone Centrum Oost-Vlaanderen and Fire chief, Fire Brigade Ghent, Ghent, Belgium (2000-).
Operational Fire officer, Fire Brigade, Brussels (1989-1999).
Technical officer, Belgian Army, Brussel (1982-1988).

Barbra Campbell, Police Service.
Police Sergeant and Inspector, Hertfordshire Constabulary (1996 - present).
Police Inspector, Events and Planning (2015-present).
Seconded to the College of Policing and Home Office (2013-2015).
Communication Capabilities Data programme.
Seconded to Project Athena (Interoperability involving 7 police forces of technical deliverables across 4 main areas of policing) Athena Management Team (2010-2013).
Police Constable, Metropolitan Police (1989-1996).
Police Constable, Strathclyde Police, East Kilbride (1975-1977).

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Electrical and computer engineer.
Managing Director Franz Mille Solutions AB, Karlstad, Sweden (2013-).
Product Manager Saab Security & Safety Management, Saab Critical System & Communication Solutions (2012-2013).
Managing Director Saab Performit AB (2007-2011).
Managing Director Performit Systems AB (1999-2007).
System designer/Programmer WM-data (Current CGI) (1994-1999).

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Dr. of laws.
Polizeidirektor (Chief of Police), St.Pølten (2004-2011).
Ministry of the Interior, Head of Sub-Division (1996-2004).
Department for State Protection, Aliens Office,Vienna (1980-1996).
District Police Stations, Vienna (1979-1980) Police Academy, Vienna (1977-1979).
Austrian Army, First Lieutenant, NBC-arm (1972-1977).

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Clinical director for Prehospital Services and Emergency Medicine. St. Olav University Hospital, Trondheim (2008-).
Medical director Norwegian Air Ambulance Foundation (2006-2008).
Base Medical Manager, Norwegian Air Ambulance, Aal (1994-2007).
Clinical director for Emergency Medicine and Prehospital Services, Buskerud County Hospital (2002-2006).
Medical director, Institute of Aviation, Norwegian Air Force (2000-2002).
Clinical consultant, Joint Medical Services, Norwegian Armed Forces (1997-2000).
Head of prehospital services, Akershus County Hospital (1993-2000).
Anaesthesiologist at several air ambulance base locations (1989-2014).

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Head of division Hilfsorganisation, Bevölkerungsschutz, Auslandshilfe und Rückholdienst ASB bundesverband (German Worker Samaritan Association)(2015-).
Head of the General Affairs Division, German Federal Agency for Technical Relief (THW) (2009-20015).
Counsellor for the Protection of Critical Infrastructures Federal Ministry of the Interior, Germany (2006-2009).
Head of the International Project Division, German Federal Agency for Technical Relief (THW) (2003-2015).
German Air Force (1991-2003).

1.4 Overview of this deliverable

This report presents activities and experiences from the end-user involvement as a research strategy. The End-User Involvement Report addresses the execution and documentation of the end-user involvement, and the meetings of the EUAB. In order to understand the end-user's areas of expertise and the context under which the expert judgements are elicited this report is structured as follows:

Chapter 2 contains an introduction to disaster management from an end-user perspective, emphasising the structures and interaction needs that will challenge the performance of the operations. The assumption is large-scale operations likely to include more than one country in Europe. The end-users comprehension of these assumptions are at the core of the end-users' expert judgements. In chapter 3 we elaborate on the term 'end-user', and the role of the EUAB, and how to comprehend expertise and expert judgements in a rather immature scientific field of disaster management. We provide an overview of the involvement activities.

Chapter 4 addresses the end-user involvement approach in the research project, to which we discuss methodological challenges in our research strategy. The final demonstration introduced a scenario based on the ammonia-nitrate explosion disaster in Toulouse in 2001. A disaster which has not yet been finalised, and which raises a large number of end-user concerns. We draw on our activities and empirical data from the project, but in our presentation of end-user involvement in "system of systems" (Chapter 5) and the following concept cases (Chapter 6) we recurrently addresses issues from the Toulouse explosion. The report concludes on end-user experiences and recommendations from the BRIDGE research strategy (Chapter 7).

2 Disaster management from an end-user perspective

Management of emergencies comprises: prevention, preparedness, response and recovery (normalisation), including lessons learnt. It involves understanding of how accidents, crises and disasters can arise, evolve, and accordingly be handled and even prevented. This chapter introduces some concepts often seen in the literature, and how disaster management systems are designed and structured seen from an end user perspective.

2.1 Conceptualizing incident, accident, emergency, crisis and disaster

Use of the concepts crisis, disaster, emergency, incident and accident is important in the BRIDGE-project to address the need for improved response systems. These occurrences have in common that they need immediate reaction by the communities to avoid injuries, fatalities and damage.

The terms "crisis" and "disaster" are often used synonymously (Boin & 't Hart, 2007) and can include a number of emergencies, incidents and accidents. But, what are the differences? 't Hart et al. (2005) claim that: "Crisis management bears directly upon the lives of citizens and the wellbeing of societies", and they speak of crisis as "serious threats to the basic structures or the fundamental values and norms of a system, which under time pressure and highly uncertain circumstances necessitates making vital decisions" (pp 1 and 2). These issues may well include emergencies, incidents and accidents.

One way to describe the differences among the concepts is by consequences, in terms of the impact and the affected area. The US Federal Aviation Administration (FAA, 2014) makes a distinction between incident and accident, which can be described as emergencies. An emergency involve a situation of distress or urgency that requires fast response by the community, for instance by the emergency services. FAA describes an accident as an occurrence resulting in fatalities or serious injuries or causing substantial damage to an aircraft. An incident is defined as "an occurrence involving one or more aircraft in which a hazard or a potential hazard to safety is involved but not classified as an accident due to the degree and/or extent of damage". An incident could affect the safety of operations (a threat). An accident, according to FAA, has more severe consequences than an incident. An emergency is local and have limited consequences. Usually it will be responded to by the emergency services, e.g. the ambulance service. The time frame is short and seldom longer than a few hours. An example is a road traffic collision involving injuries.

Rosenthal, Charles and 't Hart (1989) base the "contingent decision path perspective" on case-oriented retrospective analyses of different crises. The work is followed up in 2001 (Rosenthal, Boin, & Comfort, 2001, p. 6), in which the crisis concept is reconsidered as more than discrete events limited in time and space to "process unfolding as manifold forces interact in unforeseen and disturbing ways. Modern crises are increasingly characterised by complexity, interdependence, and politicisation". The contingent approach to crisis management includes a perspective that a system is going through temporary states, a process, in which the crisis facilitates/precipitates major changes. Private and public affairs are interwoven in crises, and preconceived notions about the functions and roles of specific players in the crisis game become unclear, clouded in practice.

Boin (2005) defines crisis in terms of a discontinuity which usually causes authorities to engage decision making under conditions of uncertainty and time pressure. According to Rosenthal et al. (2001) a crisis can be understood as a period with increasing stress, disturbing society and threatening values and structures in unexpected and unthinkable ways. A crisis will have consequences of importance, often involving questions of life and death, and is to some extent above and involve emergencies. Its scope can be local, regional or national. It can involve

several authorities, multiple emergency services and regional and national rescue centres. The Toulouse explosion in 2001, described later in this report, is a typical example.

A disaster has at least regional consequences but normally national or multinational consequences that cannot be adequately coped with by local authorities. It can last for days or weeks. The Asian Tsunami in 2004 was a disaster. Boin (2005) proposes to reserve the term disaster for crises with a bad ending. According to Kreps (1998) disasters are "non routine events in societies or their large subsystems (e.g. regions, communities) that involve social disruption and physical harm. Among the key defining properties of such events are (1) length of forewarning, (2) magnitude of impact, (3) scope of impact, and (4) duration of impact".

Some definitions of disaster use the ratio between resources and demands. Dombrowsky (1998) calls it "the lack-of-capacity" type. This defines "disaster as an agent too fast, severe or overwhelming in relation to the capacities available" (p. 23). The disaster develops too fast relative to the warning, i.e. the unwanted event evolves too suddenly, or too extensively in relation to the rescue resources available.

Alexander (2005) raises interesting and important questions related to the definition problem: "At what point do routine emergencies pass a quantitative threshold or go through a qualitative change and become disaster?" and "What functional attributes turn an emergency into a disaster?" (p. 27). The differences between the concepts seem to be more related to research environments and conventions than to specific organisational or operational factors. Rake (2003) concludes that the concepts have more in common than they have elements of diversity, and that the differences can be difficult to distinguish. Thus, in this report we look at undesired events as a continuum spanning from incidents to disasters. Our interest for the event starts when there is a need for the activation of the response systems. A vital criterion for end-users is that the BRIDGE systems of systems must be applicable in the daily work.

A major objective in The BRIDGE-project is to improve systems, tools and equipment for command and control of multiple emergency response agencies. A more thoroughly discussion of definitions is therefore not essential: every disaster, crisis, incident etc. has at least one scene where responders and authorities struggle to mitigate the consequences. The labels separating incident, accident, crisis and disaster are more or less irrelevant on scene.

In this project the terms crisis and disaster (including accident, emergency, and incident) are used interchangeable as a common description for situations when serious threats, involving injuries, death, environmental or economic loss, occur; which under time pressure and uncertainty necessitate urgent response and management in order to avoid or minimise the threat or the impact ('t Hart et al., 2005).

Large-scale crises might be a collective term on major events threatening values deemed important on a national and international level, requiring huge efforts in order to become aware of the crisis and cope with the disaster developing. 't Hart and Boin (2001) have developed a conceptual framework of crisis typologies into *speed of development* and *speed of termination* (see figure 2). The BRIDGE-assumption about events coincides with the instant occurring crisis, which needs immediate response. The situation is typically characterised by uncertainty, originated from lack of information or from large quantities of information, which need to be analysed. The time pressure is high and there are difficulties to obtain and maintain a common operational picture. The *long shadow crises*, which are "crises that occur suddenly and raise critical issues of much wider scope and significance, triggering a political and institutional crisis almost inadvertently" (p. 34), and the *slow-burning crises*, which are crises that "creeps up rather than bursts out, and fades away rather than being resolved" (p. 33), have many additional characteristics than the framework of BRIDGE were designed to meet.

Speed of termination	Speed of development: Fast: Instant	Speed of development: Slow: Creeping
Fast: Abrupt	Fast-burning crisis	Cathartic crisis
Slow: Gradual	Long-shadow crisis	Slow-burning crisis

Figure 2 Crisis typologies ('t Hart & Boin, 2001)

As far as the work in BRIDGE has progressed, the scenarios considered are fast-burning crises or to some extent cathartic crises. Such crises occur suddenly and needs to be coped with immediately in order to mitigate the consequences. We consider explosions, fires, sudden toxic releases, earthquakes, floods, terrorist attacks etc. These events are obvious candidates for the first response organisations to be part of the entire crisis management process. Cathartic crises build up more slowly, which could be exemplified with social unrest situations that reach some kind of limits or natural hazards that have been known for some time before the outbreak (for example flood and earthquake). The EUAB meeting and seminar (the fifth meeting) in Ghent is an example of the end-users involvement to describe such challenges. This meeting critically examined current disaster management practices across Europe. There was a need to scrutinise why disaster management operations sometimes are perceived as being successful while at other times they are not. At times actors involved in events assess them completely differently. The background for the Ghent seminar[1] was four cases:

1. *Terrorist attack in Norway* 22/7 2011, presented by Professor Geir Sverre Braut, Stavanger University Hospital and Norwegian Board of Health Supervision.
2. *Flood in Central Europe* (Poland, Hungary, Czech Republic and Slovakia) May 2010, presented by Director Mariusz Feltynovski, National Centre for Coordination of Rescue and Protection of Population, Poland
3. *Earthquakes Southern Italy* 2009 (L'Aquila), presented by Professor David Alexander, University College of London.
4. *Major fire in a derailed train with acryl nitrile into sewage system* 2013, Belgium, presented by Fire Chief, Ghent and EUAB member, Christian Van De Voorde

These events varied substantially with regards to *time* (development and termination), causes (background, latent and direct), *consequences* (human, environment, assets) and *phenomena* (energy and substances out of control), to which the disaster response systems were challenged in various ways. Typical finding was that the disaster response systems in any European country

[1] 5th EUAB meeting, Ghent, Belgium, 28-29 May 2013 – two-day seminar on disaster management practices across Europe

must face potential scenarios, which could be based on different design principles. Some approaches are function based adopting performance analysis principles, while others are more prescriptive based using detailed requirements to systems and solutions.

2.2 Disaster management

Disaster management is the process of preparing for, mitigating, responding to and recovering from a disaster (Rake, 2008), including lessons learnt from the management process. It contains the involved first responders' understandings of how accidents, crises and disasters can arise, evolve, and accordingly be handled and prevented. Crisis management also includes coping with non-routine phenomena and developments during emergencies. The following descriptions of the main stages are mainly taken from Rake (2008) and Rake & Njå (2009). The BRIDGE concept cases and system of systems are relevant in all the disaster management stages.

2.2.1 Mitigation

Mitigation involves action to be carried out to decrease vulnerabilities, primarily through measures to reduce causes (risk producing factors), exposure to damage and hazard events. Mitigation aims to reduce the possibility and /or the consequences of an undesirable event by e.g. building code regulations, warning response systems, disaster policies and retrofitted buildings and structures. While mitigation makes communities safer, it does not eliminate risk and vulnerability for all hazards. Communities must therefore be ready to face emergency threats through preparedness and be ready to cope immediately with an evolving crisis.

2.2.2 Emergency preparedness

Emergency preparedness encompasses actions undertaken before the crisis and accident impact, and adequate response when an incident occurs. Emergency managers develop plans of action to be effectuated when the crisis strikes. Normal activities in the preparedness stage are: preparing response plans, training employees, volunteers and response units. Acquiring suitable equipment, conducting drills and exercises and establishing evacuation plans.

2.2.3 Emergency response

Emergency responses seek quick and efficient ways to minimise impacts when the crisis occurs. An emergency response consists of immediate, time-sensitive actions to be taken during and after the impact to reduce casualties, damage and to respond immediately to the victims to avoid any threatening or emerging challenging situations. Quick, appropriate and sufficient relief efforts are typical activity. Response measures include identifying and disseminating the threats and the impact, alerting the responders, searching for and rescuing any trapped victims and providing the necessary care. The response phase includes mobilisation of the necessary emergency services and first responders.

The incident, especially in dynamic complex situations, may escalate into a major crisis if not handled correctly. The possibilities of severe detrimental effects during crises are closely tied to the authorities' and response unit's management opportunity, ability and methodology, which in turn can act as constraints on subsequent decisions and coping mechanisms.

2.2.4 Recovery

The *recovery* stage is the post-disaster stage concerned with issues and decisions that must be made after immediate needs are addressed. Recovery efforts comprise actions to repair damage of all kinds including damage to social and economic life, to reconnect, rebuild and reconstruct. The aim is to restore the affected area to its previous state. Normalisation is the main objective of this phase.

2.2.5 Focus areas in the BRIDGE project

The focus in the BRIDGE project has been on crisis management on accident scenes, which is complicated. The consequences may be severe for many people, resulting in competing and frequently ill-defined goals for the rescue operation. Uncertainties, both in situation assessment and outcome predictions, are large, i.e. there is a lack of data; information is fragmented and unreliable; the mass of non-relevant data disturbs the operational focus; and occasionally lack of expertise in vital areas as well as lack of resources compound the problem. The situations are constantly changing, with the possibility of sudden dramatic occurrences that require an entire rethinking of the rescue operation. There are multiple individuals involved in the emergency organisations and the teams involved change from incident to incident. The work domain changes for each crisis. Each scenario is unique and will only be familiar in broad general terms to the combating actors at the time of delivering the emergency response. The emergency response phases are depicted in figure 3.

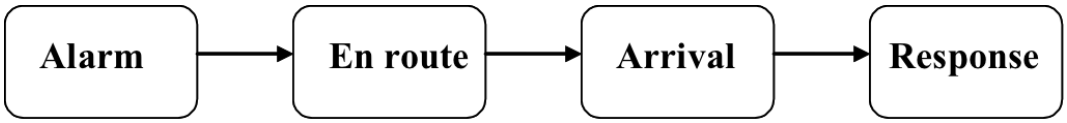

Figure 3 Main phases in emergency response (Rake & Njå, 2009)

Alarm is the time from when the first responders are notified until they are on their way to the incident. The response units are normally called out by use of internal loudspeaker, radio calling, cell phone or pager. The leader has normally less than two minutes to process information, assess and make decisions before leaving the station.

En route to the accident, the time could be used for preparations, for example to request more resources, ask for more information, communicate with the call centre and other response units, or discuss the task with crew members. However, time is often used to guide the driver through the traffic. The time to reflect, assess and to plan is hampered by the running time.

Arrival on-scene the accident includes the time from the commander and the first responders arrives at the scene, parks the engine, gets out and initially sizes up the situation. Sizing up the situation is critical in order to assess its extent and escalation potential. The time is normally less than two minutes and is affected by the incident area and the level of complexity, chaos and lack of overview. Injured people complicate the situation since they need immediate response upon the rescuers' arrival.

The *response* phase can last for hours or days, but normally the critical period is less than an hour. The critical period is delimited by the rescue potential, the time in which the rescue units can save lives or mitigate other damages. The phase is characterised by stressful and complex dynamic environments with time pressure, unique and badly structured organisations involving multiple players, critical values at stake, and unclear and competing goals.

2.3 Framework for a disaster management system

Disaster management is a dynamic process, the work domain changes for each task. Each scenario is unique and its circumstances are badly structured and, consequently, will only in broad general features be known to the combating actors. The emergency response organisations and nations involved are not static; they change from disaster to disaster. It is common to place the responsibility for governmental crisis management with designate

institutions, such as the MSB – Swedish Civil Contingencies Agency. The MSB is responsible for issues concerning civil protection, public safety, emergency management and civil defence as long as no other authority has responsibility. Responsibility refers to measures taken before, during and after an emergency or crisis. These institutions describe the strategic tasks, make plans, recommend laws, rules and budgets, and oversee implementation of the plans and rules. There seem to be only minor differences between emergency response units within and between countries with respect to formalised routines and use of technology. A typical management structure has manuals describing the organisation, leadership and the responsibilities of each of the emergency services at a major incident and disaster. These manuals and procedures intended to gather, coordinate and control the temporary systems of managing personnel and equipment at a wide range of emergencies. The procedures describe the management system and responsibilities and set out the tasks and duties of the commander of the operation. This presupposes that commanding, coordination and communication are important to the emergency response and the actual outcome of the crisis.

A typical multinational disaster (or crisis) management system and principle is the Norwegian system, presented in figure 4.

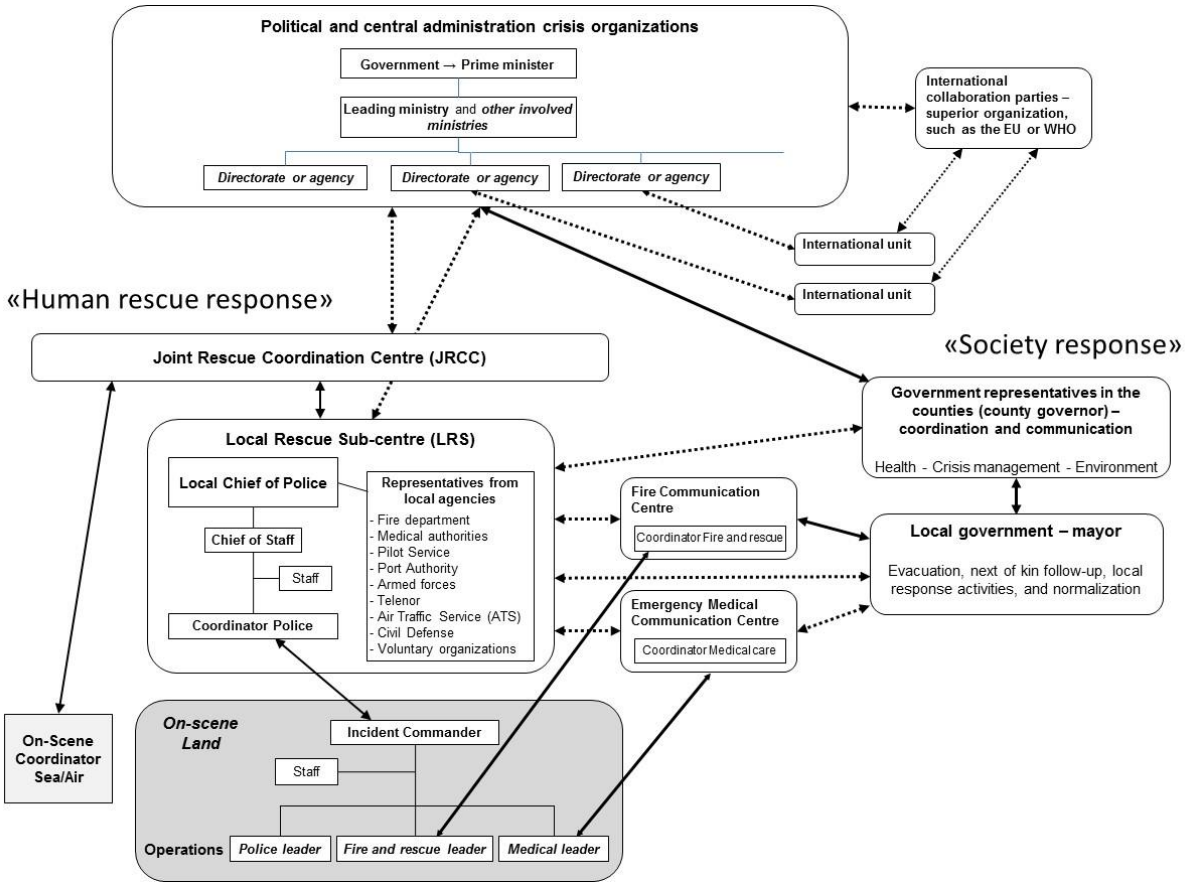

Figure 4 Crisis management system in Norway

The Norwegian preparedness structure is founded on four principles: responsibility, proximity, similarity and cooperation. These principles states that those who are responsible for and involved in day to day crisis management, at all levels, are tasked with the same responsibilities and tasks during major crisis and disaster events, as in the daily work. It also implies that the responses should be based on the emergencies ordinary responses. The structure of the disaster management will be as similar as possible the daily structures of the units and cooperation between emergency services shall be emphasized in all the work.

Figure 4 describes the political and central administration crisis organisations as the upper level of the crisis management system. The framework for international collaboration and international responses is organised and outlined at this level. The black lines describe the formal day to day responsibility and authority communication between agencies. The upper level (political and central administrative crisis organisations) decides the budgets, the regulations, legislations and the objectives and is the overarching management. The black dotted lines indicate that there are no direct formal responsibilities and authorities. It implies a duty for information and orientation about crisis, requests for support, etc.

"The Human rescue response" on- scene is headed by an incident commander. He reports to the Local Rescue Sub-Centre (LRS), where the local chief of police is responsible. In Norway two Joint Rescue Coordination Centres (JRCC, south and north) decides who will be the On-Scene Coordinator (a captain on a ship) at sea, and the JRCC coordinates the rescue activities. JRCC also coordinate activities onshore, for example when an airplane is missing and in rescue work to avalanches in mountainous area. JRCC communicates with and support LRS in crisis situations.

The "Society response", as during blizzards and collapse of infrastructure, the Counties (county governor) and municipalities (Local government – mayor) are responsible. If needed, as when life is on stake the emergency services will be coordinated by the LRS. In Norway the municipalities are the owners of and responsible for the design of the fire departments and its responses.

A typical management structure has manuals describing the organisation, leadership and the responsibilities of each of the emergency services at a major incident and disaster. These manuals and procedures intend to gather, coordinate and control the temporary systems of managing personnel and equipment at a wide range of emergencies. The procedures describe the management system and responsibilities and set out the tasks and duties of the commander of the operation.

The major aim of a standardised and hierarchal command structure is to obtain an effective and predictable command system: a functional system well known to all the responders. The crisis management systems across Europe have many similarities. The strategic, tactical and operational level (gold, silver and bronze levels) is common and constitute the framework. There only seem to be minor differences between emergency response units within and between countries with respect to formalised management systems, routines and use of technology. Crisis response efforts are inherently joint operations (combining police, fire-fighting, medical and, if necessary, other forces).

2.4 Tasks, challenges and systems at various societal levels

The professional disaster response systems are at the core of the BRIDGE-project as well as in most European countries. However, interaction with non-governmental organisations and the local populations struck by the events are highly influencing the outcomes and success of disaster response operations. Since the major perspectives of the BRIDGE system of systems is

to integrate the concept cases into the professional services' communication systems, this has also been the stance of the end-users' involvement.

The communication between the various levels depicted in figure 4, or at each level, is verbal (mobile phones, radio or man to man) or based on ICT-solutions. Problems in communication, as overload of the cell phone networks, hamper the leadership at all levels. Leadership is both a position and a process involving collaboration, teamwork, and cooperation.

During crisis responses and crisis management the main issues to be addressed are:

- Communication: How to interact between agencies, what standards, protocols, technologies and routines to use?
- Interoperability: How to cooperate on and off-scene (agencies and responders from different emergency services and nations)? How to make the results from agency or component A fit to the requirements of agency or component B?
- Coordination: How to collaborate effectively? Coordination involves the establishment of a shared operational picture, as well as collaborative planning, scheduling and decision support.
- Situation assessment: How to establish a common operational picture, address the risk and what is on-stake, monitor the situation, and share information?

In the following presentation of the various levels of disaster response we address issues that might be important to reflect upon in an assessment of the capabilities of the BRIDGE system of systems and the end user involvement.

2.4.1 Political and upper administrative levels in disasters

Large scale crises requiring cross border assistance involves the highest level in disaster response, which is the political and upper administrative level in the society, thus the governments are included. All events threatening the national security is of course a particular concern, but also events at the borders or events that requires resources beyond the national capabilities will release an effort to put international agreements into action. A sketch of the political disaster response level is presented in figure 5, reference is also made to chapter 2.3.

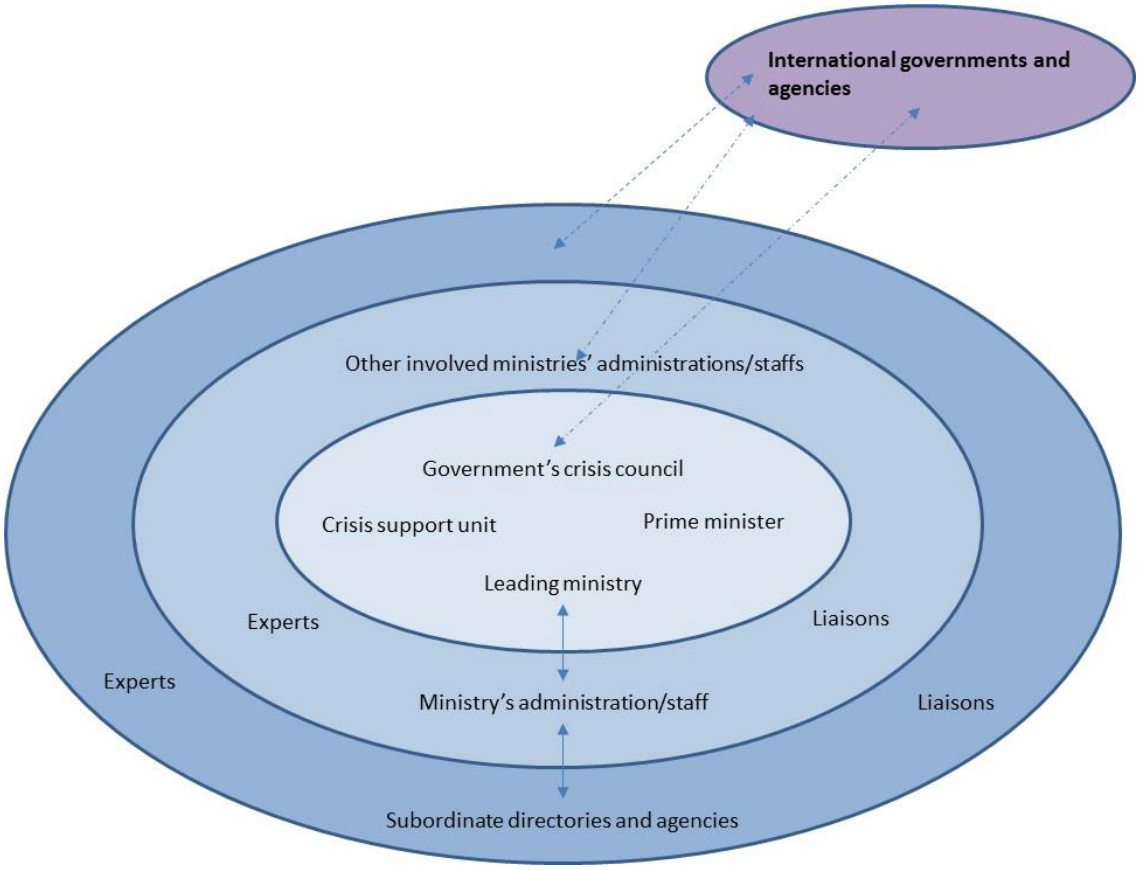

Figure 5 Systems of political response levels

In the chemical explosion scenario used in the final demonstration (we call it the Chemco disaster), there will be a huge number of actors (central to peripheral agencies) involved. They all need to be informed about the situation and provide agile responses. The issue is proactive, risk based management philosophies making use of opportunities nationally and internationally.

Uncertainties in the demonstration case:

- What agreements prevail?
- Who follow up international agreements?
- Which resources are available?
- Intelligence and possible developments?

What will be the impact on the nearby local living environments, such as schools, hospitals and houses, and the inhabitants of the disaster area in general?

The political response level will take care of local, regional, national and international common questions and interests. They will in a broad sense, especially focus on the threats to communities and the overall needs.

2.4.2 *Strategic human rescue and societal level (gold level)*

The strategic level, represented by the JRCC and LRS in figure 4, will lead and coordinate the response off-scene. They will set the strategy to solve the crisis at hand, see "the big picture" and plan for the following hours and days. They will also monitor the implementation of the strategic plan and goals at the tactical level (silver level). The strategic level will advise the political level. The strategic level allocates resources and supports the tactical level.

The decisions will normally be based on regulations and plans. The time pressure is much lower than on-scene and staff will have time for analysis and request expert judgements in various phenomenological domains. The decision makers will concentrate on the development of the crisis and future needs. The Strategic command post is located away from the site, and normally at designated premises.

Some challenges and uncertainties at the strategic level:

- How to achieve and update a strategic overview, and a sufficient situational understanding?
- How to assess the situation, deal with undcertainty and be pro-active in an efficient way?
- How to carry out collection, separation and interpretation of the information, both in social media, in media and on-scene?

2.4.3 Tactical human rescue and societal levels (silver level)

The tactical level supports the operational level with competences, capacities and communications. The staff will take care of rescued people and evacuees from the scene. They will play the role as the media information contact centre and arrange press conferences and other information activities. The point of contact for the public will normally be at the tactical level.

At this level the work tasks will be based on plans, procedures, routines, best practice and analysis. Tactical level will coordinate the activities between the strategic level and the operational level, and the strategic objects and plans must be transformed into orders and actions on-scene. A typical analysis task is the risk at hand, and how to address and deal with the risks. In short the tactical level prioritises, plans and coordinates actions on the operational level. The decisions will concentrate on supporting the operational level with analysis, information and resources. Monitoring the response activities is also important. The time pressure is higher than at the strategic level. The decisions are based upon information from the operational level as well as the strategic level in accordance with what the tactical level perceive.

The tactical level can be located on-scene, but normally near the scene or at designated locations. The staff will hardly be exposed to the threats or physical appearances from the response activities on-scene. Some challenges and uncertainties at the tactical level:

- How to achieve and update an overview of the situation on-scene and a sufficient situational understanding?
- How to assess the situation and be pro-active?
- The collection, separation and interpretation of the information, both in social media, in media and on-scene
- Time pressure
- The needs from the media

2.4.4 Operational human rescue and societal level (bronze level)

At the sharp end, on-scene, the operational level is in the bull's eye. The Incident commander and the leaders from the emergency services, see figure 4, directs the response teams performing the decided tasks. Leadership on-scene an accident can be described as a set of strategic tasks that encompass the activities associated with the scenes/stages of management. The objects and tasks directed by the tactical level must be completed. The leadership function seems pivotal to coping and vital to how the incidents evolve. The time pressure and the stakes are high.

The decisions are based upon information from the tactical level, observations by the IC-group or information from the responders. A number of decisions need to be taken relatively fast. The decisions are mostly intuitively or experienced/recognition based. The prior goal is to save life.

The incident command team establishes the command post away from the hot zone, but near the activities on-scene. The hot zone is an area where an explosive gas-air mixture or toxic gases are present. The responders in the command post will normally be minor exposed to the threats and physical appearances from the response activities on-scene. Some challenges and uncertainties at operational level:

- How to achieve and update an overview of the situation on-scene, the operational picture, and a sufficient situational understanding?
- How to assess the dynamic situation and be pro-active?
- The collection, separation and interpretation of huge amount of information on-scene
- Time pressure
- How to reduce the uncertainties and decide what is acceptable uncertainty?

3 End-User Advisory Board, expertise, expert judgements, approach and activities

In this section we present and discuss the following issues regarding end-users and expert judgements.

- What do we mean by end-users?
- What are the definitions of end-user advisory board – EU prescription?
- Who are our experts and their relevant competences?
- What is an expert and what characterises expertise?
- Expert judgements, what are the heuristics and pitfalls to consider?

From the BRIDGE project proposal:

> The end-user in this project is the first responder and other commanders responding to an accident. The short definition of the End User Advisory Board (EUAB) is a group of people that have long experience as an end-user. The group shall help development of the products produced in this project and give advises. The EUAB need to cover all emergency response organizations, and also technical expertise, to have the capability to give the best advices possibly. The board is not simply a group of stakeholders who will be brought in now and then for comments. Rather, they will be involved throughout the project: First as guides and experts in our domain analyses and scenario construction, then as participants in the gathering of requirements, as parties in design sessions, as users for testing and evaluation, as business partners for exploitation and dissemination, and so on. Moreover, one of these board members (RAKOS) is also a partner in the consortium.

3.1 End-users and the concept of expertise and expert judgement

Being an end user must imply some kind of involvement within a first response organisation on a professional basis. Being considered an expert must coincide with specific characteristics of the end-users skills, experiences, knowledge and thus, competence. Disaster risk reduction and disaster management activities are not regular events in the western part of the world, for example within the European borders. These events are rare and only few first responders will ever become included, and when they do they will only experience parts of the operation. Can we then claim that there are disaster management experts?

In order to be characterised as an expert in disaster management, the persons' explicit and tacit knowledge as well as his or her capabilities to involve him/herself in major events were considered. Judgements from experts are inferences or evaluations that go beyond obvious statements of facts, data, or the conventions of a discipline. Expert judgements in disaster risk reduction could be applied to frame information about emerging crises in "the real world", for making assumptions and communicating recommendations to researchers and technology developers in the BRIDGE consortium. Who are experts, and how can we distinguish between degrees of expertise? Dreyfus & Dreyfus (1986) have developed a five stage skill acquisition model, in which a person develops from being a novice to an expert. The five stages human skill acquisition process is presented in table 1.

Skill Level	*Components*	*Perspective*	*Decision*	*Commitment*
1. Novice	Context-free	None	Analytical	Detached
2. Advanced beginner	Context-free	None	Analytical	Detached
3. Competent performer	Context-free and situational	Chosen	Analytical	Detached understanding and deciding. Involved in outcome
4. Proficient performer	Context-free and situational	Experienced	Analytical	Involved understanding. Detached deciding
5. Expert	Context-free and situational	Experienced	Intuitive	Involved

Table 1 Five stages of skill acquisition (Dreyfus & Dreyfus, 1986)

The interesting categories (skill levels) for this work are the competent performer (3), the proficient performer (4) and the expert (5). It is important to notify the distinctions between these categories to understand what kind of expertise we deal with in gathering judgements.

A competent performer sees a situation as a set of facts. The importance of the facts may depend on the presence of other facts. The competent performer has learned that when a situation has a particular constellation of those elements a certain conclusion should be made. He/she is not entirely following context-free rules but tends to act in accordance with situational elements to obtain the goal in mind.

The proficient performer is deeply involved in the tasks he is asked to judge, and will be experiencing it from some specific perspective because of recent events. This implies that certain features of the situation will stand out as salient and others will recede into the background and ignored. The proficient performer, while intuitively organising and understanding the tasks, will still find himself thinking analytically about the situational development.

An expert generally knows what needs to be done based on mature and practiced understanding. An expert's skill has become so much a part of him that he needs to be more aware of it than he/she is of his/her own body. When things are proceeding normally, experts do not solve problems and do not make decisions, they do what normally works. While most expert performance is ongoing and non-reflective, when time permits and outcomes are crucial, an expert will deliberate before acting. This deliberation does not require calculative problem solving, but rather involves critically reflecting on one's intuition.

Dreyfus & Dreyfus (1986) describe their skill acquisition model as follows:

> The moral of the five-stage model is: there is more to intelligence than calculative rationality. Although irrational behaviour - that is, behaviour contrary to logic or reason - should generally be avoided, it does not follow that behaving rationally should be regarded as the ultimate goal. A vast area exists between irrational and rational that might be called *arational*. The word rational, deriving from the Latin word *ratio*, meaning to reckon or calculate, has come to be equivalent to calculative thought and so carries with it the connotation of "combining component parts to obtain a whole"; arational behaviour, then, refers to action without conscious analytic decomposition and

recombination. *Component performance is rational; proficiency is transitional; experts act arationally.*

Responding to tasks and challenges in crisis situations we sought phenomenological expert judgements regarding what is typically communicated, what is (mis)understood, what are the constraints in the first response activities etc. Irrespective of the topic focused, we always need a combination of experts (phenomenological expert, communication expert, social relations, technological equipment, psychology etc), of which our conception is a load-response model. Knowledge about the load (scenario, energy, toxicity, malicious intentions etc.) and the associated first responses (psychology, sociology, technology and culture of human-system interrelationships) are linked to the expert skills. It is the joint performance of experts as a group that has been guiding the construction of the EUAB.

An integration project, as BRIDGE, aimed to develop novel and promising technological approaches and solutions in the field of multi-agency emergency response. To exploit best the results from finished or ongoing research activities, partners identified key projects, bringing solutions into BRIDGE that had the potential to significantly contribute to the success of the project. In order to conceive an understanding of the performance of the BRIDGE products, we needed an overall conception of the emergency response system within certain frames. It was a criterion that the project should provide *significant* improvements to the emergency response, thus we needed to address the assumptions made. The following assumptions were important parts of the evaluation efforts made by end users:

- The characteristics of the scenarios that the results is supposed to meet – *design scenarios*
- In order to succeed with BRIDGE, certain *organisational barriers* in disaster response systems needed considerations. Such organisational barriers could be related to regulation regimes, competencies or cultural factors.

This meant that end users must discuss and agree upon a generic description of the response systems based on how they should be generally understood. The specific characteristics were for example decision making, uncertainties, collaborative efforts, response phases, time frames and local conditions. In order to explore organisational factors, we designed the Ghent seminar (see section 2.1) with invitees from all over Europe to discuss national regulation regimes, competencies, frame conditions for the crisis response systems, working practices and cultural factors. However, the project could not afford this seminar; hence organizational factors are not systematically explored in the end user involvement approach. An important approach, both for the study reported here and for end-user involvement in general has been to relate the BRIDGE system of systems and related concept cases to relevant scenarios and concrete experiences of the end users.

In the involvement of end users several pitfalls needed to be considered when adopting the end-users expert judgements. When experts are to express their knowledge related to for example the occurrence of rare events and related responses, they normally apply a limited number of heuristic principles. These heuristics reduce the complex tasks of assessing tendencies and behaviours, and predicting values into simpler judgmental operations. However, the use of heuristics could lead to severe and systematic impacts and biases. Below is listed some of the heuristics identified in the scientific literature, (Hogarth, 1987; Tversky & Kahneman, 1982):

- *Availability.* The occurrences of events where the expert easily can retrieve similar events from memory are likely to be given higher weight than the occurrence of events that are less vivid and/or completely unknown to the expert.

- *Anchoring and adjusting*. The expert tends to choose an initial anchor. Then extreme points are assessed by adjusting away from the anchor. One of the consequences is often low weight of extreme outcomes.
- *Representativeness.* The expert assesses tendency in disaster response by comparing his/her knowledge about a phenomenon with the stereotypical member of a specific category. The closer the similarity between the two, the higher the judged weight of membership in the category.

These are some of the heuristics, which could give undesired and too narrow-minded responses. The experts were confronted with questions, comments related to applied heuristics during discussions after demonstrations, and the tests they had attended.

There is also a danger that the expert is being overconfident in his/her judgements. *Overconfidence* is the expert's tendency to give overly narrow responses and neglect his or her uncertainties.

3.2 The end-users experiences and knowledge base

3.2.1 The End-User Advisory Board (EUAB)

The BRIDGE project established the EUAB consisting of an independent group of end-user experts (see section 1.3) in the fields of disaster management and emergency responses. The EUAB did not make any decisions on behalf of the project, but made recommendations to the Technical Coordination Committee. The EUAB:

- ensured that the project remained aligned with end user needs and technology trend during the course of its execution,
- ensured that the project results were always aligned with the newest end user trends,
- supported and facilitated the organisational top down perspective on the whole complex of disaster management,
- secured a bottom up perspective, in which the end user considerations were included in the development process,
- addressed collective high level requirements within various emergency organisations, and
- facilitated evaluations and discussions throughout the project and about the achievements in the BRIDGE project.

The EUAB consisted of seven members and a chair; representing the police service, the ambulance service, the fire department, the civil defence and technology development environment from different European countries. The expertise of the EUAB group is based on *educations*, as MD and 3 dr./PhD. The members have *practical experience* from many thousand emergencies and responses as first responders (police officer, medical doctor and smoke diver) and on-scene commanders. They have been attending a large number of national and international field and rescue operations on behalf of military services, UN and civilian authorities (examples are the 2005 Buncefield Oil Depot explosion, the Nepal Earthquake, the Tchad cholera outbreak and the Oslo terrorist attack. The last three examples were disasters occurred during the BRIDGE-project period). The group has *leadership experiences* acting as leaders at strategic, tactical and operational levels, they have joined *activity in expert groups*

addressing emergency and disaster topics, such as the Task Forces Fire reintegration program (EU-project). A member of the group has been a member of the editorial board of International Journal of Emergency Management, they have been given *lectures* within the field of prehospital emergency medicine and on-scene commanding. Some has practiced their own *research* (for example Rimstad, Njå, Rake, & Braut, 2014), while another have been involved in *developing* emergency response systems, such as the PARATUS communication system, while another has worked with *international and national contacts* during the German Delegation dealing with Critical Infrastructure Protection in the Council of the EU. In overall the EUAB-members possess:

- experiences from emergency responses, on-scene and off-scene, at different levels and at various types and magnitudes,
- domain experiences and expertise in the crisis management field,
- a broad network, especially related to their own service but also an international network,
- interest and practical experiences from use of technology in emergency responses and crisis management, and
- ability to understand complexity of crises encompassing responses to novel situations.

The EUAB is well balancing all the emergency services included the civil defence and industrial development of emergency systems. The EUAB is a group of experts from the on-scene responses and crisis management. The group is neutral and not representing any stakeholders in the project. They are acting as experts within their own domain.

3.2.2 SUH/RAKOS

Stavanger University Hospital (SUH) and RAKOS coordinated the end-user activities throughout the project.

The Emergency Medical Communication Center (EMCC) at Stavanger University Hospital (SUH) is the regional center and has a coordination function for the western region of Norway (1 mill inhabitants).Within the western region there are three local EMCCs, one within each local health trust. The EMCCs are located at hospitals providing emergency care. The medical emergency calls are handled by health personnel (nurses or authorized ambulance officers). The Norwegian Medical Dispatch System is a national medical, organizational, and technical system handling all medical emergency calls whether routed directly into one of the 19 large hospital-based dispatch centers. All calls using the national medical emergency telephone number 1-1-3 are automatically routed to the nearest hospital-based dispatch center. This system secures an easy and immediate access to an advanced and well-equipped EMS-system, and in ordinary situations, each patient normally receives proper medical treatment of high quality. In line with EU requirements, 112 is the emergency telephone number in Norway, routed to the police dispatch centers. In addition, the public has direct access to fire departments by calling 110, to hospitals and other emergency medical services, such as ground and air ambulance services, and the local doctor on call by calling 113.

SUH has plans for mass injuries and for regularly training personnel, both in operative and administrative functions. Functions like coordination of personnel and equipment, planning of patient logistics, finding people and rearranging hospital facilities to cope with a large number of casualties are in place. The hospital is fully equipped with personnel and technical measures to deal with multiple injuries scenarios. SUH has capacity to sort, distribute and treat patients by use of emergency units, and the personnel to take care of all cooperative functions within the

hospital. This includes; mapping of resources and contacting qualified personnel needed for the actual situation, establishment of crisis management on the medical side, and cooperating with regional and national crisis management teams. The emergency call responders (EMMC) are specialists in early injury assessment, coordination and advisory actions for victims, bystanders and professionals on scene. EMMC will also alert and coordinate local doctors and ambulance resources.

RAKOS is a regional competence centre and is engaged in work of research, networking, education and securing common understanding and similar procedures across the different areas and functions in acute medicine and prehospital services. RAKOS is the centre of competence for the western part of Norway.

SUH has a large fleet of ambulances that can be deployed when needed. The air ambulance service employs highly qualified and competent personnel that can function both in air and ground functions. There are four helicopters that each carries one patient on stretcher.

In a crisis the JRCC will establish an air bridge to transport patients to other parts of Norway or elsewhere, for example: Bergen, Kristiansand, Trondheim, Oslo and Lillehammer, and in European countries such as Sweden and the UK. The distribution of patients will be coordinated by the local medical crisis staff in corporation with the national government. The Norwegian Air Force is manned and operates a Sea King helicopter that can carry four patients on stretchers.

In addition to the above mentioned resources, SUH can deploy a large number of volunteers through the Red Cross and the Norwegian People's Aid. In an incident of magnitude, the national crisis management will also involve the civil defence and the military.

3.3 End-user involvement activities

During the project period end-user involvement activities has consisted of; EUAB-meetings, workshops, a conference, participation in demonstrations, evaluations, attending ValEdation Days, and testing concept cases in the members' organisations. Informal discussions and contacts have also been part of the end-user involvement. It is important to state that all members of the EUAB have carried out their tasks only receiving travel reimbursements, hence their time have been paid by their own organisations reflecting personal and organisational interest in the project.

3.3.1 EUAB meetings

BRIDGE carried out eight EUAB-meetings during the project period:

- 1st EUAB meeting Salzburg, Austria, 26-27 June 2011 – set oneself up, see also D01.3 PPR1: Project Periodic Report.
- 2nd EUAB meeting Flums, Switzerland, 28-29 November 2011 – discussing need for concept cases, see also D13.2 (Rake, 2012).
- 3rd EUAB meeting, Flums, Switzerland, 19-21 September 2012 – first demonstration and subsequent end-user evaluation, internal note on "EUAB Evaluation of Flums Demonstration".
- 4th EUAB meeting, Stavanger, Norway, 24 April 2013 – second demonstration and active discussion partners of visualisation and interactive design, see also D09.2, BRIDGE Demonstration I; Demonstration of Visualisation and Interaction (Skjetne & Wenstad, 2013).

- 5th EUAB meeting, Ghent, Belgium, 28-29 May 2013 – two-day seminar on disaster management practices across Europe, cf. section 2.1 of this report.
- 6th EUAB meeting, Stavanger, Norway, 24-25 September 2013 – third demonstration on collaboration technology and co-located with a large-scale exercise in the Risavika harbour area. See deliverable D09.3, BRIDGE Demonstration II Collaboration Technologies (van Veelen, 2015).
- 7th EUAB meeting Oslo, Norway, 18-19 November 2014 – combined with Nordic ValEDation Days, see also note on end-user validation (Appendix B)
- 8th EUAB meeting, Flums, Switzerland, 19-20 May 2015 – final demonstration.

3.3.2 Workshops

The project researchers have carried out a set of interviews and fieldwork involving end-users and there have been organised three end-user participatory design workshops during the project period. Early on, co-design workshops, were held where end users and project design staff discussed and designed mock ups of the foreseen ICT support tools and their interactions. This provided initial insights into what would be required of the supporting infrastructure, not only in terms of end-user functionality, but also with respect to generic architectural qualities such as systems interoperability. Later on the workshops, where EUAB members and other end-users attended developed and described functional requirements to the concept cases that emerged in the project.

3.3.3 Demonstrations

The purposes of all the BRIDGE demonstrations were to expose the progress and results achieved during the project from an end-user perspective. The demonstrations were held in Flums (2012 and 2015) and Stavanger (2013), of which three of the demonstration also included reviewers from the EU commission. The end-users focused on inter agency and cross border collaboration, and to discover the possibilities and the usefulness of the new collaboration technology. An important part of the end-user involvement was to evaluate the presented concept cases and being able to distance themselves from exercise technical features. See also section 5.4.

3.3.4 Exercises

RAKOS, supported by EUAB, arranged the demonstrations II and III in Stavanger including the Risavika Exercise 2013. The Risavika exercise (see also D09.3 BRIDGE Demonstration III: Collaboration Technologies, van Veelen, 2015) involved multiple emergency services and local authorities in the planning phase and during the exercise. Crisis Training AS employed FRITS to support the regional Exercise team during the planning phase and at the final evaluation process.

The concept cases were presented to the End-User Advisory Board prior to the execution to obtain feedback and suggestions on development of each concept case. See also section 5.4.

3.3.5 Conferences

SINTEF and RAKOS – together with the University of Stavanger – organised the Nordic Conference on Disaster Mitigation, http://nordic-conference-on-disaster-mitigation.origo.no/, hosted by the Stavanger University Hospital in Stavanger, Norway, on 26th-27th September 2013. This two-day conference with about 60 practitioners, researchers and policy-makers discussed how technology could be used as tools for first responders to mitigate disasters. The conference was arranged head-to-head with the Risavika exercise held in Stavanger by the local emergency services (September 25th) in order to practice collaboration in a mass-casualty

incident. This exercise was also part of the background for the third demonstration. This gave the conference participants an opportunity to observe the exercise and even participate as volunteers. EUAB members were invited to share their professional experiences during the conference. Four EUAB-members gave the following presentations:

1. *Long term crisis management – the case from the chemical train crash event in Belgium* - Christian van DeVoorde, Fire Brigade Ghent, Belgium
2. *Security research from an end-users perspective* - Heiko Werner, Federal Agency for Technical Relief (THW), Germany
3. *How could technical concept cases have improved crisis management and communications in the Buncefield disaster?* - Inspector Barbra Campbell, Hertfordshire Constabulary, United Kingdom
4. *Could a large-scale exercise contribute as a learning tool and simultaneously be a validation tool?* - Eivind Rake, RAKOS/University of Stavanger, Norway

3.3.6 ValEDation Days

The concept cases were subject for field testing and discussions at three locations; the Alpine validation days in Salzburg, Austria (9th September, 2014), Low Countries Validation Days (10th – 14th November, 2014) in Delft, the Netherlands and Nordic Validation days in Oslo (17th November, 2014). End-users attended all three arrangements. Separate assessments based on the end user validation tool, see Appendix B, were presented for the concept case owners.

3.3.7 Long and Short Term Evaluation

Some of the concept cases have been developed in close contact with the end users. Examples are the concept cases, e-Triage, Master and FRITS. E-triage and Master have been subjected for long term evaluations, see section 4.3. FRITS has been tested a number of times at various locations, and a specific master degree study was designed to assess learning from the system (Ove, 2013).

4 The end-user involvement study design approach

The main issue set out for this study is*: How are the end-users' perspectives integrated in the BRIDGE project, and which adaptive measures to end-users' capabilities and challenges have been emphasised during the project execution?*

Our motivation for the study approach has been principles of Participatory Design Methodology, of which end-user involvement continuously becomes part of the design process. These aspects are depicted in figure 6:

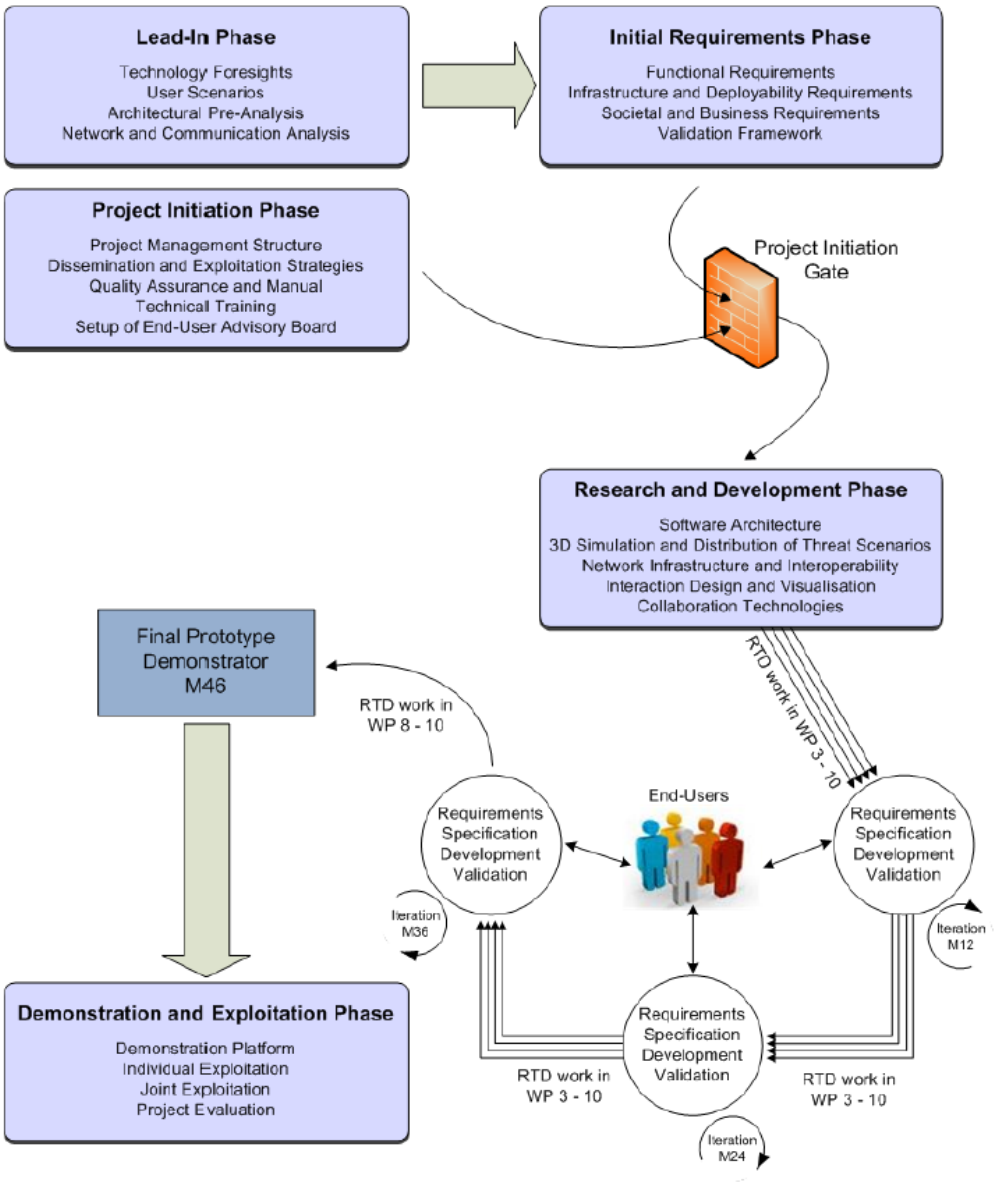

Figure 6 The BRIDGE-project and involvement of end-users

Instead of a linear process as depicted in figure 6 the methodological design in BRIDGE has followed a learning loop, in which knowledge about scenarios and associated responses were continuously discussed between the ICT developers and end-users.

- All the comments and feedback from the EUAB members were carefully recorded. Minutes of the meetings and video recordings have been made available to the consortium through the eRoom (the common information platform in the project).
- Additionally, written assessments of BRIDGE concept cases were collected from EUAB members and distributed among the consortium members.

As presented in figure 6 end-users were thought to become challenged with; Requirements, Specifications, Development and Validation. In order to meet these challenges the contents of end user involvement have changed according to the level of maturity of the products produced in BRIDGE. See Appendix A for how researchers in the WP2 Domain analysis assessed the contributions from the end users.

The final demonstration scenario (Zaitseva, 2015) was developed from the Toulouse disaster in September 2001, which occurred in the Azote de France fertiliser factory. An explosion occurred in a warehouse where the off specification granular ammonium nitrate was stored flat, separated by partitions. About 200–300 tons is said to be involved in the explosion, resulting in 31 people dead and 2,442 injured, 34 of them seriously. The blast wave shattered windows up to 3 kilometres away, and the resulting crater was 10 metres deep and 50 metres wide. For further readings we refer to (Barthelemy, Hornus, Roussot, Hufschmitt, & Raffoux, 2001; Dechy, Bourdeaux, Ayrault, Kordek, & Le Coze, 2004; Lagadec, 2005; Paltrinieri, Dechy, Salzano, Wardman, & Cozzani, 2012; Riddez & Joussineau, 2005).

In the methodology chosen for this report, we adopt the case presented for the final demonstration and provide our end-user perspectives to illustrate the challenges in a similar dramatic explosion somewhere in Europe in 2015 as was experienced in Toulouse. In this report we denote the demonstration scenario, Chemco disaster, and refer to this scenario when we make specific assessments. Direct observations from the Toulouse disaster are also referred to.

For us the final demonstration scenario and its contents addresses the end users' contextual frames and visualises to which extent the underlying needs are considered. In that respect this report will analyse the system of systems, the concept cases and their contributions to the first response systems. These issues will be addressed in the results presented in chapter 5 and 6. In this chapter, section 4.4, we provide an introduction to the scenario and how the concept cases might be integrated in the disaster response activities of the "golden hour". Section 4.1-4.3 clarify our approaches to end-user involvement during the project period.

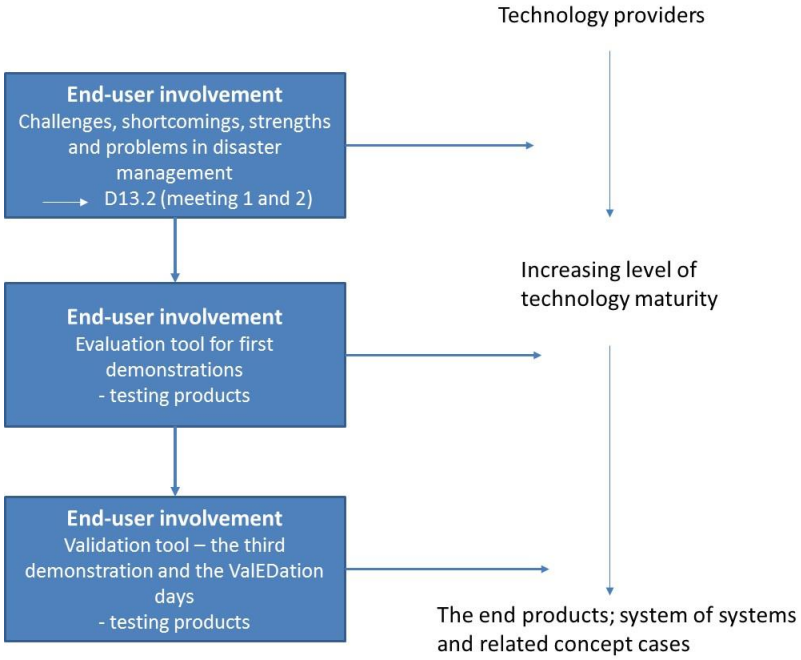

Figure 7 End-user involvements during project execution

Figure 7 shows the involvement process within the end-user group, with the first activities contributing to establish a sound design basis addressing challenges, strengths and problems related to current disaster management. The next year, in 2012, the technology developers provided concept cases, described as front end components, which were tested in Flums, Switzerland. The end-users then became evaluators assessing the demonstrated products in relation to own experiences. Finally, the work of the end-users became even more nuanced as part of the validation process and long term testing. The approaches are presented below.

4.1 Framing the challenges in disaster management

From setting up the EUAB at the first meeting in Salzburg, the members became acquainted by discussing informally experiences in disaster management and highlighting important issues. The discussions were unstructured. The topics raised also framed the discussions. "In order to learn more about the problem space and usage context of the BRIDGE project, and the end-user's needs, focus groups discussed problems the board members had experienced during responses. The result was presented and discussed in plenum. The open discussion was recorded on video and transcribed. The discussion ended with a documentation of suggestions and requests to be used in the BRIDGE project and/or on–scene" (Rake, 2012).

4.2 Evaluating demonstrations

The intermediate phases of the project included demonstrations of products, characterised as concept cases. During the demonstration in Flums 2012 all EUAB members were asked to relate the evaluated concept case to the member's own working environment and the concrete experience that he or she had. Questions like: Will the concept case apply to "your" emergency response systems? Alone and/or part of the whole response system? Consider the relevant levels; operational, tactical and strategic; which of them were important to reflect upon in the assessment of the concept cases? We developed an evaluation guide based on learning theory (Njå, 1998), encompassing situations demands and persons' competence. The assessors were

asked to relate their observations to their own experiences in order to address expected behaviour from first responders and the related consequences. The issues were organised by an interview guide:

> The evaluation issues below are the first input to an approach to EUAB evaluations. These are meant to be reflected upon when each EUAB member analyse his/her observations after the demonstrations:
>
> *Basic assumptions revealed through the demonstration*:
> - What is the intended function of the concept case presented?
> - How does the CC's apply to all emergency response phases (alarm, en route, size-up, rescue, recovery)
> - What are the emphasised frames, environment and surroundings – interacting systems (societal systems that must function parallel with the crisis response)?
> - What are the possible fallacies of the equipment?
>
> *Situation demands*
> - Is the demonstration scenario realistic? Could you say that the scenario provide realistic challenges for the actors and equipment?
> - Are the actors and equipment physically exposed in accordance with a real situation?
> - To what extent are collaborative abilities challenged in the demonstration of the equipment?
> - How are challenges related to management and interoperability reflected in the demonstration? Interoperability horizontally and vertically?
>
> *Person*
> - Does the CC's require special competence to run? Which?
> - How is the actors' practical use of the equipment demonstrated?
> - How does the equipment support decision makers?
> - How does the equipment influence on the actors' situation awareness?
> - Does the equipment improve the possibilities to perform sound situation assessments?
> - How could actors use the equipment to deal with uncertainties?
> - To what extent does this equipment/concept case improve problem solving abilities?
> - To what extent does this equipment/concept case improve standardised behaviour?
> - What would be the strength or weaknesses in the system?
> - Does the equipment enable learning in the aftermath, for example through replay?

This evaluation tool was assessed and discussed for improvements prior to the remaining demonstrations. The end users also became more involved in the next demonstrations and exercise planning in Stavanger.

During this phase of the project the end users also discussed success criteria for the disaster response in order to reveal function based requirements and obtain a sort of triangulation to the issue of needs and achievements to disaster management, as basis for the BRIDGE project.

4.3 Validation and testing

Before the final demonstration, the BRIDGE concept cases were demonstrated in a major terrorist attack exercise in Stavanger, and it was subsequently decided to organise validation sessions, in which some of the concept cases were tested at various locations. The end-users were engaged and developed a framework for end-user validation. The framework was outlined and is attached in Appendix B. The sections below present the major ideas.

4.3.1 Philosophical but practical assumptions to validation

Crisis managers, operational and technological scientists must discuss and agree upon a description of the response systems as they are generally understood. Such a mode must include specific characteristics, for example decision making, uncertainties, collaborative efforts, response phases, time frames, local conditions etc. The EUAB has been designed to reflect on these aspects in an European context, but the members have limited knowledge of the national disaster response regulations across Europe. Furthermore, there has been a need for a recognised evaluation to justify potential contributions from the BRIDGE results (validation), which address the end-user perspective. The validation process must be systematic and scientific.

The strong prevailing presumptions related to the validation concept needed to be challenged in the BRIDGE-project from an end-user perspective. What is validation and how should validation be conceived by actors assessing crisis management performance, before and after implementing BRIDGE-achievements? According to the Oxford dictionary, to validate something is: "*to prove that something is true"* (Hornby, Wehmeier, & Ashby, 2000). From the etymological dictionary we can see that the word "valid" came to the English language in the 1570s, meaning "having force in law, and legally binding". In the context of the first recorded use of the word in 1640s it was interpreted as meaning *"supported by facts or authority"* (Harper, 2001-2010).

The search for "truth" in knowledge and conditions to make knowledge possible, in this case crisis management, is based on the philosophical subject of epistemology (Barlas & Carpenter, 1990). For centuries the philosophers of science have been preoccupied with the question of how to confirm scientific theories. One method was to use the concept of inductive argument. Theory was tested by observations in nature through experiments, in our case experiments that include concept cases or systems of systems, and the theory was either confirmed or rejected. According to this view a model will either be validated or it will not. A model may be under scrutiny for its validity; however, once it has been deemed validated it becomes "immune" to further criticism.

Our stance in this project rests on Popper's criticism of induction concerning the extent to which it is possible to draw general conclusions regarding the "validity" of a theory from a single observation or a few only. We apply the concept of falsification, assuming that a theory can never be confirmed to be true but is only falsifiable. This is compatible with the complex world on crisis response; there is no truth about future successes of tools applied, only situation-based positive and/or negative experiences in the response operations. Thus, ***we do not falsify as such but raise objections about the excellence of the system under scrutiny***. This point is an important assumption of our tools and the assessor must carefully consider and adopt this issue. Neither concept cases nor models can be 100% validated (Babuska & Oden, 2004). *"A validated model is therefore one where tests have been performed which could have shown it to be invalid, but which failed to do so"* (Ivings, 2007). Validation in a practical context often aims to show that a certain approach to problem solving is the currently best available procedure, coherent with current scientific based knowledge and practice based experiences.

The claim that a model or a method for predicting the outcomes of using a crisis response concept case or system of systems has been validated is a strong statement. A validated concept

case in performance-based crisis management is a tool that the first response consultant can employ to predict the level of safety in that specific case, and is generally understood as a truthful representation. Acceptance of the systems of systems based on BRIDGE concept cases therefore implies that the crisis response consultants have convinced the relevant actors that the results are accurate enough for the intended use of the BRIDGE systems. However, from our experience there are rarely objections from any actors against the use of such analyses (validation processes), and uncertainties are not part of the discussions. In order to be structured and scientific with respect to end user validation, we must clarify the validation concept and how validation should be addressed. The most important perspective in an evaluation process is the performance criteria set to conclude on the BRIDGE results usefulness. These must address our *expectations*, *assumptions*, *uncertainties* and *observations*. The purpose with the validation tool is to provoke issues and conditions that might influence the end users' tolerances for adopting arrangements produced within the BRIDGE-project.

4.3.2 Validation of crisis response systems from the End User perspective – our model

The major "theory" to be validated is that the concept cases and/or the system of systems will *significantly improve* performance of the crisis response system. In order to simplify the subject under scrutiny we call it the *System*, meaning single or multiple concept cases, or the system of systems. In the BRIDGE-project these are the Middleware, the Advanced Situation Awareness, the Master System, the First Responder Integrated Training System, E-triage etc. The Systems should be properly defined when the process is due to start. Thus, it must be possible to express and measure the performance of the crisis response, with or without the System considered. This is a major mental simulation process (Klein, 1993) which requires experienced and proficient end-users. Figure 8 depicts our model of validation from an end-user perspective. The validation process is separated in two processes.

The starting point for the end-user validation process is the experiments established for the Alpine, Nordic and Low-countries validation days. The functional requirements, the experimental set-ups and the procedures for the technical validation outlined in work packages and information brochures, base the preparations for the end-user validation described as Validation – 1. The validation assessor prepare for the validation days by carrying out a *close reading*, which "is the kind of reading in which the reader, as a matter of habit, pays attention not only to the words and the plot but to all aspects of the literary apparatus of a text". This means that the validation assessor have obtained a clear understanding of the System, the context of the experiments and what functions and performances to be expected. During this process the validation assessor from the end user group is supposed to clarify important issues connecting his or her understanding of crisis contents and the relevant response systems, with the validation experiments and simulations (the specific ValEDation Days). The EUAB plays a major role in the Validation-1 process, since they have their own understanding of the crisis content and response systems associated with the experiments. Their assessment process would then consist of how the experiments fit with standardised procedures, typical organisations, tasks and efforts, which could be directly associated with the experiments itself, which is the core of validation – 1 (see figure 8 and the tool presented in Appendix B).

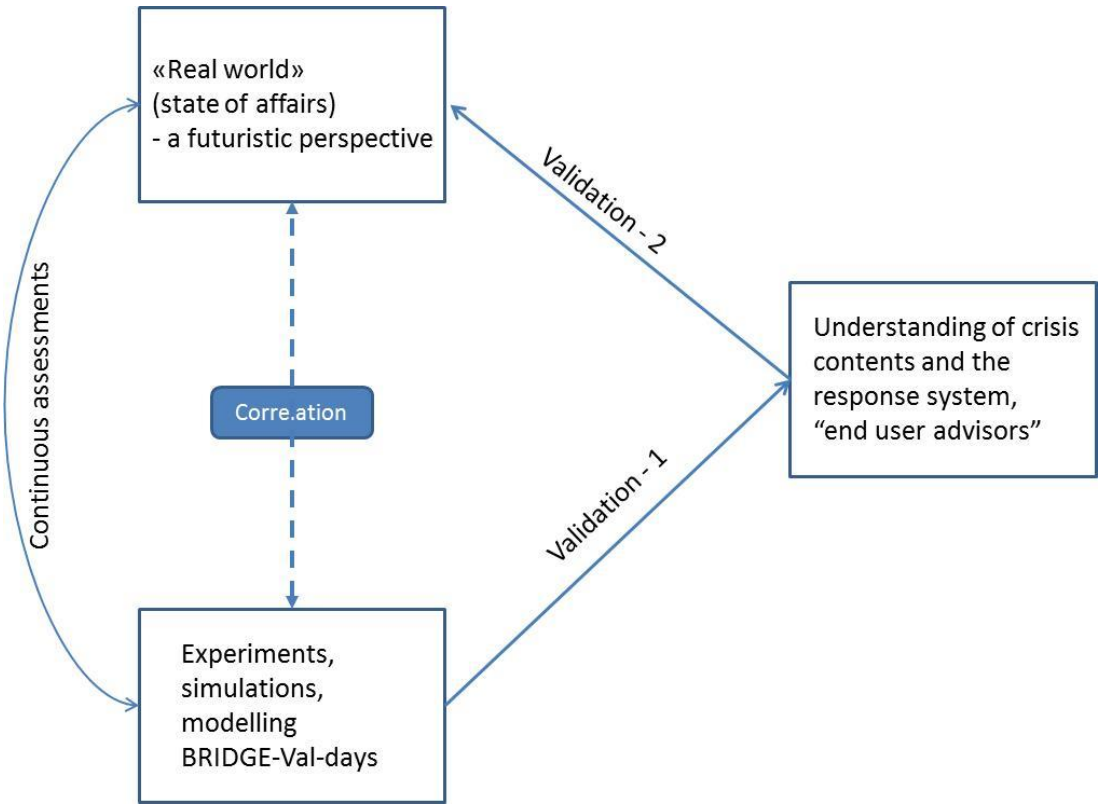

Figure 8 Validation model from an end-user perspective. Based on Borg & Njå (2013)

Validation – 2 is even more difficult than validation – 1 and require high level expertise on emergency response systems and an ability to abstract plausible worst case scenarios or even "black swans" – unknown unknowns (Taleb, 2007). Using Dreyfus & Dreyfus' (1986) scheme for characterising personnel knowledge from novice to expert, we can say that validation – 1 require a proficient performer, while validation – 2 require the experts.

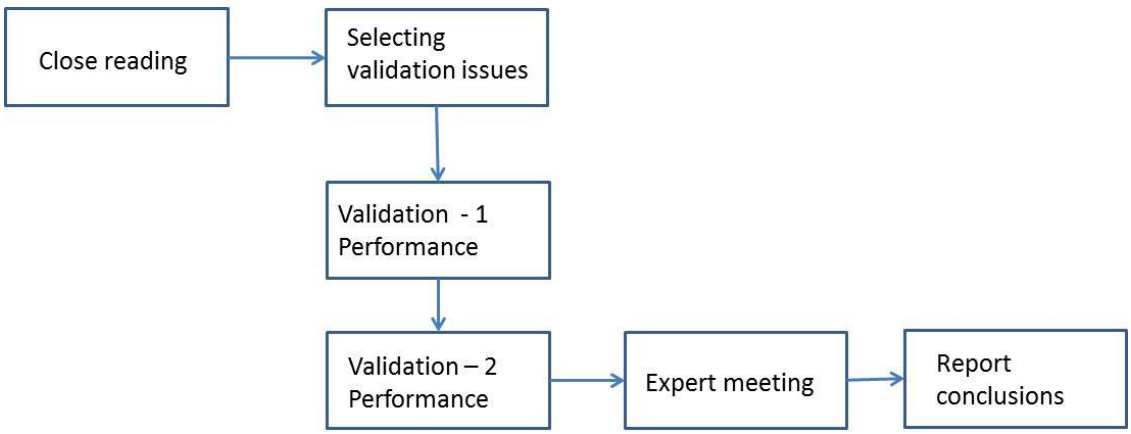

Figure 9 Validation process from the end user perspective, cf. Appendix B

The validation assessor from the end user perspective is per definition loaded with knowledge and self-experiences related to own/associated crisis response systems. This is to be regarded as

the reference for the end-user validation. However, it is very important to bear in mind that the EUAB-members carry out their sole assessment as part of the validation without any responsibility for the System development. They are to be considered as independent experts.

The principle of this tool is a checklist of issues, which are generic. Thus each end user deemed to validate at some of the ValEDation Days must select the relevant issues that would be important, and apply those issues prior, during and after the experiments as a guide to assemble and prepare the report. This is the close reading process in which the assessors have obtained a clear understanding of the System, the context of the experiments and what functions and performances to be expected. During this process the validation assessors from the end-user group is supposed to clarify important issues connecting his or her understanding of crisis contents and the relevant response systems, with the validation experiments and simulations (the specific ValEDation Days). This should be discussed in a prior meeting before the actual experiments take place, depicted in Figure 9 as the "Selecting validation issues". The validation issues are formed as statements, which the end user can agree to, the end user can raise major uncertainties or the end user reject it. These categories are as follows:

Agree. I agree the System have this weakness and more work should be done to overcome this weakness. Then the end user must address whether this is a problem for the developer or it is a weakness regarding end-users and the emergency response systems.

Major uncertainties. I cannot see that the statement is covered by the experiments or the experiments raise major uncertainties regarding whether the statement will occur or not. This is an issue for further exploration from the scientists.

Reject. I reject this statement and I am convinced that the System will improve the specific crisis response performance and even have a positive impact on the overall crisis response system.

The validation was documented in three separate notes submitted to the members of the BRIDGE consortium.

4.3.3 Long term evaluation - LTE

During a close collaboration with end-users, the eTriage and Master concepts have been exposed to a systematic testing regime. The eTtriage system has been continuously monitored through recorded, transmitted and stored information: The victim's identity, GPS, skin temperature, tracking function, manual and autotriage – LED lights, alarm functions. The movement sensor has been tested to find correlations with the patient's Glasgow Coma Scale (GCS).

The Master is a command and control system aiming to synthesise, visualise, filtering and sharing information among responders and emergency services on-scene and off-scene. The Master main functions are:

- Visualises data from the eTriage.
- Each patient has its own ID in the system.
- Several modes for visualising patient information.
- Functionality for filtering information.
- Can run on different devices (PC, tablet, smartphone).

Haugstveit et al (2015) described the process for long term evaluation (LTE) of eTriage and Master involving end-users at different locations and conditions, cf. figure 10.

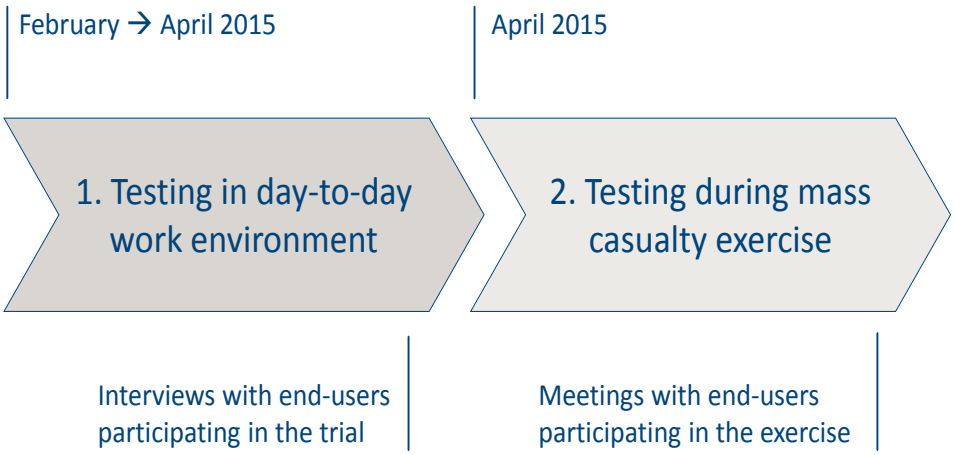

Figure 10 Testing eTriage (Haugstveit, Rake, & Eide, 2015)

The LTE included:

- One week test pilot in three Norwegian cities, Egersund, Stavanger and Trondheim.
- Four weeks testing and evaluation in the same three Norwegian cities.
- eTriage used by paramedics in ambulances in each city. Approximately 500 ambulance patients tested the eTriage system.
- MASTER used by operators at the medical emergency dispatch centres.
- Testing during a mass casualty exercise outside Trondheim. About 100 injured victims.
- Observations, meetings, interviews and a final evaluation.

Emergency responders involved in the testing were ambulance paramedics, medical emergency dispatch centres (Stavanger and Trondheim), St. Olavs Hospital (Trondheim University Hospital), the municipal emergency centre, the police and the national Joint Rescue and Coordination Centre (JRCC) in Stavanger. Thirty bracelets were used and ten persons followed the tagged patients from incident site to treatment.

4.4 The disaster case

The overarching scenario for the final demonstration in Flums was a constructed disaster where the use and interaction of different concept cases, procedures, simulations etc. from the BRIDGE project were demonstrated. The aim of the scenario description was to provide a realistic storyline that helped explain how the collaboration technologies and concept cases envisioned for BRIDGE could support the first responders and the incident commanders during a real disaster.

The final demo scenario developed for the final EU-review, was based on the AZF-explosion 21st September 2001. This was a typical fast-burning crisis (see fig.2, Boin and t'Hart 2003) dramatically challenging the first response system, if we define the crisis as the direct damages seen. However the crisis could be regarded as still ongoing (still in the French judicial system) and would hence be a long shadow crisis, cf figure 2.

We also used this case to explore the BRIDGE products and the involvement of end users. One interesting feature with this case is its lack of research into the disaster response systems and performances, the comprehensiveness with regards to affected populations and the lack of

descriptions of interoperabilities, systems of systems and whether the response was agile or not. Thus, one can only speculate in the challenges at the scene of the explosion, in the operation centres, at the strategic levels and within the French governments. The context, 10 days after the terrorist attack in the US, could be compared to the current situation seen in Europe under the conceived terrorist threat. These matters could influence the risk assessments performed by the first responders.

When we contacted colleagues in France, their response was that researchers were unlikely to be of help to us on the first response operations. Either they were not working in industrial safety at the time, or they did not wish to discuss matters as the court case was still not finished (the decision made in the retrial was recently annulled due to procedural issues). This means that there is no reception history that we have come across. We find it even better for the sake of the case in the last demo of the BRIDGE. We can abstract the explosion case into an artificial, but realistic 2015 location in Europe, without too much reference to activities, behaviours and outcomes in Toulouse. The abstracted scenario is denoted the Chemco disaster. From an end user point of view, we have developed a set of challenges that such a scenario will put on the response system and we have discussed them against the BRIDGE products in order to visualise the end user contributions.

The National Board of Health and Welfare (Socialstyrelsen), which is a government agency in Sweden under the Ministry of Health and Social Affairs, have established a system for gathering experience data from major disasters, such as the Toulouse disaster (Riddez & Joussineau, 2005). Their report emphasise major uncertainties with regards to the number of injured people, how efficient the first response effort had been, the influence of lack of communication means, the triage capabilities optimising the loads upon the emergency ward and trauma centres, and the next of kin treatment. Riddez and Joussineau report a huge number of physicians available at the scene within short time due to their paramedic system (350 physician-manned ambulances related to hospitals connected with the SAMU system[2]). In accordance with the authors' point of view, the situation became within a short period of time controlled and with a well-functioning margin of first responders. The initial phase was more problematic due to little precautionary activities performed (risk of toxic substances, other events), and the traffic jam challenging logistics. However, there are no reports on victims suffered by the situation.

The final demonstration was constructed around the Golden Hour (Zaitseva, 2015), which is shown in figure 11. The phases are described in a time-line and with sub-phases to characterise the phases. In the figure the inner circle is the Middleware, and the further is; Master; SWARM; Information Intelligence; Adaptive Logistics; Advanced Situation Awareness; Robust and Resilient Communication; eTriage; and finally FRITS. The arrows show which phases and time slots are the most relevant for each concept case. The presentations of the phases and time slots are associated with observations from the Toulouse disaster. The purpose has been to provide an overview of first response issues related to the disaster response phases (cf. section 2.2) and to relate them to the BRIDGE products.

[2] SAMU – Service d'Aide Medicale d'Urgence

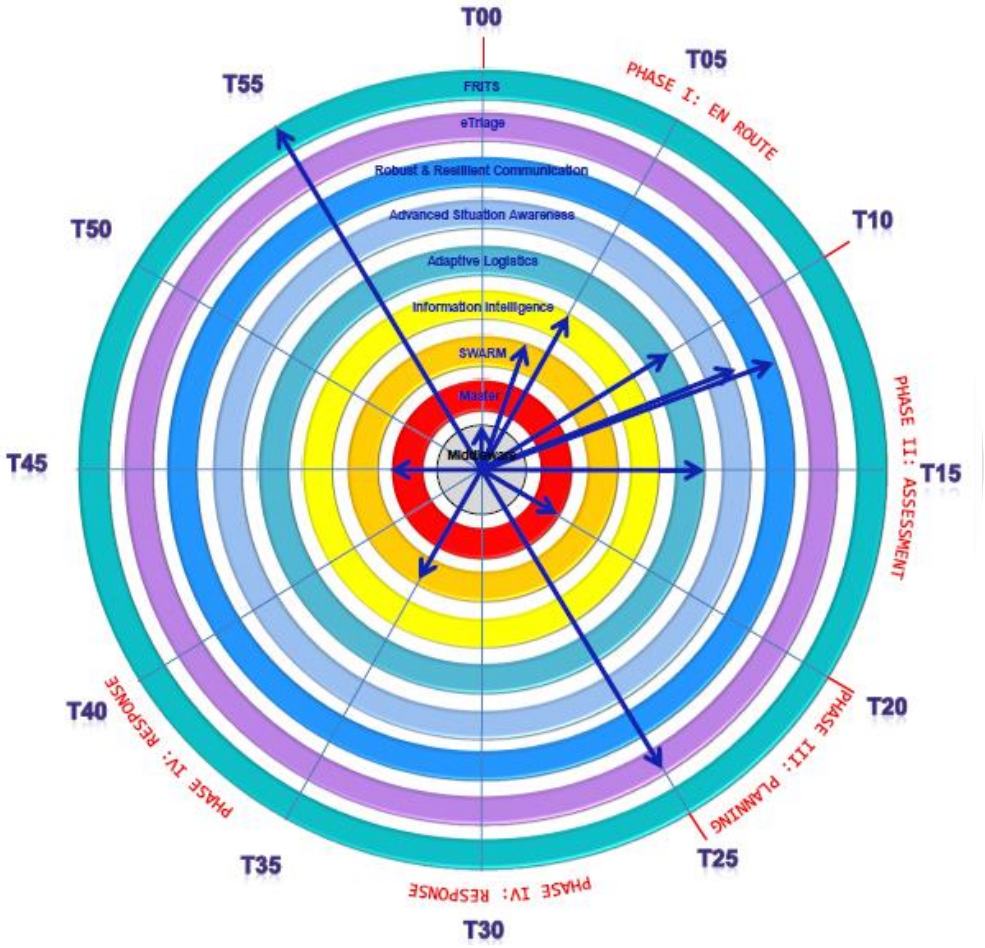

Figure 10 Golden hour – the final demonstration run (Zaitseva, 2015)

Prior to T 00

Routine operations

The first responders are preparing response plans, training, drill and exercises, maintaining and preparing engines and equipment to be used on-scene. The police, fire and ambulance services are ready for rapid responses when needed. Emergency services are on duty and prepared as normal. At the plant the employees control and work according to plans and needs on-site. The plant activity and risks are monitored. Normal activity describes the work and production at the factory.

Observations from the Toulouse disaster/AZF plant:

- Lack of sufficient training and responding to chemical accident.
- None of the internal or external emergency plan envisaged a similar scenario with the occurred explosion.
- Emergency services did not have precise information on the potential hazards at the AZF.
- More than 350 people were working on the plant.

- Gallienei High school and Ranguiel hospital were located close to the epic centre, Gallienei High School only 500 m away.
- In the morning a huge and powerful explosion occurred at the AZF. It resulted in a powerful blast wave and a major cloud of dust and smoke with unknown toxic and hazard gases.

Phase I: En – Route

T 0–10

This phase starts when the first call center (normally the police, the fire service or the ambulance center) is notified about the accident and it last until arrival on-scene.

1. Alarm
   Alarm is the time from when the emergency services are notified until the first responders are on the way to the incident. Urgency. Call out of first responders according to procedures.
   Observations from the Toulouse disaster/AZF plant:
   - The alarm system at the factory was never activated.
   - The first telephone indicated a number of traffic accidents nearby AZF.
   - The police were inundated with telephone calls from different part of Toulouse.
   - A major disaster alarm was trigged in Toulouse 20 minutes after the explosion.

2. En-route
   The first task forces are heading for the plant from different places. En route the accident, the time is used for preparations, for example to request more resources, ask for more information, communicate with the call centre and other response units, or discuss the task with crewmembers. However, time is often used to guide the driver through the traffic. The time to reflect, assess and to plan is hampered by the running time.
   Observations from the Toulouse disaster/AZF plant:
   - Major traffic problem en-route, especially near the site.
   - Extensive damage hindered or caused problem for the emergency services to reach the factory.
   - A huge orange coloured cloud with the smell of ammonia drifted towards the city centre.
   - Whether the cloud was toxic or not was not known.
   - The telephone network collapsed.

3. Arrival
   Arrival on-scene the accident, includes the time when the commander and responders arrives at the scene, normally at the main entrance, park the engines, gets out and initially sizes up the situation. Sizing up the situation is critical in order to assess its extent and escalation potential. The time is normally less than two minutes and is affected by the incident area and the level of chaos.
   Observations from the Toulouse disaster/AZF plant:
   - The first rescue team was on-scene 13 minutes after the explosion.
   - At that time the responders understood it was a huge explosion at the AZF facility and not only traffic accidents.
   - The first doctor arrives ca. 15 minutes after the impact.
   - A stream of dusty and injured persons fleeing the area were observed.

- 95% of the alarmed ambulances reached the plant faster than 15 minutes after call out.
- The emergency services were constantly arriving even though no risk assessment was carried out. They did not know whether the gas was toxic or any other explosions could occur.

Phase II Assessment

T 10 – 20

The initial size-up is done and initial information about the emergency is sent to the call centres and responders heading for the incident. The first officer and the later on arriving officers (fire officers, police officers, incident commander etc.) start the major assessment process and they need a lot of information to assess the threats, such as the toxic level of the plume and damages of constructions. What's on stake, the subsequent extent of the hot and cold zone, the number and location of injured persons etc., are prominent issues. The commander will obtain an overview, start planning and locate the incident command post. The first lifesaving response starts.

Phase III Planning

T 20 -25

It is obvious to the incident commander that the Chemco explosion is a disaster and a long time response is needed to fight the consequences of the explosion. There are important values at stake, such as injured persons who need immediate medical care. There is limited time to deal with the situation (e.g. leakage of hazardous materials) and the uncertainty involved. At the Chemco plant a huge plume of black smoke and gases is seen. Safe area for the responder, persons at the plant, the inhabitants nearby, the traffic at private and public roads has to be established. The area will change due to wind, smoke and gas (type and amount) and the terrain.
Observations from the Toulouse disaster/AZF plant

- Existing plans did not describe a scenario with such impact and magnitude.
- The emergency plan of the AZF plant concentrated upon toxic gas release as phosgene.
- The probability of an explosion was considered to be low and not described as a possible risk in the emergency plan.

Phase IV Response

T 25 – 60

The situation is dynamic and the treats are changing fast. The challenges and activities described above continue and need attention and rapid response.
Observations from the Toulouse disaster/AZF plant:

- Some equipment, such as breathing apparatus for smoke divers was found to be inadequate for the response. Normally such apparatus last for 20-25 minutes before it must be filled with compressed air.
- The communication between the emergency services was hindered due to overload and collapse.
- Delays in compilation and communication of a triage list, especially the list of serious injured persons.

- Many industrial buildings were demolished.
- Nearby residential buildings needed immediate evacuation.
- Measurement after 30 min indicated that the cloud caused by the explosion had a "low" toxic content.
- Within 12 hours 1046 firefighters from 13 districts were on-scene.
- 950 police officers were involved in the response.
- 60 doctors were on-scene.
- An operational centre was set up and became crucial to coordinate the response from the SAMU, medical personnel, fire service and police service and UIISC soldiers[3].
- A medical assembly point was located a few kilometres away from the explosion. Nearly 300 injured persons got medical care at this assembly point.
- The nearby hospital, Rangueil hospital was temporarily evacuated due to explosion damages. 50 patients in the hospital needed medical attention due to the explosion. After an inspection the hospital was reopened and it received 435 patients for triage the first day, of them were 116 admitted for medical care.
- 1048 injured persons got triage at the main ambulance entrance. ¼ were admitted to various injuries sector in the hospital.
- Injured persons were sent to or showed up at 24 medical units, several of them private.
- 30 fatalities. 21 at the facility plant, 1fatality at the Gallienei high school due to concrete structure collapse, three fatalities occurred in facilities outside the AZF, respectively 450 m (1 fatality) and 380 m (2 fatalities) from the blast.
- The Toulouse Prefecture estimated that about 3 500 people were injured, 50 of the seriously injured. Nearly 850 patients were hospitalised.
- More than 300 vehicles received damages.
- Managing a mass-causality incident requires a well-functioning communication network on-scene and between hospitals. The daily network and radio connections were not sufficient.
- Registration, identification and localisation of injured victims were not supported by ICT solutions.
- The explosion caused a crater nearly 10 meters deep and 50 meters in diameter.

Even though the underlying assumption for the BRIDGE project have been a massive explosion requiring cross country cooperation it has not been strictly focusing on this type of events as design scenarios for the BRIDGE products. The concept cases and system of systems are designed with flexibility to be adopted in any kind of scenario. For the end users a strict requirement is that the concept case should be applicable in the daily use. The Chemco case is excellent as a final reflective scenario for the BRIDGE products, since it is based on past realisations but it also opens up for abstracting the event into the current disaster management conditions and future manifestations.

[3] Intervention and Guidance Units for Civil Protection

5 Performance of holistic disaster responses and related "System of Systems"

The goal of BRIDGE - Bridging Resources and Agencies in Large-Scale Emergency Management - is to increase safety of citizens by developing technical and organisational solutions that significantly improve crisis and emergency management. The key to this is to ensure interoperability, harmonisation and cooperation among stakeholders on the technical and organisational level. Technical interoperability is crucial for improving multi-agency collaboration and continuous training, but its full potential can only unfold, if technology can be integrated and sustained into agency workflows and communication processes. Making available an increasing amount of data for crisis response has to be accompanied with developing intelligent human-computer interaction models.

The underlying principle of the research conducted in BRIDGE is described by interoperability in the orchestrated system of systems approach to produce agile responses. In a practical first responders' world these terms are difficult to grasp. In short the BRIDGE project claims to offer a holistic structure of tools (concept cases), which might easily become integrated into a regional/national and even international disaster response system that would increase the disaster response systems' performances significantly. Before we address the terms in BRIDGE the interesting question is how can we express and measure performance of a disaster response system?

From discussions in Njå (1998), *performance measures* can take many forms.

Risk reduction. Risk analysis has proved to be a powerful disaster management tool with the purpose to present the risk picture, i.e. the likelihood of occurrence and consequences of disastrous events. Anticipated consequences for people, the environment, and assets and financial interests, are some of the results obtained from such analyses. The main purpose of the risk analysis is to provide a basis for making decisions, where future conditions and consequences are uncertain. One main feature in risk analysis is to identify the emergency response arrangement potential to reduce the risks involved. Let us consider an example from reality (Nielsen, Sand, Buus Pettersen, Gudmestad, & Rettedal, 1995):

The risks to the Sleipner A(2) oil and gas production platform[4] during its construction and installation were evaluated using quantitative risk analysis. The construction involved marine operations, including the towing of the completed platform from its construction site in Gandsfjorden, Norway, through the narrows north-east of Stavanger to its installation site in the North Sea. This involved manoeuvring the gravity base structure along a route with the narrowest point being equal to twice the width of the platform. The outcome of concern was grounding of the platform. The consequence could be as severe as total loss of the platform. A risk reducing emergency response arrangement was proposed consisting of training the towing team using a simulator. The implementation of this risk reducing emergency response arrangement influenced the figures in the fault and event trees, and thus improved the risk of total loss of platform by a factor of 190. (The project management decided to carry out this training based on the benefits earned. It should also be noted that the Sleipner A(2) tow-out was actually smoothly carried out with no problems whatsoever). The example shows performance measured by risk reduction, as traditionally carried out. Measuring performance is conducted solely by modifying risk analyses. Thus, the risk analysis tool represents the major source of evaluation for the safety management. This methodology is highly appreciated by many.

[4] The Sleipner A (1) gravity base structure sank in the Gandsfjorden in 1991 under a testing operation, and was a significant loss to the operator in terms of assets, reputation and crisis management. No fatalities.

Rake (2004) developed an approach to carry out coarse risk assessments at accident scenes in order to systematically address concerns and complexities in critical decisions. The approach was more an incident commander philosophy than a time consuming procedure. However, for many first responders, assessors and decision makers, risk reduction is a difficult concept to base their assessment of performance at accident scenes upon. The uncertainties are too many and too comprehensive. There is a need to provide more absolute and concrete measures that are more easily understood. The BRIDGE concept cases are developed to meet challenges in the disaster management activities, thus the understanding of the disaster management phases are vital. All assessments of the disaster response arrangements are to be scrutinised with the question: *Is it significant difference between the BRIDGE-System considered being in place and the reference response organisation as it is today?* We recommend the following performance measures:

Reliability/availability is a measure describing to what degree the System will be there and carry out its task in an expected manner. The reliability and availability of the Middleware would be a measure of the Middleware being in operation when needed (real event) and serving all applications in case of a crisis. A quantitative measure here could be down-time, probability of functioning, etc.

Capacity. The System's capacity is a measure of the intended functionality considered, for example the number of information sources to be integrated and explored in the Master table. The capacity of a medical team could be the number of patients given medical care, based on the eTriage system. The capacity values are observable, but uncertain quantities. Capacity could be expressed by strength, number, pressure, flow rate, area coverage etc. Uncertainty should be included to express the (end user) assessor's degree of belief regarding the capacity quantities. An alternative could also be more coarse assessments.

Execution time represents the time needed for specific crisis operations. Usually it is the time from the situation has occurred to the operation or function is successfully carried out, but limiting the tasks and operations might be necessary. For a fire scenario in a road tunnel an interesting time aspect is the duration from the initial fire ignition (alarm) until every road user is rescued or found and brought to safe area. Regarding the Advanced Situation Awareness the execution time could be from the alert is given to the information about the scene and danger characteristics is on the Master table or in practical use for the Incident Commander.

Survivability/vulnerability relates to the System's ability to withstand the loads and conditions in the crisis. Electrical power might be an important issue for the System studied, which could be vulnerable in the specific event. Sensors might be damaged during explosions and fires, etc. Qualitative descriptions are often applied as measures on survivability. We use the terms robust and resilience in the BRIDGE project, of which resilience is defined as: "The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions" (Hollnagel, 2011). Barrier robustness is defined as "the ability to resist given accident loads and function as specified during accident sequences" (Sklet, 2005). From an end user perspective these terms are closely related synonyms and we use them interchangeable.

The abovementioned measures will also be relevant for assessments of the holistic performance of the system of systems in disaster response. BRIDGE system of systems innovation has to consider not only the different tasks, roles, perspectives and forms of expertise and requirements of crisis situations, but also the support of distributed sense-making and collaboration, for example to reduce information overload and support overview and situation awareness in crisis situations.

5.1 System of systems and their interoperabilities as a fundamental feature of disaster response

Ramirez and Büscher (2012) adopted the Homeland security's conception of system of systems (2004), which they defined as: "A system of system exists when a group of independently operating systems – comprised of people, technology, and organisations – are connected, enabling users to effectively support their activities". We refer to our system approach in section 2 and recognise the benefits from the understanding of system of systems as a thought construct useful for analyses and assessments. It clarify and reduce the complexity seen in the more social science research approaches which is critical to what they address as classical engineering approaches to safety and crisis management (Hollnagel, Nemeth, & Dekker, 2008; Hollnagel, Woods, & Leveson, 2006). The assumption of systems being independently operating from each other, when the issue is disaster management is challenging, but as a meaningful approach to engineering design and assessment of performances of emergency response systems, the concept of system of systems is attractive.

From an end user point of view the system of systems approach is particularly interesting when we combine it with the systems approach depicted in section 2. It could be further developed into horizontally structures of communications and task in disaster response systems, i.e at the political, strategic, tactical and operational levels (see sections 2.3 and 2.4). The issue of the systems being interoperable becomes an important characteristic to operationalise and resolve through performance assessments. The BRIDGE-project has defined interoperability as: "... the ability of different organisations to conduct joint operations. It is understood as an effect on a process. To be interoperable, human and non-human parties involved in emergency response actively engage in an ongoing process of ensuring that the systems, procedures and organisations are managed in such a way as to maximise opportunities for exchange and re-use of information, whether internally or externally".

Our interpretation from an end user perspective upon the two definitions above is that interoperability is the lubricant of system of systems positively influencing the availability, reliability, capacity, execution time and survivability of the system of systems considered. Thus operationalising the concept interoperability presuppose understanding of the disaster scenario (energies and external forces with undesired effects) and the functioning of the disaster response systems being available for combating and mitigation purposes. Dechy et al (2004) reported that 1570 firemen and military personnel and 950 police officers were involved in the emergency response of the Toulouse disaster in 2001. "The problem was that they arrived without any plan and any discussion by phone as the classical phone lines were partly destroyed and the mobile networks were saturated. The internal and external emergency plans were not prepared to this scenario and its gravity" (p.135).

The solution to the above problem has the BRIDGE-project denoted "agile response", which is: "[A] flexible, loosely coupled, but highly collaborative response effort, where people have a high and highly distributed real-time degree of awareness of activities and resources and are able to mobilise these effectively and in a coordinated manner". Agile response fits very nicely with a function based regulation regime to disaster response, in which the societal and organisational structures and behaviours are influenced by principles of high reliability organisation theory (La Porte & Consolini, 1991; Reason, 1997; Weick, 1987; Weick & Sutcliffe, 2008). As a normative premise the agile response approach is very enchanting, but the disaster response industry is in general developed from a command and control regime which is established on very different foundations. Many organisations are based on military principles relying on standard operating procedures and traditional standard equipment. There are researchers that claim that this industry is reluctant to learning (Dekker, Jonsén, Bergström, & Dahlström, 2008) and developing new and flexible procedures to crisis management. The idea of agile response will meet barriers in spite of its plausible premise.

The seminar in Ghent, 2013 was a multidisciplinary event, covering all of the blue light services (Gold, Silver and Bronze levels) and other relevant parties. The seminar/workshop intended to critically examine four disaster management cases that have occurred in Europe (see section 3.1). Several BRIDGE Concept Case owners were present in the audience and the seminar gave opportunities for discussions about the relevance of the concept cases, such as:

1. Barriers to implementation of concept cases that the BRIDGE project must overcome.
2. An overview and assessment over similarities and differences in disaster management practices.
3. How we should operationalise the concept of successful disaster management operations.

A similar arrangement was planned and executed in the Nordic Conference on Disaster Mitigation combined with the third demonstration. The seminar aimed to describe challenges in current disaster management practices across Europe. These arrangements were driven by the end user group.

5.2 Challenges and user needs in disaster management

The chemical explosion case at Chemco, from section 4.4 introduced a vast number of uncertainties that need to be dealt with in very narrow periods. These are for example:

- What has exploded, content (substances) and the amount of chemicals involved?
- Toxic releases? Environmental conditions? Safe areas?
- Causes of relevance for the possible cascading effects?
- Energy releases that are relevant for cascading effects?
- Emergency preparedness in the neighbourhood – Seveso II and other important regulations – principles present – description of contexts.
- Societal emergency response systems?
- Behaviour of victims, bystanders and societal members in a timeframe?

These uncertainties all have the potential for bringing the scenario into atypical (Paltrinieri et al., 2012) scenario causing the crisis response system out of composure. There are a number of various perspectives on the performance of disaster management, actors responsibilities, actors interoperabilities and how the dynamic of the responses are influenced in real time. Major challenges cross-sector and cross-nations are:

- Situation assessment – maintain and update a common operational picture cross-sector and different level, based on ill functioning communications systems.
- Interoperability – framing the contents of the explosion disaster.
- Structure of disaster management (regulations, procedures, frameworks, equipment and systems, formal training/competence), more than one thousand first responders involved.
- Working practices in disaster management (informal rules/approaches, vulnerabilities, climate, communications, social networks, informal authority persons etc.).
- Well-defined and functioning collaboration at various levels and across various organisations.

Some of the challenges on-scene, addressed by the EUAB and introduced for the BRIDGE project were (Rake, 2012);

- Lack of information in emergency response.
- Enable active push and pull of significant information based on uniform standards of exchange.
- Trustworthiness of information – ability to screen in real-time.
- Information overload – ability to distinguish important information from unimportant.
- Context and scenario awareness – ability to understand cues and critical factors in real time assessments.
- Situation awareness, situation assessment, treatment of uncertainties.
- Reliability of decision support systems.
- Triage processes – to which extent, based on what is beneficial?
- Logistics – especially related to transport infrastructure and visibility.
- Registration systems, how to record victims, evidence and witnesses throughout the scenario.
- Interoperability between rescue organisations horizontally and vertical, but also between nations.
- Encompassing unexpectedness – facilitate flexibility and improvisation (problem solving abilities)
- Level of standardisation, technical, procedures and plans in Europe.

These issues were presented at the earliest phases of the project and have been part of the design premise for developing the concept cases (both initial front end components and the later assimilation and reconstruction of concept cased, based on the Klagenfurt meeting in 2013). In the same setting the EUAB members also pointed out a number of important issues to be dealt with, e.g;

- Communication network break downs.
- Social media users' ability to provide information to first responders.
- Information exchange and communication interoperability between different agencies and nations.
- Common "language" including acronyms, signs and symbols.
- How to do real time observations on incident sites in order to provide a common operational picture.
- Technology to be used during large-scale emergency event, as disasters, should be used in the day-to-day work environment, as is in normal accidents and normal responses .

5.3 End users' success criteria in disaster management

In order to develop system of systems that are providing better conditions for first responders to perform optimally during disasters we need an understanding of when and how optimal performance is achieved. The EUAB-meetings in Flums (September 2012) considered it important to select an approach that did not dwell upon all the shortcomings or pitfalls in disaster management. Rather a positive perspective on the operations was advocated. In accordance with that recommendation we have revealed criteria/characteristics for successful crisis management operations. Even though most of the EUAB members are incident commanders they all have different positions and involvement in disaster management. In this case the most important information is the individual view on characteristics implying successful performance. This could be experienced through debriefs or as reflections made on

their own. Seven first responders (various levels and affiliations; Bronze, Silver and Gold working in Paramedical, Fire or Police organisations) gave their views on when an operation was considered successful.

As a starting point some statements were collected from the PhD work of Eivind Rake (2008), in which incident commanders were asked about what they considered to characterise a successful operation (not particularly major incidents).

A Swedish fire fighter (IC) said:

- To me it is that no one has been injured
- To me it must feel good

A Norwegian paramedic (IC) said:

- To me it is that the triple alarm has functioned as expected
- To me it is that the communication on scene has been good
- To me it is a feeling of getting necessary support from the hospital

Our analysis revealed that the majority of the descriptions of successful operations were related to tasks to be carried out. Thus an inherent view of what was deemed "good", "sufficient" and "clear". Such adjectives are context dependent requiring assessment of the scenario itself. These statements were often related to the "feeling" of the commander. One prominent heuristics was some kind of reference rescue operation situation thinking, in which the commander perceived what to be expected. Their views were also based on contrafactual scenario assessments; "otherwise it could have gone much worse". This lead to more "outcome" related statements. An important part of such statements was the well-being of the involved first responders themselves. Collaborative, communication and common understandings were also prominent characteristics of successes. Some issues specified technology-solutions, but then the informant did have special competence in that field. A few issues presented were also related to how external assessors perceived the response.

However, these characteristics is not to be either this or that, but combinations. Nevertheless, most commanders focused on tasks, which are exemplified with; "To me a successful operation is;

- characterised by a quick control of the situation, i.e. the crisis has not escalated after the first responder resources had arrived,
- when the medical treatment on scene is carried out the same way as under ordinary conditions,
- when we have obtained an early and effective triage and subsequently been able to monitor every patient from the disaster scene to the hospital,
- when the collaboration between the emergency organisations functions very well without misunderstandings or conflicts,
- when the responders find a tailored solution in short time,
- when all relevant resources are involved, that is, no one has been forgotten either in the triplet warning or from own resources,
- when the first responders feel, that decision makers also act in a professional way,
- is when the procedures and guidelines have been followed, but also that improvisation is facilitated when needed".

Examples on contrafactual assessments; "To me a successful operation is;

- when there is sufficient equipment to undertake the treatment and competent emergency physicians available to provide the treatment. The latter is often lacking in bad responses,
- when losses could be reduced/prevented,
- is that the technical solutions have supported the responders under a disaster or treatment".

Examples on first responders' well-being and safety; "To me a successful operation is;

- when we have managed to minimise unnecessary workload, and been able to increase the capacity of medical treatment and monitoring every patient,
- that no incident happens during operations threatening the responders' health or the equipment,
- is that the first responders are relieved and get rest and food in cases where the operations are long lasting."

Examples on collaborative, communication and common understandings; "To me a successful operation is;

- characterised by a good communication between the agencies,
- only possible when there is confidence between the leaders of the different agencies on each level,
- a good and clear communication to the media and the citizens,
- characterised by a good coordination between the agencies involved,
- when competences and responsibilities are clearly allocated and everybody is able to properly perform his tasks."

Examples of external assessments and significant achievements; "To me a successful operation is;

- when we (my team) have carried out tasks that no one would believe were possible to undertake,
- when everyone, that is first responders, management, involved people, victims, media etc. express satisfaction.

The above statements could be seen as surprisingly subjective in the sense that success is measured through individual feelings. We regard such responses as expressions on the complex world of first response and the interactions between humans and technologies are at the core, not the single person or piece of equipment. A major part of the knowledge base is tacit, expert knowledge that illustrate the respondents' involvement. In a design project as BRIDGE, the continuous collaboration between the experts and the technology developers are hence of major importance. It is the consortium's ability to consider disaster response holistically, which is important. The technology itself is not of utter importance, it is its integration in the disaster management systems that matters.

5.4 End user involvement in the planning of demonstrations and exercises in Stavanger

RAKOS, supported by EUAB, arranged the demonstrations II and III in Stavanger including the Risavika Exercise 2013. The Risavika exercise (van Veelen, 2015) involved multiple emergency services and local authorities in the planning phase and the exercise execution. One major goal was to demonstrate the BRIDGE technology and concept cases. The organisers were allowed to demonstrate the results to end-users as they exercised the scenario. The Risavika exercise was extensive enough to demonstrate the technology not just in isolation, but in coherence, pointing out how the collaboration of technologies and human professionals could increase situation awareness and operations, in turn increasing the effectiveness of the efforts. The presence of the EUAB gave fruitful discussion with the concept case owners challenging especially:

- Will the technology work as intended?
- Will the end users find the concept cases useful for improving current practice?

The Risavika exercise enabled BRIDGE to assess whether the technology developed in the BRIDGE project was able to cope with the strain of a realistic scenario. To expose the BRIDGE technology to a large group of end-users, not only the EUAB, enabled investigation into what the concept case owners thought of the usability of the technology and whether they were able to use it to improve their practice. The concept cases were presented to the EUAB prior to the exercise to obtain feedback and suggestions on development of each concept case. These presentations were useful for the EUAB in their assessments of the concept cases during the progress of the exercise.

The BRIDGE review commission and the EUAB followed the exercises. The Risavika exercise scenario was a simulated terrorist attack on Risavika harbor. Terrorists attacked the local Skangass LNG plant, the ferry terminal and a ferry waiting for departure next to the terminal. At the Skangass LNG plant a group blew up a tanker. The second group entered the ferry terminal, and killed employees and ferry passengers. The last group forced entry into the waiting ferry and shot passengers and personnel on the ferry. There were many casualties and victims. The victims were triaged and taken to Stavanger University Hospital for further treatment.

When the emergency services were notified of the ongoing events at the Risavika harbour, they deployed full-scale, to:

- stop the terrorists from causing any further fatalities, injuries or destruction of property
- triage and evacuate the victims
- extinguish fires and clear up debris caused by the terrorist attacks
- treat the large numbers of patient suffering from complex injuries (gun shots, temperature and smoke exposure, blast wave and related debris)

There were more than 50 casualties and victims. The causalities and victims were triaged and taken to Stavanger University Hospital (21 injuries) and local casuality clinics for further treatment. 200 nurses, doctors etc. gave medical treatment to the injuries in the hospital. Participating actors on-scene and off- scene also included the emergency services (response units, emergency call centres and crisis management staffs), the army, the Joint Rescue Coordination Centre, the county governor, 5 municipalities (casualty clinics and psychosocial crisis team), the civil defence, NGO's (Red Cross, Norwegian People's Aid and Scouts), the harbour administration, the Skangas LNG plant and the ferry company. In total there were 13

ambulances, 5 fire engines, 2 helicopters, more than 120 first responders, 50 responders from the civil service and NGO's on-scene during the exercise. Ca. 130 observers from all over Norway, Scandinavia and EU-countries followed the exercise. The evaluation from the Risavika exercise pointed out well known challenges, which an effective BRIDGE system of systems had the potential to significantly improve:

- *Coordination of plans.* Each emergency service had their own plan for the responses. Experiences during the exercise revealed difficulties to use these plans and coordinate them into a master plan to be used at Risavika. A common organisational framework was needed.
- *ICT-systems failures.* The communication systems, as the cell phones system failed occasionally. The incident commander had problems to communicate with the tactical level due to system failures. The ICT support system did not have sufficient capability and capacity to support the processes of individual or inter-agency or at cross-agency interaction levels. A well-functioning ICT system was stated as a prerequisite for success.
- *Leadership on-scene at complex operations.* The incident commander and his subordinates, representing the emergency services, the civil defense and NGOs experienced huge problems to maintain and update a common operational picture cross-sector and at different levels, and interoperability became complicated. The lesson learned was a need for better coordination and leadership at the incident command post and in the different sectors.
- *Overview of available resources.* The exercise demonstrated a large potential of deploying available resources from different NGOs, not attending services and private companies, to become used in disaster response.

5.5 Aspects of the Middleware development

The BRIDGE Middleware is the driver of all the concept cases developed in BRIDGE. The Middleware supports the flexible assembly of emergency response systems into a system of systems for agile response. The BRIDGE Middleware offers a consolidated set of software services organised in three layers that facilitate the orchestration of systems, the communication between the systems and the management of data produced by such systems during a crisis scenario.

End users' roles from the developers of the Middleware point of view:

During the final project period, a series of (on-line) workshops were held discussing the non-functional properties (or architectural qualities) of the BRIDGE platform, in relation to user requirements and the concept cases. Although these did not have direct end-user participation, the outcome raised issues for further end-user clarifications and contacts, and also revealed the less developed parts of the systems architecture. The nature of end-user involvement in the architecture design and integration process could be seen as more or less indirect. Perhaps the most important facet of this involvement is the development of a common language, and the mapping of emergency management concepts and terminology to some of the ICT design constructs, technologies and standards. The EUAB also included technical expertise, which provided more direct involvement, e.g., with views on the application and role of some of the technical components in the BRIDGE architecture, such as their deployment and usage in the integrated platform and the middleware and the set of software services it should expose.

The live demonstrations held during the emergency exercises and project reviews, provided hands-on tests of end-user tools, as well as the possibility to deploy the infrastructure close to realistic incident environments. From an architectural point of view this gave valuable feedback on the various constraints, and possibilities, for the deployment of the BRIDGE platform and the associated tools. From an integration point of view this gave valuable feedback on scalability, robustness as well for the integrated platform and the different individual integrations themselves. In general, during the project lifetime, the discussions held with exercise participants and the members of the EUAB, during the various demonstrations gave feedback, which was fed into the architectural design process.

Some inputs from the end user assessments:

The BRIDGE Middleware is not one single software but a lot of interfaces between the BRIDGE software's. The concept cases drive the development of the Middleware. This might challenge the BRIDGE project presenting the Middleware as a specific concept case and product from the project. For an end-user interested in the BRIDGE products, it is hard to know what is needed if he/she only wants some of the BRIDGE software. Because the interfaces are not handling security, the end user faces problems in asking for the data: Has he/she the right to see the data? This makes it hard to understand if any organization will be able to implement the interface without also introducing some changes. In order to benefit from the BRIDGE concept cases and the Middleware, it might be necessary that whole communities (emergency organisations) provide packages (set of BRIDGE products).

We have not seen it, but there must be some kind of interface descriptions that is going to be presented. For users of other software beside the ones developed in BRIDGE the end-users need to adapt their software to the BRIDGE interface descriptions to be able to interact. A Middleware description is needed, and as end-users we wonder which Middleware software is required and which other products might be optional. As such it has not been possible to validate the Middleware in accordance with the end-user validation model, cf. section 4.3 and Appendix B

6 Concept cases and assets

During the BRIDGE project there have been eight concept cases that have been presented at the final demonstration. According to the results and findings elaborated in the domain analysis, co-design workshops and the EUAB meetings, the initial eight concept cases have been better aligned and adjusted. The result was a consolidation of these domain-relevant applications and a clearer picture of the BRIDGE project. Basically, the concept cases have experienced a shift towards a higher level abstraction, leading to the following list of concept cases:

1. Advanced Situation Awareness (ASA)
2. Adaptive Logistics
3. Dynamic Tagging of the Environment (eTriage)
4. First Responders Integrated Training System (FRITS)
5. Information Intelligence
6. Master table
7. Robust and Resilient Communication (RRC)
8. Situation aWare Resource Management (SWARM)

The capabilities of concept cases have demonstrated the progress of the BRIDGE ever since the first demonstration in Flums in September 2012. This first demonstration focussed on interoperability between several people, organisations and technology, and also aimed at demonstrating the integration of the various pre-existing technologies contributed by the various partners to BRIDGE. This chapter discusses each concept case, what their overall achievement is meant to be and its descriptions. Furthermore, we present what the concept case owners describe has been the end user involvement in the development and finally we present some typical inputs from the end-users. The context is the Chemco-disaster and the dramatic loads and challenges put onto the crisis response systems and the concept cases as part of these systems.

6.1 Advanced Situation Awareness (ASA)

6.1.1 Overall achievement

ASA provides fast support for crisis managers to make a better shared situational awareness and more qualitative decisions during critical response phases

6.1.2 Description

Advanced Situation Awareness (ASA) assists first responders and commanders on scene in increasing situational awareness by supplying real-time visual and other information on the extent of the disaster and its consequences. ASA helps with reducing risk to life, property and environment. Main Functionality BRIDGE ASA consists of the following three components: Unmanned Aerial Vehicle (UAV), Expert System, and Modeling Module.

The UAV consists of

- Flying platform with electric engines
- Global Positioning System (GPS)
- Electronically stabilized gimble housing for video and infrared cameras
- On-board signal processing units
- Environmental sensors for gases, aerosols as well as radiation
- Ground control station fitted with monitors and flight deck

The UAV provides a live video from a bird's-eye-view perspective, a parallel infrared video, and real-time environmental sampling data, which help to assess the magnitude of destruction, fires and health hazards to first responders and affected population. It helps identify hot and cold zones, people, construction damage, count victims etc. The UAV can be controlled manually or put into a pre-programmed automatic flight mode. The UAV's lifting capacity and the spatial flexibility of its payload bay make it possible to add additional sensor or mobile tracking equipment (e.g. Help Beacon, triage-units) The ground station is fitted with the flight-deck software enabling the pilot to accurately track the technical parameters such as battery status, energy consumption, altitude, orientation of the craft (GPS coordinates & artificial horizon), flight speed, and actual location on a real-map.

The Expert System collect expert knowledge at one place and give the first responder a user-friendly and fast interface to data. The System automatically analyses the incoming environmental measurements data that is supplied by the UAV to the Ground Station. The data is compared against national and international standards, and combined with expert recommendations. The aim of the Expert System is to help the incident commander interpret the obtained environmental data and ease the decision-making in a complex emergency.

The Modelling Module is used to create computer models of the incident site and of plumes in case of an uncontrolled release. It can draw on the pre-programmed generic models of reality-based structures contained in the BRIDGE Critical Infrastructure Library. This module enables the user to assess the physical damage to buildings, estimate the number of victims, and predict the dispersion of hazardous plumes based on metrological data.

6.1.3 End-user collaborations and contributions (information provided by concept case owner)

- One pilot field test of the *Advanced Situation Awareness (ASA)* system during the simulated car accident exercise by the volunteer firefighters and police of St. Gilgen, Austria, on 16 August 2014 in preparation for the *Alpine ValEDation Days* in September 2014 (http://www.bridgeproject.eu/en/news/PLUS-Conducts-Field-Test-of-ASA-Concept-Case_151)
- Actual field test of ASA integrated with Help Beacons and Master carried out in cooperation with the local volunteer firefighter and police during the *Alpine ValEDation Days* in St. Gilgen, Austria, on 9 September 2014 (http://www.bridgeproject.eu/en/news/BRIDGE-Conducts-Alpine-ValEDation-Days-in-Salzburg--Austria_158)
- Introduction of the ASA system to Austrian stakeholders and end-users and collection of the feedback during the *Exploitation and Dissemination Event* organized by PLUS as part of the *Alpine ValEDation Days* in Salzburg, Austria, 12 September 2014
- ASA Focus Group Meeting with Austrian stakeholders and end-users to review the progress of the ASA concept case since September 2014 and suitability for practical operations in the field, Salzburg, Austria, 6 February 2015
- Several iterations of PLUS contributions to the content of the BRIDGE JIRA with regard to ASA concept case, focusing on the requirements of first responders (police, paramedics, firefighters)
- Meeting with Prof. Alan Leigh MOORE, research team leader on unmanned aerial vehicles at University of Alabama, Huntsville (USA), on specific needs of security forces in Ashville (North Carolina), September 2014

- Three preparatory meetings with volunteer firefighters from St. Gilgen, Austria, in July and August 2014 with regard to the field test of the ASA system as part of the *Alpine ValEDation Days* held in September 2014
- ASA Sub-Project meeting with Salzburg professional firefighters to review the personal protective equipment and sensor technology currently used by professional firefighters in Austria for the subsequent adaptation of the ASA system (i.e., Expert System and sensor platform), Salzburg, Austria, 27 February 2015
- Several informal meetings between PLUS technical experts and Salzburg professional firefighters to review the Expert System and the Modelling Module and adapt them to the needs of the potential end-users (e.g., improve the design, increase user-friendliness) in Salzburg in February and March 2015
- Two meetings with members of the security community (civilian and military experts) at the *International Security Competence Centre GmbH* (2500 Baden-Vienna, Kaiser-Franz Josef Ring 21, Austria) on their specific needs with regard to the CC *ASA* in March and April 2015
- Several UAV pilot skills training sessions (a total of 9 hours) with a representative of the Austrian volunteer firefighters in St. Gilgen between February and April 2015.
- One pilot field test of the *Advanced Situation Awareness (ASA)* system during the simulated car accident exercise by the volunteer firefighters and police of St. Gilgen, Austria, on 16 August 2014 in preparation for the *Alpine ValEDation Days* in September 2014 (http://www.bridgeproject.eu/en/news/PLUS-Conducts-Field-Test-of-ASA-Concept-Case_151)
- Actual field test of ASA integrated with Help Beacons and Master carried out in cooperation with the local volunteer firefighter and police during the *Alpine ValEDation Days* in St. Gilgen, Austria, on 9 September 2014 (http://www.bridgeproject.eu/en/news/BRIDGE-Conducts-Alpine-ValEDation-Days-in-Salzburg--Austria_158)
- Introduction of the ASA system to Austrian stakeholders and end-users and collection of the feedback during the *Exploitation and Dissemination Event* organized by PLUS as part of the *Alpine ValEDation Days* in Salzburg, Austria, 12 September 2014
- ASA Focus Group Meeting with Austrian stakeholders and end-users to review the progress of the ASA concept case since September 2014 and suitability for practical operations in the field, Salzburg, Austria, 6 February 2015
- EUAB informal coordination meeting in Salzburg the 9th of April 2015. To evaluate and advice on the new UAV and improved Expert system.

6.1.4 End-user related concerns and discussions throughout the project

In the Chemco disaster the ASA will be deployed together with the first vehicles from the fire department. The uncertainties are in the initial phases large and many, challenging the en - route and entrance of the first responders. What is at stake? How and where to start the initial response? What are the threats? In this case the ASA system could be very powerful providing accurate information to the disaster management system (including the Master table), and providing expert knowledge on plumes and dispersion of dangerous substances as well as retrieving relevant mitigating measures and procedures. The usefulness of the ASA/Hexacopter's ability to provide situation awareness and responders' understandings has been clear, and it has been possible to learn and improve from the system. Some uncertain issues discussed were:

- Mobilisation time. How long time will it take in the Chemco disaster event to provide the incident command the data that was given during the Alpine validation?
- The reliability of data and information provided from the sensors through the EXPERT system needs to be validated and documented.
- Who will be available to perform the setup in the early stages of an emergency?
- The lack of work force in crisis response operation is often precarious until a certain overview is obtained.
- There has to be significant changes to crisis organisations in order to ensure operation of the Hexacopter. What kind of skills and certifications would be necessary?
- The legal aspects in the different European countries must be explored to adopt the ASA.
- The resolution on the screen is important to ensure, especially in the first minutes.

The concept case owner has discussed abovementioned issues and reflected upon them in the concept case development.

6.2 Adaptive Logistics

6.2.1 Overall achievement

Adaptive Logistics coordinate efforts of both human participants and artificial components.

6.2.2 Description

Adaptive Logistics characterize large-scale emergency management operations as Complex Dynamic Multi-Agency Distributed Systems. During the development process the researchers have explored how they can coordinate the efforts deployed by all the systems' human participants and artificial components, in such a way that the BRIDGE system-of-systems as a whole displays coherent, goal-directed behaviour, realizing its goals effective and efficiently.

To organize a dynamic multi-agency collaboration the developers use workflows (or more specific: a 'WorkFlow Generation and Management (WFGM) sub-system'). To organize this collaboration the WFGM sub-system requires system awareness and specific capabilities to plan, instantiate, monitor and adjust activities. Advanced Logistics establishes a collaboration between various BRIDGE system components, including DEIN, Situation aWAre Resource Management (SWARM), the Risk Analyser Modeller and Advanced Situation Awareness - Prediction Modelling. The purpose of system awareness information is to make explicit what the capabilities of the emergency responders and their technical systems are: what roles, causes and effects exist in the operation domain and what does the overall emergency management operation currently tries to achieve.

6.2.3 End-user related concerns and discussions throughout the project

In the assessment phase of the Chemco disaster there will be situations characterized by chaos, stress, ill-defined goals, information overload, ambiguous information, uncertain but severe damages etc, which put a lot of pressure onto the incident command at various levels. So far there has been little discussion about the concept case amongst end-users in order to align and adjust the Adaptive Logistics to concrete tasks in a crisis response.

6.3 Dynamic tagging of the environment (eTriage)

6.3.1 Overall achievement

eTriage offers a viable approach to supporting triage without interfering with triagers' work. eTriage assists in marking and monitoring victims and in creating real-time situation awareness. It aims to ease the triager's task and bridge the process from triage to hospital admission. The eTriage system is made up of several components that work together, but independently, to mark and monitor victims.

6.3.2 Description

Bridge Dynamic Tagging System assists first responders in marking and monitoring significant locations of the disaster site and in creating real-time situation awareness. It aims to ease the annotation of the field with digital information targeting at an improved spatial reference system and shared mental model for fire fighters. Such an annotated disaster site enriches the process of spatial sense making performed by first responders in the field.

The tagging process is as follows:

1. In their exploration process of the incident site, first responders mark specific points in space either
   a. physically through the deployment of a sensor tag or
   b. virtually through some type of digital information such as a specific symbol, a voice recording, a text, etc.
2. The Master receives the sensor values or the digital information associated with a GPS position and visualizes them on the map.
3. Other first responder teams in the field use a mobile device with a map view or an augmented reality view to discover the information deposited by the former first responder team in the field.

A colored, reflective plastic bracelet, just like the ones being used currently for triage in a number of countries, is snapped on a patient’s arm. This plastic bracelet is augmented with microelectronic components and various sensors that do not need contact with the victim's body (e.g., air temperature, infrared, etc.). The eTriage bracelet is easy to put on, easy to operate, allows wire-less continuous transmission of data to the EMCC, medical commander on scene and to the receiving hospital.

Triage and seamless transmission of underlying information are crucial processes in facilitating efficient patient-flow both in civilian every-day practice and in mass-casualty events. The eTriage bracelet is in that respect the sampling device while the “Master application” provides several possible solutions for a user interface enabling dynamic and accumulated oversight to any concept case using existing and/or mesh networks.

6.3.3 End-user related concerns and discussions throughout the project

The Chemco disaster could cause thousands of injuries to affected people, which in the early stages of the situation complicates the emergency medical work. What is needed of resources that could handle the medical situations, and how should patients become prioritized? Who are the patients and what are their conditions? The questions are numerous which is also reflected by Riddez and Joussineau (2005).

The overall eTriage concept and requirements were collected and described at a workshop in Oslo, where 10 persons from fire, police, health and civil defence participated. Requirements

and concepts were also collected through interviews with at least 35 first response leaders in Norway. The eTriage and its concept were validated in a workshop in Lancaster and by the usage at demonstration I, II and III.

eTriage has been tested and validated in a long-term evaluation (LTE), see section 4.3.3. The concept case was presented and discussed at the National Search and Rescue conference in 2013 and 2014 – 150 attended (Norway), National Ambulance Forum 2014 – 300 attended (Norway) and Nordic Acute medicine conference 2015 – 50 attended.

Preliminary findings from the long-time evaluation of eTriage and Master (see section 6.6), by observations and interviews, indicates that the participants (the end-users) found value in the technologies, the system was perceived to support information sharing. The eTriage was perceived as uncomplicated and easy to operate. Information displayed in the Master gave a situational picture to people not located at the incident site (off-scene).

The LTE unveiled the importance to explain the purpose of the new technology to the practitioners – "what's in it for the patient, the ambulance service and me". The training session prior to the test period must be well planned due to include personnel in duty rotation. A pilot study and simplified test was valuable to expose user problems and bugs, which were mostly corrected in time before the formal test period. It also seems that to involve end-users creates motivation and provides valuable input for further development of the technology, but it is important to have an open mind to both positive and negative feedback from end-users during the test period.

The mass causality exercise involved mostly first responders not familiar to the eTriage and Master, which were interesting and produced new and valuable input for further development:

- The next version should at least have the option to measure pulse, respiration rate, body temperature, blood pressure, oxygen levels in the blood and GPS
- The attachment of the bracelet need to be improved
- A small display on the bracelet is desired to give relevant information about the patient (ID etc.)

6.4 First Responder Integrated Training System (FRITS)

6.4.1 Overall achievement

FRITS improves the emergency response actor's readiness and operational awareness

6.4.2 Description

In order to improve the emergency response actor's readiness and operational awareness, proper training and regular exercises are major activities for all crisis management actors. Expert interviews, technical surveys, and domain analyses underpinned the understanding of current practices in high-tech training. It outlined a need for an optimized cost- and time effective learning and training process on all levels, customized to each actor's specific roles and responsibilities. It also outlined a need for supporting tools given the baseline for good learning and evaluation processes.

The high tech training concept, FRITS combines BRIDGE developed methods and tools together with COTS (Commercial off the shelf)-technology to ensure flexibility and to provide scalability for different end-user training needs. Also, by focusing more on using various virtual and constructive tools in addition to real life exercises, a quantified cost effective end-result is

possible to achieve over a relatively short timeframe, ranging from base theory to large-scale multi agency exercises. The idea behind FRITS is that tailoring any of these tools creates a scalability and flexibility in order to achieve quality assured training and exercise objectives.

6.4.3 End-user collaborations and contributions (information provided by concept case owner)

FRITS has been accomplished through active participation in a number of end user organised training processes where the CTAS Training methodology has been adapted as much as possible and where relevant supporting tools have been tested.

The following end-user involvement activities set up by the BRIDGE-project have been important for FRITS:

- Demo 1 in FLUMS (2012). This live demonstration was based on how firefighters could handle a real explosion and fire scenario in a busy road tunnel, adopting the technologies proposed in the BRIDGE Concept Cases.
- Demo 2 and 3 in Stavanger (The Risavika exercise). The main activity for long term evaluation and validation of FRITS, has been carried out by the involvement in the Risavika setting up and execution of the training process. From a BRIDGE perspective, this training process was the backbone for Demonstration 2 and 3, which was accomplished with a full scale real life exercise in the Risavika Harbour. The main objective for the exercise was to test the regional emergency organisations ability to handle a complex terrorist attack against an important and critical infrastructure for the region.
- The Hell tunnel (2013) exercise was a regional inter-agency exercise with actors from the National Rail Road Authority, The Norwegian Road Authority, Emergency organisations and Municipalities. The objective was to assure optimal handling of an accident in tunnels. CTAS supported the exercise in analysing and defining Main Training Objectives, preparing Evaluators managing their role during the exercise, and leading the evaluation process with an evaluation report as the end result. The CTAS training methodology was the back bone for the overall training process.
- Fu Shan Hai (2013). One of the largest oil spill accidents in the Swedish history occurred in 2003. The oil from the ship Fu Shan Hai's sinking hit both Denmark and Sweden. The accident resulted by others in a cross border project developing a better structure for cross border leadership, collaboration and communication. The results of this process was verified through a Cross border, inter- agency table top exercise in May 2013. BRIDGE representatives participated, supporting the exercise management team in their planning, execution and partly in the evaluation of the exercise. The performance of the evaluation tool was validated for use in major table top purposes.
- The Inter agency live exercise Dragvoll (2014) should train relevant regional actors in their crisis management of a terror attack. Relevant actors were the emergency organisations, the Trondheim Municipality, NGO´s and infrastructure owners/student organisations. CTAS supported the exercise in analysing and defining Main Training Objectives, preparing Evaluators managing their role during the exercise using TEMIS, act as an Evaluator at the Emergency Operational Centre and leading the evaluation process with an evaluation report as the end result. The CTAS training methodology was the back bone for the overall training process.
- The purpose of the exercise Brage (2014) was to demonstrate that the emergency response organisation for an oil operator can perform its tasks in accordance with the

relevant emergency response plans and specific requirements for the activities. A table top exercise was performed for this oil operator's 1st, 2nd and 3rd level emergency preparedness organisation. The exercise was based on the MeTracker Concept and the use of TEMIS.

- Sola Airport (2014). A regional inter agency training process based on a mass casualty aircraft accident. The training process consisted of an inter-agency table top and a live exercise.
- CTAS supported the table top exercise as an evaluator and by using the Virtual training simulator for scenario build up. The Virtual training simulator was demonstrated for a dedicated group of end users mainly for validation purposes.
- HarborEx15. A full scale live exercise for a multi-dimensional incident in the Sjursøya area in Oslo. The main exercise was held in May 2015. CTAS developed a virtual training environment for HarborEx15 and a virtual training activity was performed for 18 incident commanders in March 2015. This, as a part of the incident commander's preparation for the live exercise

In addition a number of workshops managed by WP 2, Domain Analysis, and the Nordic ValEDation day have been important for the development of FRITS. A number of presentations and demonstrations for potential end user organisations have given important feedback for developing FRITS in accordance with the end-users needs.

6.4.4 End-user related concerns and discussions throughout the project

The Toulose disaster revealed lack of sufficient training and responding to a chemical accident. This will also be a very relevant issue considering the Chemco disaster, both in order to cope with mass casualties and injuries, but also in order to maintain operational pictures. FRITS have been discussed with end users from the start of the project. In Flums in September 2012 the conclusion was that it should be tested in various domains and end-users activities in order to reveal its potential.

Later on the end-users were involved in the validation processes. The following issues were raised:

Strengths

- Reduce resources during training and exercise
- Help defining structures in training
- Observing against predefined objectives
- More focused training and feed back
- Visualization of observations
- Improved training methods over the time
- Porting training results into improved operational practices

Risks/concerns/ideas for improvement

- Will the achievements on-scene, the responses, be better than before the exercise?
- Close the loop of transfer of experience. The lesson - learned into changed practice is crucial to succeed.

- Will the system have the right information => type, objective, quality and reliability?
- Virtual tool lacking for strategic and tactical/operational level (gold and silver level).
- The system need experts/well trained persons to use.

In a study the end-users involved a master student who did her master project with the aim to examine why training solutions assisted by technical tools increased the learning potential from training (Ove, 2013). She tested FRITS in real life training sessions.

6.5 Information Intelligence

6.5.1 Overall achievement

Information Intelligence performs and examines automatic analysis approaches of crisis-related data (e.g., social media data and data collected from within the field).

6.5.2 Description

The main idea of Information Intelligence is the creation and examination of approaches to analyze crisis-related data. People document any situation they are confronted with in social media, also during a crisis. The prototype developed within the Information Intelligence allows an automatic analysis/aggregation of social media data in addition to live data from within the field. The result of the aggregation is a sort of situational report. This report could be used as an additional source of information for situational awareness. The concept case allows new information/communication channels into crisis management.

6.5.3 End-user collaborations and contributions (information provided by concept case owner)

The integration of the end-users opinion into the development and research process is based on the results from the domain analysis and the formal demonstrations in Flums and Stavanger. The work was presented and the EUAB-members discussed the functionalities and future research. During the validation meeting in Delft the current work was also presented and followed by a discussion with the end-users.

In addition, a survey for initial steps in design, implementation, and research has been conducted. With the help of the survey, an overview of social media usage in the work of end-users was created. Summarized, the survey focuses on:

- First responders' attitude to social (multi-) media in emergency management
- Assessment of a first mockup of a social media aggregation tool (e.g., initial design suggestions, functional requirements, new functionalities, etc.)

Insights obtained from the discussions and first responders feedback have been documented by contributions to the BRIDGE JIRA database regarding end-user needs and requirements to Information Intelligence.

6.5.4 *End-user related concerns and discussions throughout the project*

In the earliest phases of the Chemco disaster scenario, there is lack of verified information (what, where, how, threats, etc.). Obstacles, such as traffic jams, related or unrelated events could happen, to which people may communicate important information are examples of important emergent features in the event. These features might be helpful for situation awareness and first responders' disaster response strategies and operations.

The Information Intelligence was demonstrated in Stavanger, but as a practical crisis management tool there has not been any structured set-ups of tests and systematic discussions with end users' practical use. However, the potential is large and the use of learning tools seem promising, and should be further explored.

6.6 MASTER

6.6.1 *Overall achievement*

Synthesizing, visualizing, filtering and sharing information for responders on-scene and off-scene

6.6.2 *Description*

Master is a command and control information system for use in emergency management. It assists commanders and other central actors in keeping a common operational picture of the situation, and in allocating their resources efficiently during the response. Master provides a map-based common operational picture, mechanisms for resource allocation, message communication, and access to predefined plans. The system is intended to be distributed across all command chain levels in the organizations that take part in the response effort (i.e. across commanders and decision makers on the strategic, tactical and operational levels). To support users on different levels the tool is available in several different versions, tailored to run on different devices, including desktop PCs, collaborative multi-touch tables, tablets and phones. The Master provides functionality to present and act on three types of real-time information, which are accessible through the BRIDGE system:

- *Information about the incident added by other master users*, e.g.,
  - incident location
  - response elements
  - patients and victims retrieved from the eTriage and HelpBeacon systems
- *Information about the response*, e.g.,
  - response personnel and vehicles tracked by the SWARM system
  - relevant social media elements collected by the Information Intelligence system
  - unmanned vehicle video streams retrieved from the ASA system
  - model overlays (e.g. plume models) retrieved from the ASA system
  - expert advice retrieved from the ASA system
  - hospitals and available bed capacity information where available
- *Information from external services*, e.g.,
  - weather

Users of Master can view, filter and add information in the common operational picture. Newly added information is automatically synchronized with all other running instances, allowing all users to keep an up-to-date view of the situation. The resource allocation mechanisms in Master allow users to allocate personnel and vehicles to specific tasks and locations using drag and

drop in the map-based view. The allocated resources are notified via the SWARM system running on their mobile phones. The system also support message communication with other users, access to predefined object plans (e.g. documents, blueprints, certain types of 3D models where available), weather forecasts, and freehand drawing on the map for local planning of the response effort.

6.6.3 End-user collaborations and contributions (information provided by concept case owner)

The MASTER concept was developed with strong participation from end-users. The following list some of the activities:

- The overall concept and requirements were collected at a workshop in Oslo where 10 persons from fire, police, health and civil defense participated, 2013
- Requirements and concepts were collected through interviews with at least 35 response leaders in Norway
- The MASTER was validated in a workshop in Lancaster, 2014
- The MASTER concept was user tested with three response leaders
- The MASTER concept was validated by users at demonstration 1, 2 and 3
- A survey to 35 response personnel during the 3rd Demonstration at Risavika validated their situation awareness using different tools

The MASTER was presented at different end-user meetings:

- Search and Rescue conference in 2013 and 2014 – 150 attended
- Ambulance Forum 2014 – 300 attended
- Nordic Acute medicine 2015 – 50 attended
- Annual Conference for Norwegian Industrial Safety Organization 2014 – 150 attended

6.6.4 End-user related concerns and discussions throughout the project

Recurrent problems in disaster management are related to information flows between the tactical, operational, strategic and political levels, either across actors at the same level or through the management system. This was certainly the case in the Toulouse disaster, as it would have been in the Chemco disaster. The Master has the potential to solve these information flows issues. The concept case has caught lot of attention amongst the end-users.

From the first demonstration in Flums end users claimed that the concept case had large potential, but users must be trained in order to fully understand its possibilities. The demonstration in Risavika showed similar findings. The end users also emphasized that the Master table would suffer if there were negative feedback or experiences with the system.

Later on some other issues has been raised: The Master concept seems to be well interacted with the other concept cases. However, there are some uncertainties, such as the System is not tested in environments that could be expected in real situations, at present the Master table does not concur with standardized procedures, it may increase workload on first responders already heavily exposed, and there is a risk that important information could be lost in the System.

Using MASTER table in the accident site as today with a big screen (table) is not a good idea. It is too big and complicated. In accidents that extend over a longer period it is relevant. The MASTER table should be used on a portable PC, like a tablet.

Strengths

- Reduction of work load
- Establishing common operational picture and understanding of the actual situation and prevent diverging interpretations
- Cross levels of command & agencies (and nations…)
- Filtering information's role-dependent
- Situation awareness/assessment can be better by use of Master
- Optimize use of resources
- Logistic oversight
- Control with available assets and their movement

Risks/ concerns/ ideas for improvement

- Possibility of information overflow
- Micro management possibilities on- scene
- Technology dependent => electronic availability only
- Validation of information
- Legal conflicts, ex privacy
- Reliability of data and information
- Secure data transfer (BRIDGE system)
- Include risk assessment systems (BRIDGE system)

6.7 Robust and Resilient Communication (RRC)

6.7.1 Overall achievement

- **Mesh** improve networking on the incident site by creating an ad-hoc networking infrastructure
- **HelpBeacons** system provides a way for people to call for help using their Android smart phones

6.7.2 Description

The main goal with RRC is to create an ad-hoc networking infrastructure that provides networking services on an incident site. The BRIDGE Mesh network allows other systems to exchange data locally or send them to other networks such as the Internet. The Help Beacons application allows people to use their smartphones to advertise their need for help. Robust and Resilient Communication comprises several components:

1. Wireless Mesh routers that form an ad-hoc network (called the BRIDGE Mesh) to provide a networking infrastructure for other systems on the scene (e.g., eTriage)
2. The Help Beacons victim application that allows people to call for help using an Android smart phone
3. The Help Beacons responder application that is used by first responders to collect SOS messages

The wireless mesh routers form an ad-hoc networking infrastructure that can be used by other concept cases to exchange data. All routers provide wireless access points to allow other devices (such as smartphones, notebooks or the eTriage bracelets) to join the network. Some routers

provide gateways to other networks such as the Internet and bridge different wireless technologies. The Help Beacons System provides a way for people to call for help using their Android smartphones. The Help Beacons system uses the Wi-Fi wireless technology to advertise short help messages. First responders that use a Help Beacons responder application can collect beacons in their vicinity and locate victims.

6.7.3 End-user collaborations and contributions (information provided by concept case owner)

Many of the implemented components of RRC were developed using an iterative, user-centered design approach. In the frame of the BRIDGE demonstration meetings and plenary meetings, feedback was gathered from potential end users and further domain experts (e.g., consultants, experts for risk management). Analyzing this feedback helped to inform the design of the systems that have been developed. The following events contained end-user participation organized by BRIDGE:

- Oslo User Workshop, Oct 2011
- Delft User Workshop, Dec 2011
- Lancaster User Workshop, Apr 2012
- 1st demonstration in Flums, Sep 2012
- 2nd demonstration in Stavanger, May 2012
- 3rd demonstration preparation meeting in Salzburg, Jun 2013
- 3rd demonstration in Risavika, Sep 2013

The design of the Help Beacons and Local Cloud systems are based on a series of interviews and workshops. Different type of end users, such as first responders, experts and consultants for crisis management and members from the public were interviewed in several separate meetings. In particular, first concepts and ideas for these two systems were generated and discussed at the Oslo and Delft user workshops. At the Lancaster workshop, the first prototype of the Local Cloud system was evaluated in a shooting scenario. Two domain experts, i.e., a mountain rescuer and a police officer with experience of social media usage in emergency response situations, and three students, playing the roles of victims, participated in the user study. The findings of this study were published in a research paper presented at ISCRAM '14.

The Bridge Mesh infrastructure and Help Beacons systems were demonstrated in two exercises in the course of the first and third BRIDGE demonstrations. Discussions with the first responders that used these systems and members of the EUAB led to a series of suggestions for improvements. Additionally, interviews were conducted with the people that acted as victims and used the Help Beacons application to send distress signals during the Risavika exercise. In the second demonstration, we presented the BRIDGE Mesh and the Help Beacons systems to several first-responders (i.e., fire fighters and police offices) and got valuable feedback about the potentials but also limitations of these systems. We discussed potential deployment strategies for smart phone applications in the ISCRAM 2014 “Practitioner Cases and Practitioner-Centered Research” track. In the course of various events (conferences), we could discuss our systems and concepts with fellow researchers and (potential) end-users that attended the venues. All iterations of the implemented network visualization technologies were accompanied by internal user tests at the particular partner locations. These user tests focused on aspects that do not require expert users, such as general usability issues. Furthermore, focus group discussions were conducted among the BRIDGE members.

6.7.4 End-user related concerns and discussions throughout the project

In major crises there are many challenges in order to efficiently establish the command and communication structure. What is the operational picture? In the Toulouse case the network went down. Conditions seem to be much better in the current systems, but there are likely to be major problems also now. RRC has caught lot of interest amongst end users. From the first demonstrations the end users acknowledged the potential, but were concerned about the stability and availability of MESH. Help Beacon was tested successfully in the Risavika case. Other concerns have been; increasing workload on first responders, and lack of testing in real emergencies.

6.8 Situation aWare Resource Management (SWARM)

6.8.1 Overall achievement

SWARM improves resource management for both incident commanders and first responders.

6.8.2 Description

BRIDGE SWARM (Situation aWAre Resource Management) is a mobile system for tracking the location and status of resources in real time, and for notifying resources of the assignments they have been allocated to perform. The system is intended to be distributed across all personnel and vehicles that take part in the response effort. SWARM combines resource management (resource identification, involvement, task assignment, status reporting) with technology for achieving situation awareness, in order to:

1. Provide a continuous overview to first responders of the resources in their immediate surroundings (including human resources)
2. Communicate the state and context of human resources (e.g. their condition and health, environmental conditions like temperature, background noise, etc.)
3. Provide better context-aware predictions of activities of resources, e.g. estimated times of arrival for moving resources

For achieving these tasks, the SWARM relies on the technical capabilities of smartphones (such as 3G, GPS, sensors) which are the tracking and communication devices for the resources and the Master System, which gathers and displays the locations and activities of the resources in a unified visual field.

The users of the system can be divided into the following user groups:

- *Resources:* Individuals or entities that can take active part in the emergency response when needed. This group of users will use the SWARM system to track their current location and status, and to receive task assignments from commanding personnel
- *Commanders:* Individuals or entities that has authority to command one or more participating resources. This group of users will use the MASTER system to monitor and command their resources
- *Commanding resources*: Individuals or entities that are acting both as a resource and as a commander (as described in the above points). This group of users will be using both the MASTER system and the SWARM system

- *Observers*: Individuals or entities that does not have direct authority to command specific resources, but still require information about the emergency response. This group of users will use the MASTER system to monitor relevant information

The design of the SWARM app has partially been tested in the context of one of the exploitation activities of Almende's daughter company ASK Communication Systems. Based on the activities in BRIDGE, ASK has created the StandBy app for availability management of human volunteer resources.

6.8.3 End-user related concerns and discussions throughout the project

Throughout BRIDGE demonstration III in Stavanger, the SWARM app has been tested and validated by policemen and ambulance drivers during the large-scale emergency exercise. Preparation for this exercise was done during demonstration II, in which various conversations with end-users proved to yield valuable information about the SWARM app's functionality and, in particular, its look-and-feel.

In the Toulouse case the vast amount of resources was difficult to organise, because of the information systems being down. The victims needed prompt reactions from the first responders, even though it has been difficult to identify live lost due to delays. Furthermore, sufficient control over the huge number of resources available is a huge challenge.

SWARM has been frequently discussed between end users and the developers, of which some issues were; It's a need to have an overview in a glance of the resources at hand, where they are located, when and place of attendance when notified; The system must be simple to implement, use on-scene and to update; The SWARM could implement more functionality to improve usefulness of the system; The end users today carry a lot of equipment with them and if the SWARM functionality could be implemented in current used equipment, it will be a plus.

7 Concluding remarks

The end user involvement as part of the Participatory Design Methodology has been extensive and continuous spanning from informal contacts to structured evaluations of demonstrations. The technology developers have had a humble approach to the disaster response domain, being observant and sensitive to input from end users. The achievements presented through the eight concept cases and the underlying Middleware are developed through a process with continuous feed-back and adaptation to end users' needs and challenges. The researchers from WP2 Domain Analysis have been important as drivers of the research methodology, constantly bringing in end user perspectives. Especially the TCC-meeting in Klagenfurt, 2013, reconsidered all concept cases, recommended revisions and restructured the concept cases. The end users were then part of the development process of the new premises, which were regarded very positive. The process can be characterized as incremental with end users involved to provide feedback to single concept cases and the system of systems. We conclude that all concepts have potential to significantly improve the disaster response systems, both as individual concepts and part of a holistic system of systems.

However, the concept cases are still immature with the need for extensive end user validation, for example based on the developed validation tool (appendix B). There are also need for further studies of similarities and differences in the frame conditions for the disaster management systems across nations in Europe and how the collective international disaster response effort can adopt and integrate the BRIDGE systems, which are the organisational factors.

We consider the design of the BRIDGE project's active use of participatory trial research as promising and a basis for further development in future EU projects in the disaster risk reduction domain. The professional end users should be more involved in the beginning of the projects to bring in systematic founded expert judgements. The role played by the end users in the validation processes should be carefully considered in future projects. We think that this is an important area for the EUAB to take an active part, both in the design of validation experiments and the validation tools provided. Disaster management includes so many challenging tasks and conditions, which are very difficult to predict in advance, thus end users are needed to framing the constraints, discussing potential plausible worst case scenarios and address capabilities and performances of the first response systems.

Some concept cases have been included in end user organisations for long testing approaches. We see this step as an important issue for integration and validation of products that will also reveal organisational factors. The BRIDGE-project has envisioned the need for "implementation research" as part of the design science approaches.

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Appendix A Perspective on End-user involvement from the WP2 - Domain analysis

Description of domain analysis and the process

BRIDGE has pursued a research and design strategy that is grounded in user needs and practices, combining domain analysis and co-design (see D2.1 and D2.5). The project stands in the tradition of user-centred design that suggests a close collaboration between end-users, domain experts and designers as well as iterative and agile forms of technology development. In order to cooperate with end users as closely as possible during the research and development in the project, BRIDGE has utilized a number of qualitative empiric research methods including interviews with emergency response professionals, (non-)participant observations of emergency response work practices (mainly in the context of close-to-reality exercises), and workshops in which the users where invited to participate in the development and evaluation of design sketches as well as prototypes in later stages of the project. In this context, video ethnography played a particularly important role that allowed for a detailed and highly granular domain analysis of user interactions.

This exploratory process was ongoing, but can be roughly divided up in four (kinds of) iteration, from an opening exploratory movement through a more structured movement on to gradual closure (see Figure A.1):

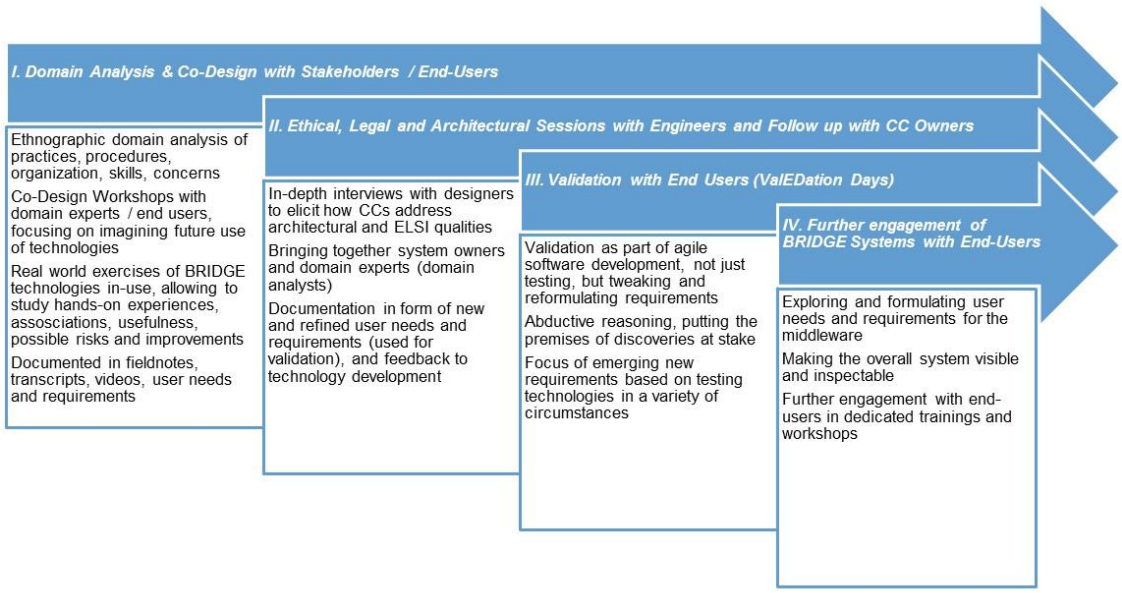

Figure A.1: Overview on the Co-Design Process

The first iteration was mostly engaged with various kinds of stakeholders, but especially emergency response personnel and organized co-design workshops where the end-users was encourage to engage in sandboxing exercises, playing through scenarios using paper or more advanced prototypes of our technology. From this "stories" were described, which contained themes, narratives and descriptions of practices, necessities, qualities and matters of concern that the stakeholders discovered in these engagements. From these stories in vivo quotes or topics were taken and translated into user needs (and requirements) which were gathered in a JIRA database. This was a collaborative effort of in principle all BRIDGE team members, who could make entries, comment, label and enrich what was there. For the first years, JIRA database has been the main collaboration platform for describing user needs and requirements.

During the last period of the project, focus switched from this exploration into a more structured mode, sorting the requirements by concept cases and having intensified exchange with the concept case owners, where WP 10, Validation, put a lot of effort into co-formulation of requirements. At the same time WP 2, Domain analysis, worked on the validation of the technologies and for this formulated (distilled from domain analysis, end user engagement and literature reviews) architectural, ethical and legal qualities and requirements and had a series of 2h+ sessions with the concept case owners where we evaluated those aspects of the technology. Domain analysis as it is implemented in BRIDGE is based on interviews, ethnographic studies and observations, mobile methods and rapid response practices to clarify problems, opportunities and emergent future practices.

The topics of the Domain analysis have been investigating how collaborative design has been used. The analysis from end users point of view has pointed to the needs of the different first responder groups. Clearly medical personnel have different needs than police and firefighters, but they all have to collaborate in the efforts put forth by the actual situation. To make this happen end users have given their evaluations, reactions and comments to ensure that CCs where actually both designed and functioning as collaborative tools. This activity has led to new change on weight, size and form of hardware, and software moderations and additions include expert (end-user) experiences.

The process was designed to both give input for changes, to check the actual function levels of planned systems and to give feedback regarding usability.

On the point of interoperability, D2.2, Domain Analysis I: Interoperability and Integration, states: "A key lesson learnt from the discussions documented in this deliverable is that interoperability and integration do not emerge automatically out of a technical artefact or infrastructure which enables communication, interoperability emerges out of a practical-political context which supports interagency collaboration, a willingness to take part in such collaboration, and the ability to practice good collaboration and coordination – potentially in new ways, augmented by new technologies. *It is critical that technologies do not disrupt or impeded human practices of interoperability and integration, but support them*. As such, the success of technological innovation is highly contingent upon the work practices of all who work in the field and has given end-users tools that function". This quote highlights the fact that technology by itself is not the answer. To reach the goal of interoperability it is necessary to incorporate both existing practices and routines, and cultural and socio-political agendas. But the evaluation of many big incidents over the past decades, inclusive the terrorist attack in Oslo in 2011, have focused on projects which can increase the safety of citizens in such situations, and contribute to a more efficient total medical treatment in terms of reducing the mortality and reduce the damage.

A situation characterized as a disaster is a disparity between needs and available resources, both qualitatively and quantitatively. Medically this leads to increased mortality compared to a "normal civil situation". Today's way of handling an emergency is characterized by little availability of customized ICT-solutions and as a consequence lack of use in comparison with society in general. Use of the BRIDGE CC's aims to replace and or support manual processes in order to reduce workload, enhance situational awareness and increase treatment handling and capacity, improve the quality of data-gathering and processing, individual monitoring and treatment. The Domain analysis aims to support this processes.

Transformation to concept cases

The transformation process of the multiple raw data sets, generated from workshops, interviews etc. with EUAB and other end-users are complicated. The information's and needs were

analysed by the concept case owners and founded an important base for development. The transformation process is from the standing point of the end-users more or less impossible to track. Particularly for the CC's, as the Adaptive logistics, which is used by other CC's.

The main findings in the domain analysis are methodological and awareness creating. This should mean that the best way to consider the outcomes would be to check with developers and end-users how they used the different approaches outlined in the deliverables 2.1, Methodology, Infrastructure and Processes for Requirements Engineering and Domain Analysis, 2.2, Domain Analysis I: Interoperability and Integration and 2.3, Domain analysis II: User Interfaces and Interaction Design.

From an end-user standpoint, the elements of the domain analysis are essential to ensure success and actually working CCs. And as that, it can contribute greatly in the continuing development of BRIDGE related systems. To the end-users the most important is the final results, which is the practical use during an emergency response. Our impression is that the transformation process was conducted in a way that led to improvement and strengthened the responses on- and off-scenes. The collaboration of end-users and researchers has led to vital improvements towards end products that comply with end-users specifications.

Appendix B Technology driven innovations as means of collaboration between crisis managers. Validation from the End User Perspective

Technology driven innovations as means of collaboration between crisis managers

Validation from the End User Perspective

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September 2014

Introduction

Rescuers respond to emergency situations that are unique. Decision-making on-scene an accident is context bound, embedded in ever-changing environments. Thus, decisions in action sometimes involve huge uncertainty. In order to ensure self-protection and to optimise the outcomes of life saving and damage mitigation activities, the rescuers' competence must span from automatic skill-based behaviour to problem-solving, knowledge-based behaviour (Rasmussen, 1983). The crisis command system orchestrates the entire response effort, maintaining the hierarchical command structure on scene.

How can technology provide positive influences in the most critical phases of an emerging crisis? How can technology within complex emergency response systems enhance performance in situations, for example when the crisis is in its early stage, the consequences may be unclear, different authorities may be involved, many actors may be involved in the on-scene crisis combating and the media may be paying particular attention? Incident commanders in neither the police, the ambulance service nor the fire brigades have substantial experience from large/major incidents, thus novelty is an important feature. The questions are numerous and uncertainties large, especially since the BRIDGE project assume large-scale crises. Such crises infer that the pre-crises phases have emerged, in which the contextual condition will vary and the working conditions for the first responders accordingly. The end user advisors assigned to the BRIDGE-project play an important part as experienced and reflective professionals able to address the concepts and systems of systems to "real world" contexts.

In order to conceive an understanding of the performance of the results from the BRIDGE project, we need an overall conception of the emergency response system within certain frames. It is a criterion that the project should provide *significant* improvements to the emergency

response, thus we need to address the assumptions made. When can we say that the BRIDGE concepts and BRIDGE systems of systems provide significant improvements to the crisis response? This issue is to be resolved by the validation tool presented in this note.

Philosophical but practical assumptions to validation

Crisis managers, operational and technological scientists must discuss and agree upon a description of the response systems as they are generally understood. Such a mode must include specific characteristics, for example decision making, uncertainties, collaborative efforts, response phases, time frames, local conditions etc. The End User Advisory Board (EUAB) is designed to reflect on these aspects in an European context, but the members have limited knowledge of the national disaster response regulations across Europe. Furthermore there is a need for a recognized evaluation to justify potential contributions from the BRIDGE results (validation), which address the end user perspective. The validation process must be systematic and scientific. The strong prevailing presumptions related to the validation concept needs to be challenged in the BRIDGE-project from an end-user perspective. What is validation and how should validation be conceived by actors assessing crisis management performance before and after implementing BRIDGE-achievements?

According to the Oxford dictionary, to validate something is: "*to prove that something is true"* (Hornby, 2000). From the etymological dictionary we can see that the word "valid" came to the English language in the 1570s, meaning "having force in law, and legally binding". In the context of the first recorded use of the word in 1640s it was interpreted as meaning *"supported by facts or authority"* (Harper, 2001-2010).

The search for "truth" in knowledge and conditions to make knowledge possible, in this case crisis management, is based on the philosophical subject of epistemology (Barlas & Carpenter, 1990). For centuries the philosophers of science have been preoccupied with the question of how to confirm scientific theories. One method was to use the concept of inductive argument. Theory was tested by observations in nature through experiments, in our case experiments that include concept cases or systems of systems, and the theory was either confirmed or rejected. According to this view a model will either be validated or it will not. A model may be under scrutiny for its validity; however, once it has been deemed validated it becomes immune to further criticism.

Our stance in this project rest on Popper's criticism of induction concerning the extent to which it is possible to draw general conclusions regarding the "validity" of a theory from a single observation or a few only. We apply the concept of falsification, assuming that a theory can never be confirmed to be true but is only falsifiable. This is compatible with the complex world on crisis response; there is no truth about future successes of tools applied, only situation-based positive and/or negative experiences in the response operations. Thus, ***we do not falsify as such but raise objections about the excellence of the system under scrutiny***. This point is an important assumption of our tools and the assessor must carefully consider and adopt this issue. Neither concept cases nor models can be 100% validated (Babuska & Oden, 2004). *"A validated model is therefore one where tests have been performed which could have shown it to be invalid, but which failed to do so"* (Ivings, 2007, p. p. 10). Validation in a practical context often aims to show that a certain approach to problem solving is the currently best available procedure, coherent with current scientific based knowledge and practice based experiences.

The claim that a model or a method for predicting the outcomes of using a crisis response concept case or system of systems has been validated is a strong statement. A validated concept case in performance-based crisis management is a tool that the first response consultant can employ to predict the level of safety in that specific case, and is generally understood as a truthful representation. Acceptance of the systems of systems based on BRIDGE concept cases

therefore implies that the crisis response consultants have convinced the relevant actors that the results are accurate enough for the intended use of the BRIDGE systems. However, in our experience there are rarely objections from any actors against the use of such analyses (validation processes), and uncertainties are not part of the discussions. In order to be structured and scientific with respect to end user validation, we must clarify the validation concept and how validation should be addressed. The most important perspective in an evaluation process is the performance criteria set to conclude on the BRIDGE results usefulness. These must address our *expectations*, *assumptions*, *uncertainties* and *observations*. The purpose with this report is to provoke issues and conditions that might influence the end users' tolerances for adopting arrangements produced within the BRIDGE-project.

Validation of crisis response systems from the End User perspective – our model

The major "theory" to be validated is that the concept cases and/or the system of systems will *significantly improve* performance of the crisis response system. In order to simplify the subject under scrutiny we call it the *System*, meaning single or multiple concept cases, or the system of systems. In the BRIDGE-project these are the Middleware, the Advanced Situation Awareness, the Master System, the First Responder Integrated Training System, E-triage etc. The Systems should be properly defined when the process is due to start. Thus, it must be possible to express and measure the performance of the crisis response, with or without the System considered. This is a major mental simulation process (Klein, 1993) which require experienced and proficient end-users. Figure 1 depicts our model of validation from an end-user perspective. The validation process is separated in two processes.

The starting point for the end-user validation process is the experiments established for the Alpine, Nordic and Low-countries validation days. The functional requirements, the experimental set-ups and the procedures for the technical validation outlined in workpackages and information brochures, base the preparations for the end-user validation described as Validation – 1. The validation assessor prepare for the validation days by carrying out a *close reading*, which "is the kind of reading in which the reader, as a matter of habit, pays attention not only to the words and the plot but to all aspects of the literary apparatus of a text". This means that the validation assessor have obtained a clear understanding of the System, the context of the experiments and what functions and performances to be expected. During this process the validation assessor from the end user group is supposed to clarify important issues connecting his or her understanding of crisis contents and the relevant response systems, with the validation experiments and simulations (the specific ValEDation Days). The EUAB plays a major role in the Validation-1 process, since they have their own understanding of the crisis content and response systems associated with the experiments. Their assessment process would then consist of how the experiments fit with standardized procedures, typical organisations, tasks and efforts, which could be directly associated with the experiments itself, which is the core of validation – 1 (see tool below).

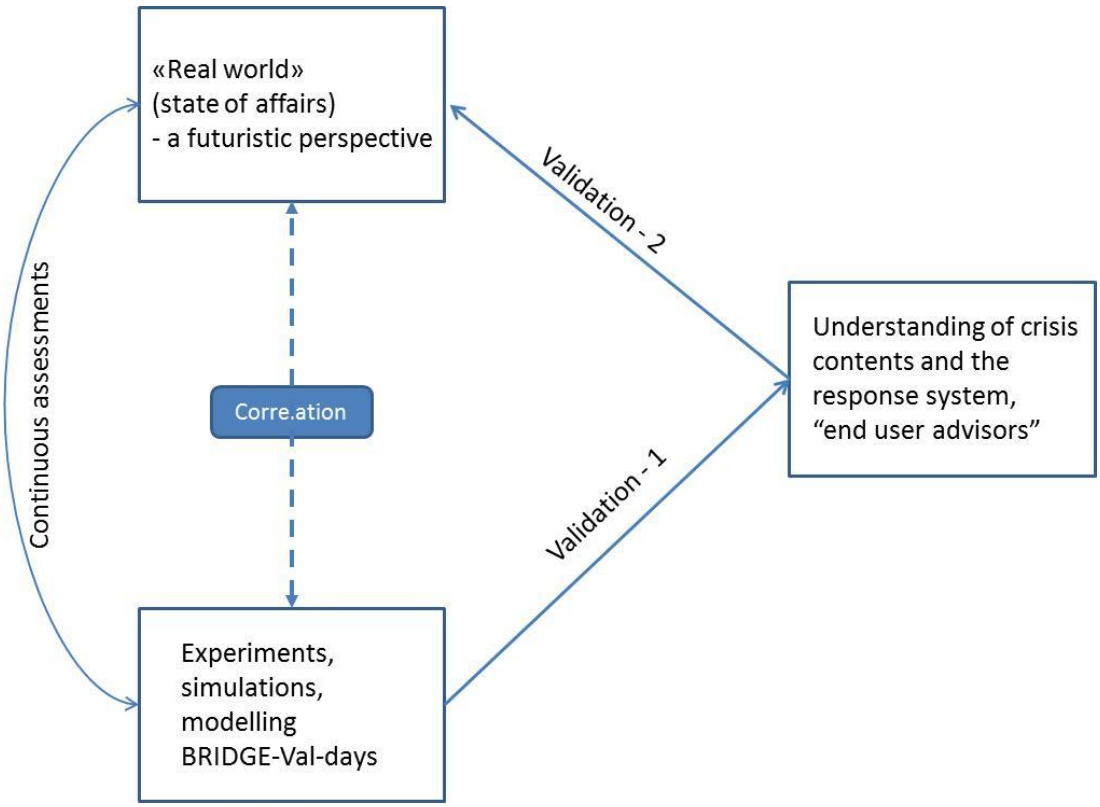

Figure 1, Validation model from an end-user perspective, based on Borg & Njå (2013)

Validation – 2 is even more difficult than validation – 1 and require high level expertise on emergency response systems and an ability to abstract plausible worst case scenarios or even "black swans" – unknown unknowns (Taleb, 2007). Using Dreyfus & Dreyfus' (1986) scheme for characterising personnel knowledge from novice to expert, we can say that validation – 1 require a proficient performer, while validation – 2 require the experts. An expert generally knows what needs to be done based on mature and practised understanding. An expert's skill has become so much a part of him that he needs to be more aware of it than he/she is of his/her own body. When things are proceeding normally, experts do not solve problems and do not make decisions, they do what normally works. While most expert performance is ongoing and nonreflective, when time permits and outcomes are crucial, an expert will deliberate before acting. This deliberation does not require calculative problem solving, but rather involves critically reflecting on one's intuition. Dreyfus & Dreyfus (1986) describe their skill acquisition model as follows:

> "The moral of the five-stage model is: there is more to intelligence than calculative rationality. Although irrational behaviour - that is, behaviour contrary to logic or reason - should generally be avoided, it does not follow that behaving rationally should be regarded as the ultimate goal. A vast area exists between irrational and rational that might be called arational. The word rational, deriving from the Latin word ratio, meaning to reckon or calculate, has come to be equivalent to calculative thought and so carries with it the connotation of "combining component parts to obtain a whole"; arational behaviour, then, refers to action without conscious analytic decomposition and recombination. Component performance is rational; proficiency is transitional; experts act arationally."

With such characterisation of the expert end-users the validation – 2 process will contain a screening of future demanding events relevant for the System, various factors influencing the

flexibility of the response system, how complexity in the situations would be resolved and how collaborations and coordination activities could or could not succeed. A major task for the expert is to make his/her assumptions and assessments explicit, cf the definition on expert above. Our model presupposes an expert meeting after the experiments to clarify and discuss observations in order to finalise the validation – 2 process.

The validation model is an ongoing process which to various extents has been part of the EUAB involvement in the project. Initially they participated in workshops to identify challenges of current practice and to describe future needs on-scene an emerging crisis. The EUAB has been involved in the demonstrations performed, the EUAB has had distinct meetings of which the meeting in Gent discussed large-scale crises, such as the terrorist attack Terrorist attack in Norway 22/7-2011, Flood in Central Europe (Poland, Hungary, Czech Republic and Slovakia) May-2010, and Earthquakes Northern Italy May/June-2012. The topics for the discussion were; Interoperability – framing the contents; Structure of disaster management (regulations, procedures, frameworks, equipment and systems, formal training/competence); and Working practices in disaster management (informal rules/approaches, vulnerabilities, climate, communications, social networks, informal authority persons etc.). Such assessments need to be ongoing in order to identify correlations between experiments, simulations etc. and the "Real world". The final demonstration in BRIDGE will be developed from the Toulouse disaster in 2001, which occurred in the Azote de France fertiliser factory. An explosion occurred in a warehouse where the off-specification granular aluminium nitrate was stored flat, separated by partitions. About 200–300 tons is said to be involved in the explosion, resulting in 31 people dead and 2,442 injured, 34 of them seriously. The blast wave shattered windows up to 3 kilometres away, and the resulting crater was 10 metres deep and 50 metres wide.

The seminar in Stavanger also included the train fire in Ghent, the Buncefield explosion and other events important for the reflection on the relevance of the BRIDGE-systems.

THE VALIDATION TOOL

During the demonstration in Flums (2012) all EUAB members were are asked to relate the evaluated System to the member's own working environment and the concrete experience that he or she had. Questions like: Will the concept case apply to "your" emergency response systems? Alone and/or part of the whole response system? Consider the relevant levels; operational, tactical and strategic; which of them were important to reflect upon in the assessment of the concept cases? Such issues are extremely important in the validation process. The validation assessor from the end user perspective is per definition loaded with knowledge and self-experiences related to own/associated crisis response systems. This is to be regarded as the reference for the end user validation. However, it is very important to bear in mind that the EUAB-members carry out their sole assessment as part of the validation without any responsibility for the System development. They are to be considered as independent experts.

The principle of this tool is a checklist of issues, which presented below are generic. Thus each end user deemed to validate at some of the Validation Days must select the relevant issues that would be important, and apply those issues prior, during and after the experiments as a guide to assemble and prepare the report. This is the close reading process in which the assessors have obtained a clear understanding of the System, the context of the experiments and what functions and performances to be expected. During this process the validation assessors from the end user group is supposed to clarify important issues connecting his or her understanding of crisis contents and the relevant response systems, with the validation experiments and simulations (the specific ValEDation Days). This should be discussed in a prior meeting before the actual experiments take place, depicted in Figure 2 as the "Selecting validation issues". The validation issues are formed as statements, which you can agree to, you can raise major uncertainties or you reject it. These categories are as follows:

Agree. I agree the System have this weakness and more work should be done to overcome this weakness. Then you must address whether this is a problem for the developer or it is a weakness regarding end-users and the emergency response systems.

Major uncertainties. I cannot see that the statement is covered by the experiments or the experiments raise major uncertainties regarding whether the statement will occur or not. This is an issue for further exploration from the scientists.

Reject. I reject this statement and I am convinced that the System will improve the specific crisis response performance and even have a positive impact on the overall crisis response system.

In order to carry out the assessment there is a need for specific performance measures that can aid the validation assessor. All assessments are to be scrutinized with the question: *It is significant difference between the System considered being in place and the reference response organisation as it is today?* We recommend the following performance measures:

Reliability/availability is a measure describing to what degree the System will be there and carry out its task in an expected manner. The reliability and availability of the Middleware would be a measure of the Middleware being in operation when needed (real event) and serving all applications in case of a crisis. A quantitative measure here could be down-time, probability of functioning, etc.

Capacity. The System's capacity is a measure of the intended functionality considered, for example the number of information sources to be integrated and explored in the Master table. The capacity of a medical team could be the number of patients given medical care, based on the E-triage system. The capacity values are observable, but uncertain quantities. Capacity could be expressed by strength, number, pressure, flow rate, area coverage etc. Uncertainty should be included to express the validation assessor's degree of belief regarding the capacity quantities. An alternative could also be more coarse assessments.

Execution time represents the time needed for specific crisis operations. Usually it is the time from the situation has occurred to the operation or function is successfully carried out, but limiting the tasks and operations might be necessary. For a fire scenario in a road tunnel an interesting time aspect is the duration from the initial fire ignition (alarm) until every road user is rescued or found and brought to safe area. Regarding Advanced Situation Awareness the execution time could be from the alert is given to the information about the scene and danger characteristics is on the Master table or in practical use for the Incident Commander.

Survivability/vulnerability relates to the System's ability to withstand the loads and conditions in the crisis. Electrical power might be an important issue for the System studied, which could be vulnerable in the specific event. Sensors might be damaged during explosions and fires, etc. Qualitative descriptions are often applied as measures on survivability.

The evaluation issues below are the first input to an approach to EUAB evaluations. These are meant to be reflected upon when each EUAB member analyze his/her observations after the demonstrations:

VALIDATION – 1

The validation must be made on the premises developed through the experimental set-up and compared with situations very similar to the assumptions made.

System clarity:

The functional requirements set by the technical validation (ref the approach developed by WP9) is not met by the System.

It is not possible to express the usefulness of the System.

The System is not tested in environments that could be expected in real situations.

The System's ability to provide situation awareness and responders' understandings is unclear

It will be impossible to learn and improve from the system

The important information from the crisis is blurred.

The System does not facilitate an early and effective triage and subsequently enable monitoring every patient from the disaster scene to the hospital

The System negatively influences the end users abilities to recognize dangers (risks)

Integration in organisations:

It is not possible to integrate the system to work in parallel with other societal systems.

The System require too much knowledge to run efficiently

The regulations and decision making systems hinders integration of the System in the society's crisis response system

Crisis response organisations are too sceptic to integrate the system (regulatory barriers, financial barriers, risk aversion etc)

The System does not enhance trust (interaction humans and systems)

Operational conditions:

The System is cumbersome to mobilize in the alarm phase.

The System is not easily daily operated, thus it will not function when needed.

In a size-up phase the System will hinder effective mobilization of resources.

The System does not concur with standardized procedures

The System compromise effective functioning of the triple alarm

The System hinders quick control of the situation, i.e. the crisis is likely to escalate after the first responder resources have arrived

Medical treatment on scene becomes more difficult with the System

The System easily leave relevant resources out, that is, several has been forgotten either in warning or from other type of communication influenced by the System

Lack of competent resources due to System shortcomings

The System increases workload on first responders already heavily exposed.

Important information could be lost in the System

Collaborative and coordinating efforts:

The System does not facilitate interoperability between organisations.

The System does not facilitate interoperability between on-scene, operations centre and strategic coordination centre

The System does not facilitate useful analyses for immediate decision making and action

The communication on scene is becoming more difficult in light of the System

The System does not improve conditions for necessary support from the hospital

The System implies bad collaboration between the emergency organizations functions with probable misunderstandings and conflicts

VALIDATION – 2

In this process the validation assessor must reflect on possible future large-scale crises to which the System is expected to function.

Complexity

Large-scale crises will be too complex for the System

There are so many unknown but important factors in possible large scale crises that the System will not manage.

There are issues more important than the technical solutions that become down-sized.

Politications and media exposure compromise the System's abilities

Social media is too complex to become effective source of information used by the System

Flexibility

The System's ability to meet various challenges have not been addressed.

Various cultures, nations and working practices of crisis response organisations will compromise the System

Interactions between bystanders, victims, local resources and first responders is not facilitated by the System

Improvisation

The system does not address how to improve problem solving abilities under large uncertainties

The System does not encourage first responders to find a tailored solution in short time

Summary of Process

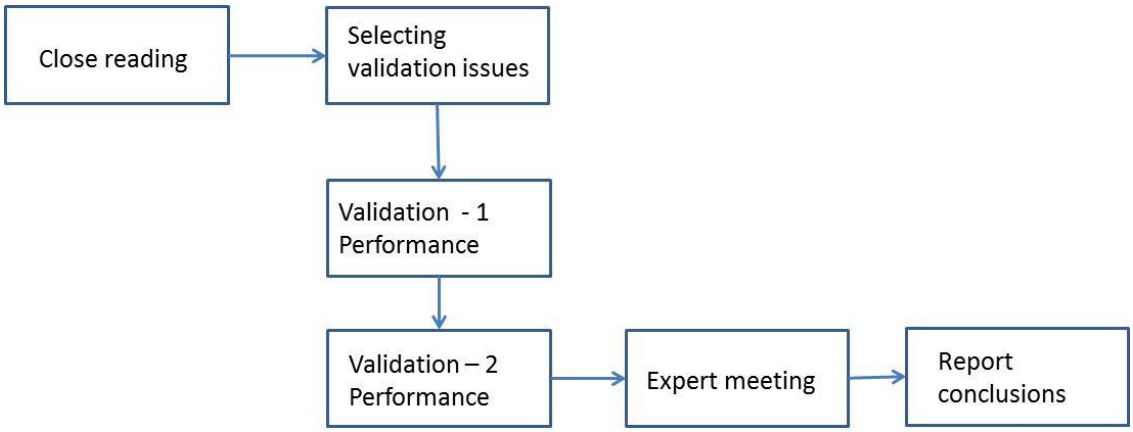

Fig. 2 Validation process from end user perspective

NB! The process will provide objections to the System considered. However in the final conclusion the importance of these objections must be assessed, and only then the final End-User Validation can be concluded upon, together with all the assumptions and premises made.

Appendix A Large-scale crises

Large-scale crises might be a collective term on major events threatening values deemed important on a national and international level, requiring huge efforts in order to become aware of the crisis and cope with the disaster developing. ‘t Hart and Boin (2001) have developed a conceptual framework of crisis typologies into speed of development and speed of termination. The BRIDGE-assumption about events coincides with the instant occurring crisis which needs immediate response. The situation is characterised by xxx (there has been discussions about the characteristics of the scenario covered by BRIDGE in the various TCC-meetings. Therefor we have not finalized this appendix yet, and we need comments from the partners to this issue).

Speed of termination \ Speed of development	Fast: Instant	Slow: Creeping
Fast: Abrupt	Fast-burning crisis	Cathartic crisis
Slow: Gradual	Long-shadow crisis	Slow-burning crisis

Rosenthal, Charles and t’Hart (1989) base the “contingent decision path perspective” on case-oriented retrospective analyses of different crises. The work is followed up in 2001 (Rosenthal, Boin, & Comfort, 2001: 6), in which the crisis concept is reconsidered as more than discrete events limited in time and space to “process unfolding as manifold forces interact in unforeseen and disturbing ways. Modern crises are increasingly characterized by complexity, interdependence, and politicization”. The contingent approach to crisis management includes a perspective that a system is going through temporary states, a process, in which the crisis facilitates/precipitates major changes. Private and public affairs are interleaved in crises, and preconceived notions about the functions and roles of specific players in the crisis game become unclear in practice.

Appendix B Crisis command structures for fast burning crises

Rescue operations are usually based on rigid management systems. Such systems are traditionally emergency plans, written procedures and predefined arrangements and measures for on-scene activities (LESLP, 2007; Sikich, 1995). The structure is based on a “military” strategy, in which management is authoritative and centralised around the incident commander. Incident commanders normally fight “small/minor” crises, for which practices and procedures have been developed and are acknowledged to work very well. A typical incident rescue organisation is depicted in figure 2.

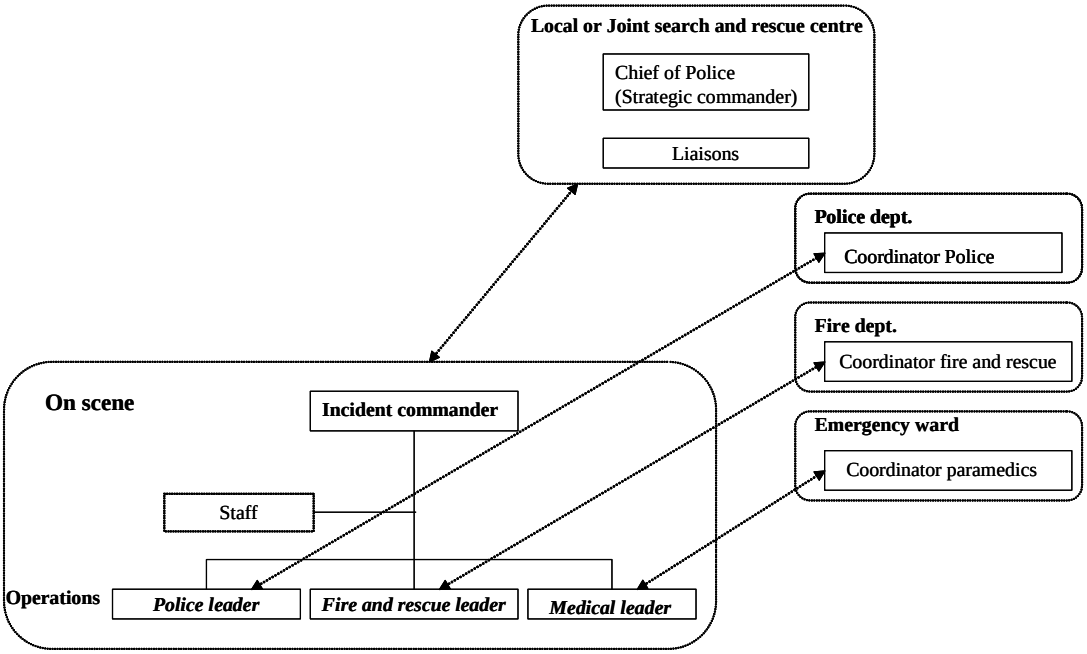

Figure 2. The Norwegian Incident Command System: Basic Functional Structure, based on the PhD work of Eivind Rake (2008)

Figure 2 presents the Norwegian emergency management organisation, emphasizing the sharp end structure. Some main communication lines are shown as arrows, being important means of decision support for the incident commander and the operational leaders. The on-scene management structure remains the same for all types of incidents, assuming the incident commander as having the holistic view of the situation, deciding where to locate the control/command post, managing the staff (e.g. communication, log function, reconnaissance, and resource), preparing the superior aims and plan, initiating the rescue operations and assessing the resources. The incident commander is a nominated police officer normally reporting to the local rescue coordination centres (rescue sub-centres), headed by the Chief of Police. The principles of crisis management structure on scene are quite similar worldwide. Great Britain relates its strategic, tactical and operational levels to the Gold, Silver and Bronze concept (Flin 1996; Pearce & Fortune 1995). The system is intended to be flexible in accordance with the demands of different crisis situations. If a situation involves injuries to people, environmental spills or energy out of control, and is also protracted, requiring a number of simultaneous responses, all parties in figure 2 would be in action. The US incident command structure (FEMA 2007) is also fairly comparable to European approaches. The difference seems to lie in the practical implementation of the systems, where on the one hand a strictly hierarchical system is adhered to and on the other a function-based perspective is adopted, in which the structure (rank hierarchy, dedicated persons, etc.) may be altered from case to case in order to achieve the established goal.

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Appendix C Example End-users activity

The overall objective of WP12 was to inform socio-technical systems of systems innovation in the BRIDGE project with insights into ethical, legal and social issues. These objectives have been described and addressed in the documents D12.1, D12.2, D12.3, and D12.4 The workpackage had a strong focus on end-user engagement throughout the project and the researchers in the workpackage provided a list of the main activities presented in table C.1.

Table C.1: WP 12 End-user activity

Date	Activity & Participants	Outcome for BRIDGE
20110427	**International Workshop** 'New Social Media and Crisis', Centre for Interdisciplinary Research, Bielefeld University http://www.lancaster.ac.uk/fass/projects/new-interaction/documents/NewSocialMedia_Call.pdf **Academics** working with practitioners, **BRIDGE EUAB**: Barbra Campbell	Insight into experiences and ELSI (Ethical, Legal and Social Implications) in social media in crisis response and management, international perspectives
2011-2015	Over 20 **interviews** with **BRIDGE EUAB members** and **External Practitioners,** contacts often facilitated through EUAB members, eg in Stavanger (RAKOS), in the UK (Barbra Campbell), Belgium (Christian Van de Voorde), Gemany (Heiko Werner)	In-depth insight into particular ELSI issues, such as the legal regulations around police national computer searches (UK) and logging of paramedics' activities (Stavanger), documented in WP2 and WP12 deliverables and informing BRIDGE innovation
2011-2015	Participation in **EUAB meetings** ULANC team	In-depth insight into particular ELSI issues emerging in relation to BRIDGE innovation, documented in WP12 deliverables and informing BRIDGE innovation
2012-1015	**Observations at exercises** facilitated by EUAB members, including Flums Training exercise with Cork City Firebrigade, Pukklepop Festival Exercise, UK Interoperability exercise London 2012 (Lisa Wood), Stavanger Risavika Exercise (all BRIDGE), Swedish Marine Collision Tabeltop exercise (CTAS, USTOCK) **External Practitioners** from Norway, Sweden, Belgium, Ireland	Insight into ELSI arising in real world contexts, international perspectives
20120417-19	**BRIDGE Co-Design Workshop**, Lancaster **BRIDGE EUAB**, >15 **External Practitioners**, including Martin Annis, Senior Emergency Planning Officer, British Red Cross Society, Secretary to the Voluntary Sector, Civil Protection Forum	Hands-on experimentation with BRIDGE early prototypes, discussion of ELSI arising in practice in the appropriation of new technologies

20120910	**Workshop Mobilizing Emergency Response**, September 2012 http://www.lancaster.ac.uk/security-lancaster/news-and-events/workshops/mobilising-emergency-response/ **Academics**, **Industry, SME** - please see website for details **BRIDGE EUAB**: Heiko Werner (THW, Germany)	Insight into ELSI in IT innovation in crisis management and response from diverse perspectives
20130508-09	**Invited Presentation**, Social Media & Whole Community Security, Cork Annual Chief Fire Officers' Conference, Cork, Ireland, 8-9th May 2013 Monika Buscher, **External Practitioners:** Over 100 Fire Officers from across Ireland, including Finian Joice, Chief Fire Officer with Leitrim County Council, Secretary of Federation of European Union of Fire Officer Associations (FEU) and Peter Holland, The Chief Fire and Rescue Adviser (CFRA), Department for Communities and Local Government	Debate about the role of social media in crisis response and ELSI arising from this in practice, international perspectives
201304 and 201309	**Co-Design Workshop**, **Exercise and Review**, **Conference** **BRIDGE EUAB members**, **External Practitioners** from Norway, Webinar participants in session with Christian Van de Voorde, Monika Buscher and SINTEF speakers invited by US ICS network	Insight into how BRIDGE technologies would be used in practice, ELSI arising, international perspectives
201405	**ISCRAM ELSI Track** with 7 papers http://iscram2014.ist.psu.edu/sites/default/files/misc/ISCRAM-Program2014.pdf **Academics & External Practitioners** ISCRAM is a conference attended by academics, professional responders, industry and SME involved in IT innovation in crisis management. We had an audience of around 40 people in all our sessions.	Insight into ELSI in IT innovation in crisis management and response from diverse perspectives
201405	I**SCRAM Panel** Doing IT Right: Ethical, Legal, and Social Issues of IT-Supported Emergency Response Moderator: Monika Buscher **Academics:** Michael Liegl (Lancaster University, UK), Caroline Rizza (Telecom Paristech, France), Leysia Palen (University of Colorado Boulder, USA), Zeno Franco (Medical College of Wisconsin, USA), **SME:** Hayley Watson (Trilateral Research & Consulting, UK), Kush Wadhwa (Trilateral Research & Consulting, UK), **BRIDGE EUAB**: Heiko Werner (THW, Germany)	Insight into ELSI in IT innovation in crisis management and response from diverse perspectives
201406	Paderborn University Ringvorlesung (**Open Lecture**) Monika Buscher, **External Practitioner:** Giulio Gulotta (Bundesamt für Bevölkerungsschutz, German Ministry for Civil Protection)	Public debate about ELSI in IT innovation in crisis management and response, international perspectives
201406	**I-Triage EU Proposal Workshop**, Brussels June 2014 Michael Liegl, **External Practitioners:** including representatives from Royal Military Academy (Military Hospital Queen Astrid), Belgium Federal Public Service Health, Department of Disaster	Discussion of BRIDGE and BRIDGE ELSI research and ELSI Diesgn Methodology for IT supported CBRN Triage, international perspectives

	Management, Belgium The Fire Department Dortmund, Germany The National Institute for Public Health and the Environment, The Netherlands Belgian Nuclear Research Center, Belgium German Aerospace Center, Germany Centre national civil et militaire de formation et d'entraînement aux évènements de nature NRBC-E, France Thales Communications & Security SAS, France European Organisation for Security, Belgium The Netherlands Standardization Institute, The Netherlands	
20141209	**SecinCoRe Co-Design Workshop** - the project draws on BRIDGE to develop a Common Information Space Concept **BRIDGE EUAB member** Christian Van de Voorde and 13 **External Practitioners** from Spain, Greece, UK, Finland	Insight into how BRIDGE ELSI play into common information space innovation and the use of cloud computing, international perspectives
20150524-27	**ISCRAM Track** with 9 papers **Academics & External Practitioners** ISCRAM is a conference attended by academics, professional responders, industry and SME involved in IT innovation in crisis management. We had an audience of around 40 people in all our sessions. The feedback from this was excellent with practitioners expressing that this was the most interesting and important track at the conference. Emergency Communications (Martin Onstad, Telenor), and Bart Van Leuwen, Professional Fire Fighter / Software Architect, passionate about linked data in the emergency response business https://twitter.com/semanticfire Short Video Interviews available at https://itethicsincrisis.wordpress.com/iscram-2015/	Insight into ELSI in IT innovation in crisis management and response from diverse perspectives
2011-ongoing	BRIDGELancaster Twitter Account https://twitter.com/BridgeLancaster 176 Followers, including the **External Practitioners,** e.g. FirstAid company @thefirstaidcomp, Finian Joyce @JoyceFinian, LAFD Conversation @LAFDtalk is for queries and casual discussion with the Los Angeles Fire Department	Insight and conversation s around emerging and topical issues, international perspectives