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Bridging Resources and Agencies in Large-Scale Emergency Management

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BRIDGE Demonstration IV: Integrated Demonstration in Real-Scale Networks under Crisis Conditions

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Abstract / Executive summary:

This report documents the final BRIDGE Demonstration in the underground test facility of VSH, in May 2015, with special emphasis on the integration of BRIDGE technology to provide a common operational picture to incident managers in large crisis management.

The Demonstration highlighted the contribution of Concept Cases embedded into the timeline of the Golden Hour with reference to a historical incident, the Toulouse AZF explosion in September 2001. The tested and integrated BRIDGE technologies include:

- Adaptive Logistics
- Advanced Situation Awareness
- eTriage
- First Responder Integrated Training System FRITS
- Information Intelligence
- MASTER,
- Robust and Resilient Communication
- Situation aWare Resource Management

This demonstrator combined the three prior demonstrators and included aspects of the 3D visualization and simulation technology. It addressed all relevant stakeholders involved in the above mentioned crisis scenario.

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1	Version 1	27.7.2015	Max Wietek
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1 The BRIDGE Integrated Demonstration in Real-Scale Networks under Crisis Conditions

1.1 Purpose of the demonstration

In accordance with the description of work, the purpose of demonstrations is summarized in three objectives, including

- to demonstrate interoperability of systems and tools developed during the project,
- to show progress of work in compliance with end users' needs and requirements, and
- to bring innovation close to the market.

Demonstration, from the very beginning of the project, was closely linked with validation (WP10) and following satisfaction of end user needs. As a consequence, well defined and useful demonstration scenarios were considered being the sound base for exposing project achievements to the critical eyes and judgement of our End User Advisory Board, several representatives of first responders, and finally also the reviewers as well as the PO of the European Commission. Taking a look at the BRIDGE demonstrations from the top down perspective, increasing complexity as well as a growing level of integration was the basic idea to guide the consortium through the four demonstrations during the entire project duration of 54 months – peaking in an integrated demonstration of the BRIDGE system of systems with a focus on a real scale in situ network and aspects of visualization and simulation technology.

1.2 BIRDGE Final Demonstration – The "Golden Hour"

On May 20th 2015, the fourth and final demonstration of the FP7 security research project BRIDGE took place in the facilities of Hagerbach Test Gallery VSH in Switzerland. The intention was to show tangible results created during the project phases after having been evaluated and validated. Main objective of the final demonstration was to show the integration of all different technical and conceptual parts created by the BRIDGE Consortium.

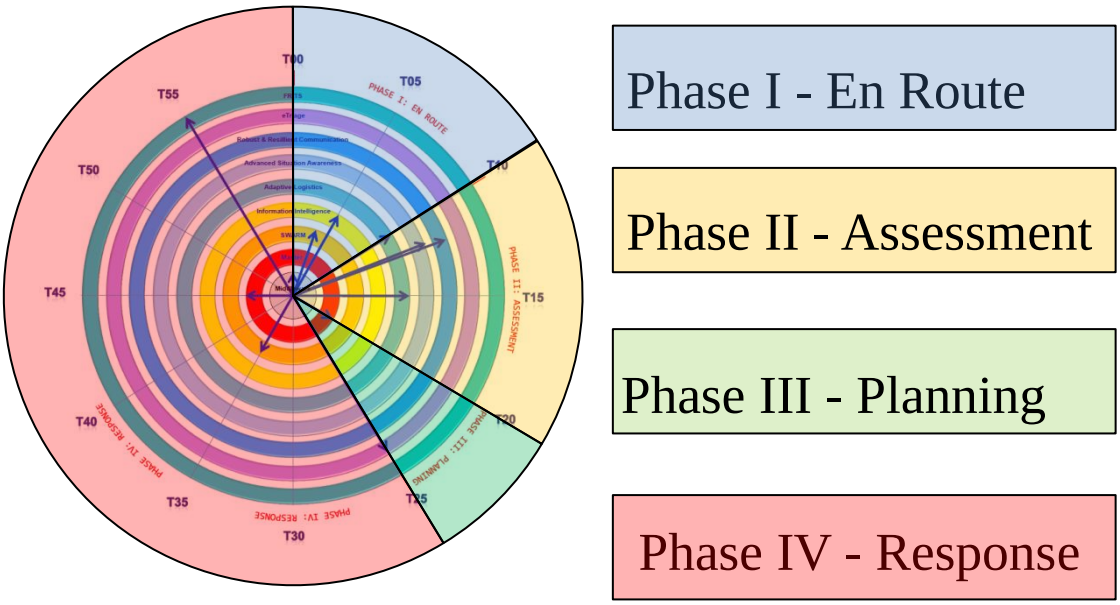


Figure 1: The "Golden Hour" Concept for the BRIDGE Demo

In order to make end users and the reviewers see where large crisis management would benefit from BRIDGE technology, the demonstration was organized in a way to establish links between specific snapshots on the timeline of the "Golden Hour" and each of the Concept Cases – providing support from different perspectives.

Phases	Snapshot	Zoom target	Summary
Normal operation	T - 5	Operational integration	Technical and first responders integration: These timeslots are meant to provide a very short CC intro, the elaborate details of the situation, have an integration also on first responders level.
1. En Route	T + 3	SWARM	Information about available resources to incident
	T + 5	Info Intelligence	
	T + 10	Adaptive Logistics	based on information needs of IC AL makes plan, including ASA, DEIN, RAM, Expert Sys etc. to do area safety assessment and victim prediction / assessment
2. Situation Assessment	T + 12:	ASA	Virtual demo, provision of visual information, atmospheric, toxic gas concentration, radiation levels,

		RRC	location of heat sources, 3D model of damaged buildings, 2D model of toxic plume dispersion, advise on PPE, and protective measures for public, victim application, seeker application, integration with UAV, optimisation of distance
	T + 15	Adaptive Logistics	demonstrate that AL can make plan for SAR, directing SWARM, teams equipped with eTriage braceletts; prepare triggeers for evacuation in case victims are found / eTriaged, demonstrate use of for policy settings and QoS management
3. Planning	T + 20	Master	consumes data from various services supports IC / leaders to get situation awareness (filtering, commanding, clustering), distribute incident information different instances - distributed at operational level & command level
4. Response	T + 25	e-Triage	triaging of victims, network reliability, view on master & triager tablet, dealing with GPS problems, patient monitoring (temperature)
	T + 35	SWARM	track & trace of resources (shown in coop. with Master), situation awareness information, situation information update to the resources, task assignment (routing information, incl. ETA communication (SCALING UP?), interaction with AL, producing triggers for QoS and AL
	T + 45	Master - Integration	technical integration of CCs

1.3 Opportunities and implications from the third BRIDGE demonstration

1.3.1 The 3rd BRIDGE Demonstration

The 3rd BRIDGE Demonstration was linked with a large scale exercise in Risavika, Norway, where the preparation was in hands of the Stavanger Region Exercise Organizing Committee – supported by BRIDGE suggestions. The scenario was a bombing and shooting involving a ferry in the passenger terminal of Risavika Harbour.

Lessons learnt from the third BRIDGE Demonstration were to a large extent related to the level of integration the consortium would achieve with the involvement of all different types of

technologies – on different levels of technical readiness in the final Demonstration. So the consortium decided not to focus on technical integration only (however doing that wherever possible) but also to show the organisational and operational integration by zooming into specific situations in the golden hour of an incident.

1.3.2 BRIDGE Validation

Since the third BRIDGE Demonstration, big efforts have been made to validate BRIDGE technology against ethical, legal and social aspects. VSH as the leading Validation partner, have had meetings with all Concept Case Owners in order to discuss the way of implementation and consequences of BRIDGE solutions from ELSI perspective. In this document, an entire subsection is dedicated to Concept Cases and ELSI. Furthermore, three ValEDation Days have been carried out on three different partner locations (Alpine ValEDation Day in Salzburg, Austria, Low Countries ValEDation Days in Delft, Netherlands, and Nordic ValEDation Days in Oslo, Norway). The main purpose of ValEDation Days was threefold:

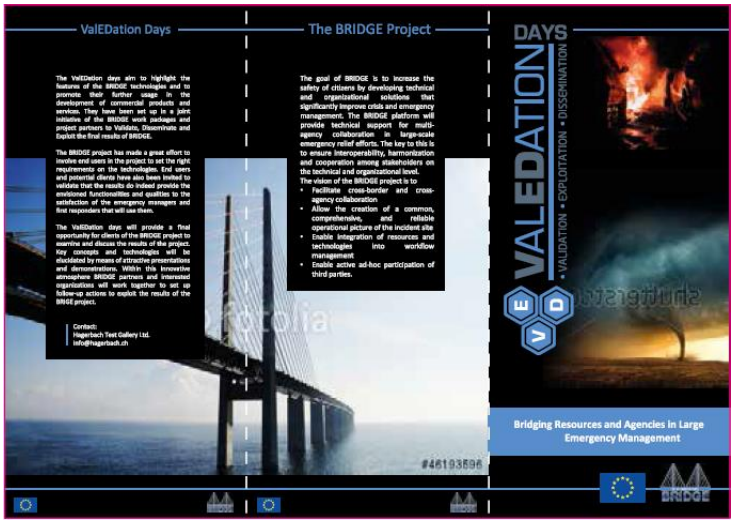


Figure 2: ValEDation Days Folder

- **V**alidation
- **E**xploitation
- **D**issemination,

This is why we called it **V**al**ED**ation Days. More details regarding Validation of this phase of BRIDGE is to be found in Deliverables *"D10.3 Validation with the collaboration technologies demonstrator"* and *"D10.4 – Real Scale Training and Tests".*

1.3.3 BRIDGE Dissemination

In Addition to paper presentations at different Conferences, Dissemination was one of the three main purposes of the ValEDation Days. The idea was to invite - depending on the selection of Concept Cases - the most relevant stakeholders of the corresponding region to promote and exploit BRIDGE technologies and concepts.

There were three different focuses on the three ValEDation Days. The Alpine ValEDation Day was dedicated to advanced situation awareness and the networks needed to make collected data available. The central device was the unmanned aerial vehicle (UAV) equipped with several sensors, and providing environmental data relevant for the incident managers. Important stakeholders included fire fighters from the region as potential users of the UAV system in an incident.

At Nordic ValEDation Day Master, eTriage and the Trainings System were exposed to the critical eyes of fire brigades, police and medical services. The interest in the BRIDGE Concept

Cases was very high, leading to follow up activities with the eTriage Concept Case with Norwegian Medical Services in Stavanger.

The Low Countries ValEDation Days have been dealing with the Concept Cases Adaptive Logistics, SWARM, Middleware and Information Intelligence. End users involved in this event were mainly from the consortium, in principle those decision makers who would enable and support the use of BRIDGE technologies on the way to produce useful tools for crisis management.

Through carrying out these ValEDation Days, this kind of dissemination was done on a very sound base of stakeholders, involving users of our products from the development phase until the utilization during incident management.

Figure 3: Dissemination activities during the Alpine ValEDation Days

2 The Final Demonstration Scenario

2.1 Introduction

The Toulouse explosion incident in 2001 was chosen as a scenario to demonstrate how BRIDGE technologies can help in a specific incident to master crisis management and support the work of first responders. The involvement of many different groups and types of responders, blue light services and NGOs was an important criterion for the selection of this scenario, as this results in a high level of complexity with regards to organisation, communication and logistics.

The first step of preparation was an analysis of the incident phases down to the level of details of a minute-wise temporal resolution. The understanding of what had happened in the real incident lead to a list of certain situations each of which would benefit from the availability of BRIDGE technology. The idea was to demonstrate in the theoretical environment of a specific incident situation what each of the Concept Cases could bring in. Finally, the phases of incident management, the correlation of BRIDGE highlights linked with corresponding snapshots of the entire incident was proofed by the End User Advisory Board.

2.2 Description of the location

Location of the final Demonstration was a big cavern called Glückauf Kaverne at the premises of Hagerbach Test Gallery in Switzerland. The cavern was large enough to build a circle representing the “golden hour watch”, where Concept Cases was demonstrated in an integrated way and with a clear link to the timeline of the first hour of the incident.

Figure 4: Final Demo in the Golden Hour setup

Additionally, a large seminar room with a capacity of approximately 80 persons was available. All locations are equipped with W-LAN or cable internet access to allow integration of different technologies and showing them on the Master.

2.3 Toulouse incident Scenario description

The following table shows a list of snapshots of the emergency response in the Toulouse incident. Circumstances and emergency response actions are described

Timeline /Phase	AZF Emergency Response 2001
-00:10	Routine operations
00:00	
00:05	1. The alarm system at the factory never activated. [1] 2. The shockwaves were so powerful that police were inundated with reports of explosions in different parts of the city. [8] 3. A local operational center was set up almost immediately after the explosion. It played a crucial role in the coordination between the emergency medical service (SAMU), general medical practitioners, firefighters and UIISC soldiers. [6] 4. Major traffic problems quickly arose around the site after the explosion, creating difficulties for the emergency services to reach the scene.[1] 5. Besides, extensive damage hindered rescue services in their efforts to reach the factory. [1]
00:13	1. Despite major traffic problems, the first rescue team was on-scene 13 minutes after the explosion. [1] 2. Search and rescue operations began immediately after the first firefighters arrived on scene. The rescue units encountered a stream of dusty, injured persons fleeing the industrial area on foot. [1] 3. Rescue work began without a preliminary risk assessment for the rescuers. [1] 4. The firemen, arriving on scene first, were not protected with adequate equipment for any toxic cloud and with devices to detect those toxic gases. [5] 5. The rescuers were particularly shocked by the complete dumbness among the people at the factory who survived the explosion. None of them could speak. However, after a while these people started to recover and actively help those who needed it. [7]
00:20	1. A major disaster alarm was triggered in Toulouse 20 minutes after the explosion, signaling for a rescue effort to commence. [1] 2. The operations were conducted on the premises of the factory and in the adjacent districts. [7] 3. People who got stuck start to broadcast emergency signal in ad-hoc manner.

00:23	1. Accident Response Plan and local Disaster Alert (Plan rouge) were activated. [11] 2. As many citizens attempted to leave the area in their cars, they suddenly encountered police blockades at the main roads to the south and at the central city ring road. [3] Acting upon the order by the municipal authorities, local police closed off all motor-ways and the ring-road. However, movement on the roads was virtually paralyzed, because so many residents rushed to their cars in an attempt to pick up their children and family members from schools and work places and leave the city. [7] 3. Emergency response was carried out in accordance with two pre-existing disaster plans: the emergency medical aid plan (known as PPI or "Red Plan") and the plan foreseeing the deployment of a network of emergency medical facilities ("White Plan"). [7] 4. This ensured a quick mobilization of the necessary personnel and equipment to provide medical aid to the victims and minimize possible losses. [7] 5. Having staffed ambulances with doctors who were on stand-by duty, a lot of medical experts could quickly reach the site, although initially there was a shortage of means of transportation. After a few hours, 60 doctors were present on-scene, most of them performing their duties at an assembly point set up a few kilometers away from the source of the explosion. [1]
00:43	1. Only after 30 minutes [since the arrival of the first rescue team] did measurements show that the cloud of dust and smoke caused by the explosion had a “low” toxic content. [1] 2. The assembly point started to receive the first injured at 11:00 [7] and provided medical care to nearly 300 persons. [1] The first aid was administered mainly to the seriously injured victims. About 85% of all seriously injured received such aid. [7] 3. At the initial stage of the response, there was a shortage of material resources. [1]
01:00+ Medical transport Transport and distribution Triage Evacuation	1. Seriously injured persons were taken to hospitals for special care, many of them - using private cars. [7] 2. During the first day, 862 patients were taken to hospitals. The two largest hospitals in the region—the University linked Rangueil and Purpan Hospitals—received >1,500 injured persons. [1] 3. Rangueil Hospital received 435 injured persons; more than one-quarter of them were admitted for medical care. In addition, 50 people, who were injured at the hospital when it was damaged, also received care. [1] 4. During the day of the explosion, Purpan Hospital received 1,048 injured persons; one-quarter of them were admitted. [1] 5. Three-quarters of the injured who were received at Rangueil and Purpan Hospitals were able to leave the hospital the same day. Of those remaining at the hospital, 25 had suffered injuries, some of them serious. Four people were evacuated to other hospitals. [1] 6. Injured victims also presented at 24 other medical units, several of them private, or presented to their private general practitioners. [1] 7. In order to cope with the influx of injured persons, the staff at Purpan Hospital improvised, and conducted initial triage at the main ambulance entrance, where they allocated the injured to various injury sectors in the hospital. [1] 8. Acting in accordance with the two emergency plans, the municipal authorities announced the formation of a 30-km safety zone around the city of Toulouse. They closed the local civil aviation airport, stopped all flights over the city, closed off all motor-ways and the city ring road, shut the railway station, stopped all railway transport, and evacuated the metro system. However, movement on the roads was virtually paralyzed, because so many residents rushed to their cars in order to pick up their children and family members from schools and work places and leave the city. [7]

02:08 Situation and Risk assessment	1. An AFP cable states that “according to initial findings of the police investigation, the very violent explosion that occurred on Friday morning at the AZF petrochemicals plant […] was ‘probably due to accidental causes’”. [11]
03:00 Situation and Risk assessment	1. It took a full three hours before it was established that there was only one blast and that there was no evidence of terrorist activity. [8]
04:00 Triage and pre-hosp care	1. Within several hours an assembly point with 60 doctors was established several kilometers from the explosion site. [1] [This is conflicting with reference [7], which claims that the assembly point started receiving the first injured already at 11 am, i.e., 47 minutes after the explosion. LZ]
12:00 Scaling up Communi-cations	1. Within 12 hours, 1,046 firefighters from 13 different fire prevention districts were on-site. It quickly became clear that the number of rescue staff exceeded requirements, but this made it possible for them to relieve each other. [1] 2. The phone lines were repaired only late in the evening. [7]
20:00 SAR	1. The Search and Rescue operation was still ongoing after 20 hours, with around 400 firefighters working through the night. Four bodies were recovered during the night, bringing the total to 29. [12]
24:00+ Scaling up	1. In the following days of 21st September, 1570 firemen and militaries, 950 policemen were involved in the emergency response and housing monitoring. They reportedly arrived on their own initiative without any plan or any discussion by phone as the classical phone lines were partly destroyed and the mobile phone network was saturated. [5]

Figure 5: Visualisation of the incident scenario

3 Demonstration IV Technologies

3.1 Chapter overview

In BRIDGE we have defined nine Concept Cases, which combine relevant BRIDGE technologies into sensible emergency response capabilities. The nine BRIDGE concept cases are:

- Adaptive Logistics
- Advanced Situation Awareness
- eTriage
- First Responder Integrated Training System FRITS
- Information Intelligence
- MASTER,
- Robust and Resilient Communication
- Situation aWare Resource Management

3.2 Concept Cases and Ethical, Legal, and Social Implications (ELSI)

BRIDGE has integrated consideration of ELSI into the development of the BRIDGE middleware for the assembly of systems of systems as well as the design of prototype systems or 'Concept Cases' (CC). This has not been a 'tick-list' approach that looks for solutions to ethical, legal or social puzzles and the overall goal of increasing efficiency, agility and efficacy of crisis response and management. Such 'solutionism' is, as we discuss in D12.4, inadequate in view of the opportunities and challenges arising (see also D12.3 and Liegl et al 2015). However, we have mapped a concrete set of architectural, ethical and legal qualities and requirements informed by analysis of social, ethical and legal practices. These are inter-related, with ethical and legal qualities defining key issues arising from a societal perspective and architectural qualities integrating and complementing these challenges with a view to the overall added value of the system 'architecture' and the edifice of systems of systems that can be assembled with it. These qualities are listed below. They are explained and elaborated in the Requirements Specification for BRIDGE (D2.5) and other deliverables and publications (e.g. D4.2, D10.3, D12.1, D12.2, D12.3, Al-Akkad et al 2013, Wood et al 2013). Our efforts to provide an integrated demonstration in the final project demonstration have showcased some of the ways in which BRIDGE has attention to ELSI 'inside', and they have highlighted further opportunities and challenges for systems of systems innovation.

In this section we selectively summarise key aspects. The systematic for selection is to comprehensively show how BRIDGE has aimed to address all qualities (tagged below with the labels AQ (architectural), EQ (ethical), LQ (legal quality)). However, most qualities are contextual and could apply to all BRIDGE Concept Cases in different ways during different phases of crisis response and management. Judgement about the usefulness and success of how they have been addressed also depends on who is concerned and what their interests are. For example, an individual's ability to make informed decisions about disclosure of personal medical data partly constitutes his or her 'autonomy' (EQ). This is an essential value in European Societies and a quality people should be able to realise in technologically augmented contexts. However, in a crisis, it may be legitimate, and necessary or highly desirable for all or some parties involved to override an individual's autonomy and to collect and process such personal data even without their consent. We have discussed the legal basis for such exceptions in D12.1 (p.26ff) and explored the implications in D12.2, D12.3 and various publications (e.g.

Buscher et al 2015). The selective review in this deliverable aims to exemplify and provide an overview of how BRIDGE has concretely responded to ELSI opportunities, challenges and risks through its technological innovations, based on the final demonstration. We elaborate on these responses in D12.3, where we draw out key themes, and in D12.4, where we highlight some implications for policy, legal and regulatory frameworks.

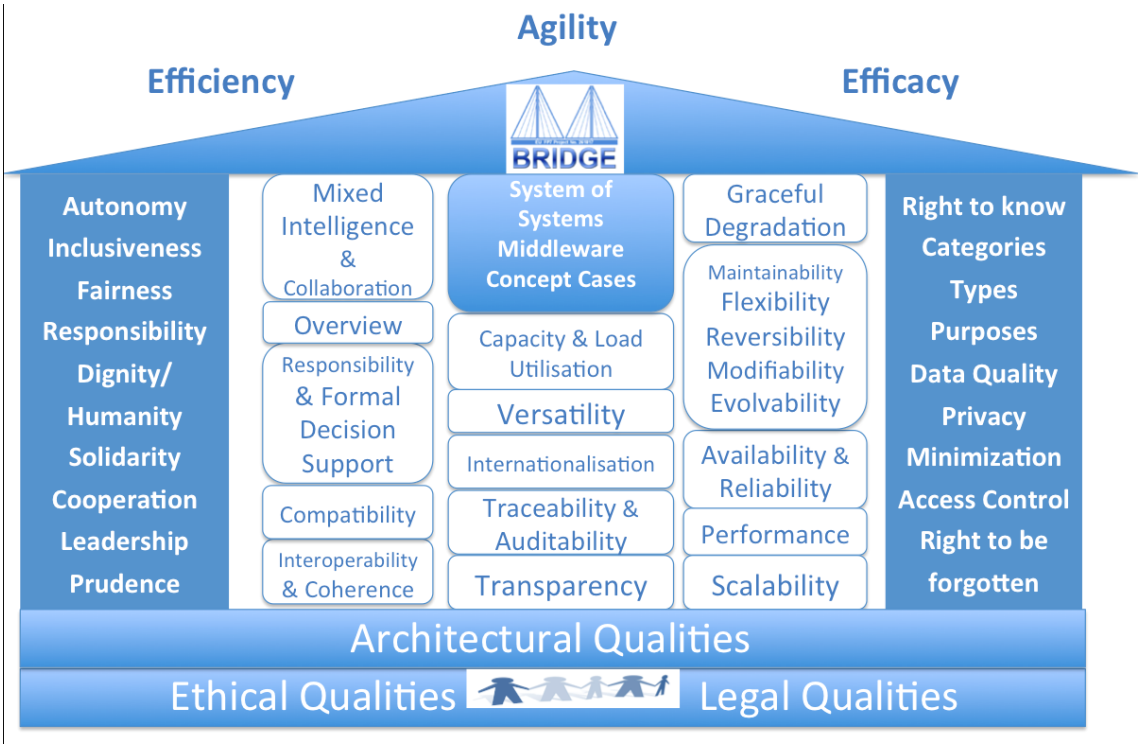


Figure 6: Architectural, Ethical and Legal Qualities

3.2.1 BRIDGE System of Systems Integration and Middleware

The scenario to demonstrate BRIDGE starts at T00 – before the incident. At this point, operations are routine. Emergency operators are on normal duty, the BRIDGE middleware is running in some agencies, monitoring of key sensors and resources is taking place using BRIDGE Advanced Situation Awareness, the Master and SWARM. At the Police Headquarters, for example, the BRIDGE Information Intelligence system is used to monitor social media for reports on emergencies. These uses are not integrated into a common information space, but demonstrate how the quality *Availability and Reliability* (AQ) is realised.

At T05 – when in the original situation emergency centres were overwhelmed by a flood of conflicting emergency calls, responders in different BRIDGE emergency centres can see that some monitored sensors and resources have disappeared from the MASTER because of the explosion. The BRIDGE Middleware service catalogue, orchestration and data model and management services are used to enable data from different CCs to be pushed to the BRIDGE system, and the MASTER system presents them on the map, which also enables organisational interoperability by supporting establishment of a common operational picture. All relevant partners are allowed to access the MASTER, using standard web-browsers. This illustrates how emergent *Interoperability & Coherence* (AQ) are achieved with the BRIDGE system.

The BRIDGE CCs connect via the middleware to other systems (e.g., the Master) to disseminate information. The orchestration service provides generic format and structure transformation services, information is disseminated based on existing standards (i.e., XML and EDXL) and

the BRIDGE Middleware support for emergent interoperability also allows integration of taxonomy services like EMERGEL[1], evidence of how *Internationalisation* (AQ) is supported.

Privacy (LQ) is supported by design. The BRIDGE middleware supports security, trust and privacy as a combination of guidelines, models, and supporting technologies including Privacy Level Agreements, Trust agreements and standard cryptographic operations for protecting confidentiality, integrity and authenticity of messages. Message-related services provide functionality for hiding the identity of the sender, the content of a message or the recipient of a message. However, while BRIDGE leverages the state of the art of development in this field, the usefulness of 'privacy by design' in system of system innovation is limited. The exceptional context of emergency response, where interconnection with 'smart city' services is increasingly sought generates complexities that are beyond existing approaches. We have developed conceptual resources to develop more innovative support for human practices of controlling privacy, trust and security. These were explored in presentations at the demonstration and are documented in deliverables and publications (e.g. Buscher et al 2015, D12.4).

At T13, the assessment phase begins, as first responders are en route to the incident. There is further bootstrapping of the BRIDGE System of Systems: All services register with the BRIDGE Service Catalogue, the BRIDGE QoS Repository and frequently update their status in the BRIDGE Resource Status Repository. There is an option for agencies to register their policies in the BRIDGE Policy Database, which addresses legal qualities around the *Right to know* categories, types and purposes of data collection and processing (LQ). This also responds to the call for *Responsibility* (EQ) in the sense of enhanced preparedness – where all organizations and individuals that might have a role to play in emergency response and recovery should be properly prepared and be clear about their roles and responsibilities.

The BRIDGE middleware's support for emergent interoperability allows a degree of flexibility that supports *Inclusiveness* (EQ), in the sense that information from a wide range of sources, including medical sensors, social media, mobile phones, drones, apps (such as the BRIDGE Helpbeacons) can be integrated swiftly and taken into consideration for the common operational picture. While this does not include *all* systems (e.g. all emergency response legacy systems and feature phones), there has been attention to accessibility.

3.2.2 Adaptive Logistics

Adaptive Logistics plays a special role in the BRIDGE innovation effort, as it uses the middleware services most extensively (see also D2.5). Therefore this concept case is described in greater detail than other BRIDGE concept cases.

The capability to orchestrate a vast amount of information systems into a coherent system of systems illustrates a need for awareness of data controllers, data flows and data management protocols. The BRIDGE team identified a need for *Responsibility and Formal Decision Support* (AQ) that can make users aware of technical, legal or regulatory regimes or social/ethical constraints that may affect operations. The Adaptive Logistics CC addresses this quality by automating parts of implementing policies for agreements between agencies in terms of how to deploy resources and how to achieve results (inter-organisational). It can help organizations to cooperate with each other in a way that is compliant with the rules of engagement. However, embedding support for responsible conduct and decisions in systems of systems is another 'wickedly' complex challenge. BRIDGE has developed conceptual resources for the development of such support (see, e.g. D12.3) and this is being taken forward in discussions for

[1] http://vocab.ctic.es/emergel/

further research proposals and in the SecinCoRe project[2], where insights from BRIDGE ELSI research are integrated into the design of advanced common information space concepts.

The workflow generation and management mechanisms provided by Adaptive Logistics are designed on the one hand to make the complex computational process transparent in the sense of 'invisible' to the user. On the other, they enable inspection through the BRIDGE Annotated Workflow Language (BRAWL). These efforts thus support *Transparency* (AQ) in two senses and in ways that empower human practices of acquiring skill and controlling the highly complex processes of crisis management. However, our work also highlights that transparency is in the eye of the container; it cannot be embedded statically by design, but depends on users being able to understand the invisible operation or opened up documentation of the system. There are opportunities and challenges arising from recognising the contextual nature of transparency, which are explored in D12.3 and a range of publications (e.g. Wood et al 2013, Perng and Buscher 2015).

During the Assessment phase of the response, a critical task for the Incident Command team is to determine where they can expect victims to be, an estimate of numbers and the types of injuries that can be expected. In response to this need, the Adaptive Logistics Collaborative Workflow Generation and Management Mechanism computes a workflow 'Victim Assessment' and kicks off key services, including RAM, DEIN and PLUS Modeling as a Service (MaaS). The result of this information gathering effort is to be displayed on the Master. The execution of the workflow is monitored by the QoS Monitoring Service. By mobilising these advanced resources, the BRIDGE System of Systems enables enhanced *Mixed Intelligence and Collaboration* (AQ), that is, it enables unprecedented capabilities to combine human reasoning with computational calculations of relevant variables. It thereby becomes possible to prepare in a more informed manner for the triage process and the reception of patients in hospitals. In a broader perspective, this is an example of how BRIDGE Systems of Systems support a more informed exercise of *Fairness* (EQ), as it becomes possible to distribute scarce service resources more effectively to those who most need it as well as those who are most likely to benefit. More generally, this is an example of how BRIDGE supports greater levels of *Prudence* (EQ) than is currently possible by supporting practical wisdom and the exercise of discernment, perspicacity, judiciousness and discrimination on the basis of more and more accurate information.

Adaptive Logistics brings together the capabilities of a vast array of human participants and artificial components and enables their coordination. In doing so, it supports *Solidarity* (EQ) and subsidiarity, that is, the principle of devolving decision-making to the lowest possible level whilst supporting coordinative action at a higher level.

3.2.3 Advanced Situation Awareness

During the first 15 minutes of response during the Assessment Phase, the first rescue team flies the UAV over the explosion site and sends the first images of the destruction and environmental sensor data from the smoke cloud. Using the data, the Expert System provides advice to the Incident Command team regarding self-protection measures for first responders and precautionary measures for members of public. The Modelling Module produces a plume dissipation model for the next few hours based on the current meteorological data. The UAV are able to obtain real time multi-sensory information more cheaply and more safely than is currently possible, and they can go closer to sources of risk than any other resource.

Through supporting new forms of *Mixed Intelligence and Collaboration* (AQ), the Advanced Situation Awareness CC enables enhanced *Leadership* (EQ). Moreover, its modelling capacities

[2] http://www.secincore.eu

are often based on exceptional efforts to obtain *Data Quality* (LQ) and *Flexibility* (AQ). With regard to the former, the triangulation between modelling results and real world measurements (such as correlation with high quality visual documentation of explosions (D10.1) and photographic evidence of injuries from the London bombings) allows high levels of confidence in the models. With regard to the latter, the establishment of a library of models enables fast and flexible exploration of likely impacts in relation to a wide range of settings where incidents may occur, including railway stations and airports. While this does not eliminate the rule of uncertainty in the dynamic high risk environments of crisis management (see e.g. Perng and Buscher 2015), it supports more informed and 'prudent', efficient, agile and effective response.

The demonstration highlighted a currently highly problematic regulatory situation in Europe that creates barriers for use. Due to the *Dual Use* capacity of UAV there are restrictions on how systems like Advanced Situation Awareness can be utilised. To travel from Austria to Switzerland, the UAV´s flight capacities had to be disabled, because it can carry a payload of more than 5kg, which could be used to mount a weapon. Furthermore, the capacity of UAV to take high quality video virtually anywhere raises concerns over surveillance and leads to further restrictions, which differ widely in different EU countries, showing that there is a need to establish clear data controller and data processing regulations. While the aim must be to safeguard the *Right to know* the categories, types and purposes of data processing (LQ) as well as the *Right to be forgotten* (LQ) to leverage the capabilities of BRIDGE System of System innovation, innovative regulatory and design approaches are needed. We discuss this issue further in Kerasidou et al (2015) and D12.3 and D12.4.

3.2.4 Dynamic Tagging (eTriage)

At T20, the Planning Phase of the response to the incident in the BRIDGE Golden Hour scenario has begun. Triagers start triaging people. BRIDGE triage bracelets are conceptualised to turn on automatically as soon as they are pulled from the pack, realising qualities of *Performance* (AQ). They report position and category of victims. For victims in areas without GPS, triagers scan and set the position manually. In areas without network coverage the bracelets are conceptualised to send triage data over the triage relays. The design of e-triage as an example of dynamic tagging of the environment enacts the quality of *Graceful Degradation* (AQ), that is, when encountering difficulties, the system does not stop providing its services, but continues to provide them as well as possible with the resources that are still available, e.g. through redundant network connectivity. When the quality of a service decreases, users are made aware of this and supported to enact 'manual' workarounds. The system also embodies a quality of 'graceful augmentation' (Jul 2007), that is, it continues to support practices that have evolved around paper-based triage (e.g. through the colours of the bracelets) so that even if the digital aspects of the technology were to fail completely, effective triage would be possible.

Dovetailing with other systems in the BRIDGE System of Systems, such as Adaptive Logistics (see above) and SWARM (see below), Dynamic Tagging supports a more circumspect approach to the *Fairness* (EQ) of triage, but also the overall *Dignity/Humanity* (EQ) of response. By allowing responders to bring more information about victims into the common operational picture and to reason about the categorisation of victims more swiftly and in a more informed and dynamic manner, people will suffer less.

As described in the introduction, this may conflict with values of *Autonomy* (EQ), which could be problematic despite the fact that it is legitimate in times of crisis (as outlined in D2.1), because there is a risk that data may 'spill' beyond the delimited context of the crisis. The CC addresses this quality by engaging in *Data Minimization* (LQ). It collects the minimum amount of information necessary for triage. In addition, the CC facilitates *Traceability and Auditability* (AQ) by logging the positioning, tracking and monitoring of victims as well as categorisations made. The demonstration reflected manifold discussions with responders who, faced with the

capabilities of BRIDGE integrated eTriage appreciate the potential, but also worry about implications for their liability. The quality *Responsibility* (EQ) refers to the state of being accountable. Liability for decisions, such as those made during triage, is transformed in the appropriation of technologies like the BRIDGE eTriage, where logging can become an issue discouraging first responders from certain actions for fear of liability. There are no easy ways of balancing *Traceability and Auditability* and *Responsibility* and ultimately the *Right to be Forgotten* (LQ) (more on this below). The BRIDGE team have developed conceptual resources to enable the people involved in crisis management and response to notice and manage such conflicting demands (see D12.3 and D12.4, as well as Buscher et al 2014 and Kerasidou et al 2015 forthcoming)

3.2.5 First Responder Integrated Training System - FRITS

As demonstrated in a presentation after the BRIDGE Golden Hour, FRITS seeks to establish an optimal learning and training methodology, supported by the integrated BRIDGE System of Systems. In doing so it strongly supports *Prudence* (EQ), especially with a view to the preparedness of responders and their capabilities of mobilising advanced technologies effectively into the crisis management and response effort. FRITS takes *Traceability and Auditability* (AQ) to unprecedented heights. As was demonstrated, it is possible to monitor the movement, communications and vital signs of responders and to retrospectively inspect the unfolding of decisions with a richness and flexibility that is highly valuable. FRITS also addresses *Scalability* (AQ) in a way that demonstrates the power of BRIDGE System of Systems innovation. It can support training activities on all levels from training related workshops, through table top exercises and up to full scale exercises. The supporting tools can be scaled to fit these different training activities and can be chosen and adapted to suit cost- and learning-effectiveness training. The exercise management team can adjust which of the 5 phases and activities in the Methodology Tracker (MeTracker) is relevant for each training activity.

While such richness and flexibility is highly valuable, responders have voiced concerns over how they can exercise their *Right to be Forgotten* (LQ), especially when lessons learnt from training exercises carried out with their participation could be used to train subsequent groups with different participants. BRIDGE responds with an awareness that personal data no longer required for the purpose of the processing stated at the time of collection should be securely disposed of after it is no longer needed, as this was discussed during many encounters with responders and during the internal Privacy Impact and Ethical Impact Assessments. However, this could simply lead training organisations to state their purposes as wide as possible, including re-use of data for training subsequent clients, which does not address the responders' concerns. The BRIDGE team are developing concepts of designing 'for' privacy and the right to be forgotten, for example, by leveraging state of the art capabilities for homomorphic encryption and accountable datamining data mining (D12.4). We are developing ideas for research proposals that leverage these, building on BRIDGE innovation, given the fact that training is a domain where the richness and flexibility of monitoring and analysing responder activities is taken to unprecedented heights within a safe and experimental, non-libellouslibelous environment.

3.2.6 Information Intelligence

As remarked upon by one of the reviewers at the demonstration, the rise of social media use in crisis situations is seen as frightening by many emergency response professionals. There are debates about the reliability and utility of the information generated for situation awareness, and the dangers of rumors, self-organised responses and vigilantism (D12.2, D12.3, Perng et al 2013, Pohl 2014). But it is critical to be aware of the conversations and self-organized volunteering that emanate from 'the crowd' the sheer amount and the 'noise, misinformation, lost context and the unstructured nature of social media updates all contribute to an emerging

information processing problem, with information seekers forced to "drink from the firehose" to identify the data they need' (Starbird 2012).

The BRIDGE Information Intelligence CC addresses this issue of information overload by enabling advanced *Mixed Intelligence* (AQ), that is, analysis that combines computational processing with human sense-making in a way that provides richer and more accurate insight and supports *Prudence* (EQ). There is no automatic decision performed, the CC forces a collaboration between the technology and the user. For example, the user has to look at identified sub-events and mark them as important to push them to the BRIDGE system to be consumed by concept cases like Master.

Tracking communication about 'sub-events' in a crisis also allows responders to react more dynamically and in a more informed manner to information and activities orchestrated by members of the public using social media. More detailed knowledge about this opens up the potential of more *Inclusiveness* and *Cooperation* (EQ) in crisis response, as emergency responders can engage more directly with the public if required (Buscher and Liegl 2014).

The simulation engine in the Information Intelligence CC also supports *Prudence* (EQ) in another way, by enabling integration of simulated social media communications to dynamically be fed into exercises, enhancing the preparedness of responders.

Because the Information Intelligence CC processes personal information provided for purposes other than crisis management there are mechanisms to prevent unauthorised access, including login mechanisms, realising qualities of *Access Control* (LQ) to protect *Privacy* (LQ). In relation to this, the BRIDGE team have also explored the design of representations that could be inspected by users allowing them to understand how their social media entries are used and how they are analysed to be able to take control of their privacy in a more circumspect manner. However, a suitable explanation/representation of the analysis approach would be needed, which is understandable by non-experts. Research building on BRIDGE could develop this.

There is a frequent concern regarding *Fairness* (EQ) when the organization of search and rescue missions shifts from a grid based approach to a potentially more accurate and sped up approach which relies on location information, provided by social media. Such an organizational shift entails the potential for a digital divide if first responders prioritize such calls for help. At the same time first responders might be under pressure if they stick to other established criteria and do not prioritize those calls / information. Information Intelligence addresses these issues in that the sub-event approach scans for clusters of incidents / people affected and heavily impacted areas, thus not privileging individuals but providing *Inclusion* (EQ), since the notion of a sub-event raises awareness not only for those who reported it, but also other people effected who are in the area / nearby.

A further important issue in relation to Information Intelligence is the reliability of data provided by members of the public, raising issues around the legal quality of *Data Quality* (LQ). In D12.2 we discussed how providing or acting on crowd-generated information about conditions carries potential legal liability (p. 118). As demonstrated the Information Intelligence CC responds to this possibility to post malicious or inadvertently false information within social media. For example, it is designed so that the number of reporters discussing the same sub-event is currently displayed as a simple reliability gauge. In the future, additional "trust-models" to identify reliable information can be developed.

3.2.7 Master

The Master addresses many of the qualities already mentioned, and many of the other CCs support the qualities the Master excels at. As the visual portal to the BRIDGE System of

Systems it supports *Cooperation* (EQ) and *Overview* (AQ) in an exemplary manner, which is why we have reserved discussion of these qualities until now.

Users can subscribe to information from a vast array of diverse systems and have it displayed, demonstrating also the capacities of BRIDGE to achieve *Scalability* (AQ) and *Versatility* (AQ) in systems of systems. The use of EDXL means that a wide range of systems can connect to the Master, facilitating *Interoperability and Coherence* (AQ). Users can push information to others and enter into message communication, access predefined emergency plans and collaborate *in situ* and in distributed settings, for example by drawing on the Master map, which can flexibly be turned to be visible for all connected, or be kept private, for example to the command and control center. Cooperation is also supported through the resource allocation mechanism, which can assign responsibilities via drag and drop. It can also be used to minimize complexity for users when the system scales up.

Mixed Intelligence and *Privacy* can be realised through the use of filtering. *Mixed Intelligence* or computationally augmented human reasoning is supported in unprecedented ways, because information is automatically synchronised, and it is possible to assemble it visually in precise and easily understandable ways, also utilising mechanisms of visual information aggregation that reduce information overload and clutter. This enables production and maintenance of a rich common operational picture across many distributed locations.

There is a risk that users of the system can focus too much on things shown on the map and forget that there are more elements involved, undermining *Inclusiveness* (EQ). For example, victims who are not tagged with e-triage bracelets will not appear and could be forgotten. There may also be responders, resources and bystanders involved in the crisis who are not tagged and therefore not visible. The experiments with BRIDGE prototype systems of systems show that practitioners already always combine the use of new technologies with analogue systems or systems that cannot be integrated easily. Thus socio-technical means of responding to this challenge exist, reminding us of the fact that BRIDGE is only a partial not an all encompassing system of systems that has to fit into an ecology of practices inside and outside its boundaries.

3.2.8 Robust and Resilient Communication

At this demonstration the focus was on the integration of the Help Beacons system into BRIDGE system of systems, for example, combining its functionalities with the Advanced Situation Awareness CC and the Master. Like most of the development undertaken in the Robust and Resilient Communication CC, the Help Beacon system exemplifies the BRIDGE response to challenges arising around the qualities of *Maintainability & Flexibility & Reversibility & Modifiability / Evolvability* (AQ), apart from also addressing many of the other qualities already discussed. The Help Beacons system does this by utilising remnants of networking (Al-Akkad et al 2013 and in preparation). The concept was inspired by how people make use of the names of Wi-Fi home networks (SSIDs) to broadcast short messages conveying simple, anonymous information. For instance, some SSIDs may express neighbourly requests as "Turn the noise down". A Wi-Fi network is visible in a certain range and the advertised SSID is usually the first thing people become aware of in terms of wireless networks. Essentially, people can easily relate and understand SSID names. They represent an interesting point of contact between people.

The creation of an emergency beacon defines a sort of "Help me" signal (also called a HelpBeacon), which may help professional first responders to find persons, addressing the quality of *Dignity/Humanity* (EQ) by reducing fear and suffering. As default settings in smartphones notify users of the presence of detected networks, any arbitrary person in vicinity may discover the emergency signal and become involved in the rescue process.

The design supports *Compatibility* (AQ) by using Android, the most widespread operating system for mobile devices, and by supporting lower API versions the system can be installed on a wide range of devices. The App can be installed virally, as long as one person within range has it on their device. As soon as the victim application is launched it starts to search for available Beacons. Also users can select from predefined help messages or type in a new one.

The design supports *Modifiability*, *Evolvability* and *Reversibility* (AQ) in particularly interesting ways. *Modifiability* is the way in which the BRIDGE system of systems approach supports enhancements to individual components while keeping the system as a whole working. By integrating the Help Beacons system with Advanced Situation Awareness and Master CCs, the capabilities of all three are extended. *Evolvability* allows users to extend the assembly of systems whilst assuring continuity of the whole. This is demonstrated in the *Graceful Degradation* (AQ) of the Help Beacons system in 'broadcast' mode (to be used, for example, in an earthquake situation), where victims send out beacons to be received by responders to the 'seeker' mode, where victims silently send a beacon, which can only be read by authorised response personnel (to be used in a shooting or terrorist incident situation). This capability responds to the potential misuse in certain scenarios, where there is a threat that people may generate fake distress calls, which could be harmful for first responders that react based on such false information. Similarly, the distress signals could reveal information about the location of victims which could put them in danger if read by the wrong people. This capability also illustrates the BRIDGE approach to realise the quality of *Reversibility*, which allows designers and users to revert to previous states and change the design, as the BRIDGE systems of systems approach provides a service oriented and component based architecture.

3.2.9 Situation aWAre Resource Management

The SWARM system critically supports capacities of resource management. It provides a complete *Overview* (AQ) of resources (including assets and first responders), their status, availability and their location, to incident commanders as well as first responders in the field (overview limited to their immediate surroundings). It supports *Cooperation* (EQ) through allowing managers to communicate tasks to first responders with more detail and room for negotiation and explicit acknowledgement, by means of text message based task descriptions, as an alternative to radio communication. It also enhances *Cooperation* by providing new ways to involve human resources in a more ad-hoc manner, by means of dynamically creating teams which adhere to location constraints, availability constraints and capability constraints, reducing the operational efforts of incident commanders and enabling them to focus on the tactical level.

By being able to carry out these functions with a potentially vast number of resources, the SWARM exemplifies the BRIDGE response to *Scalability* (AQ). Utilising the middleware, it is able to visually communicate resource and task status updates to all relevant first responders and command posts within 30 seconds after these statuses have been updated, illustrating how BRIDGE addresses the qualities of *Performance* (AQ) and *Capacity* & *Load Utilisation* (AQ).

More specific information regarding the technical realisation of these qualities is provided below and in the respective technical deliverables, as well as summarised in D2.5.

3.3 Concept Case Adaptive Logistics

3.3.1 Overall Goal

Adaptive Logistics is aiming for observing, controlling and managing the big amount of resources in a large scale incident. Dynamic response on changing situations should guarantee the best possible support to both incident managers and the teams acting on site.

3.3.2 Main Functionality

Main functionalities include the observation of movements of all kinds of resources as well as offering support in decisions to be made regarding consequences of logistic actions.

3.3.3 Integration with other Concept Cases

All Concept Cases relevant for the collaborative workflow generation are to be considered for integration and embedded in BRIDGE system. This Concept Case is a very generic one.

3.3.4 Features visible in BRIDGE Demo IV

Features shown in the final demonstration include

- workflow concepts
- collaborative workflow generation
- integration
    - embedding in BRIDGE
    - requirements elicitation
- implementation
    - use case from CC Adaptive Logistics.

3.4 Concept Case Advanced Situation Awareness

3.4.1 Overall Goal

The overall goal of the PLUS demonstration was the operational readiness of the CC ASA for deployment in a disaster.

3.4.2 Main Functionality

The main functionality of the CC ASA is the collection of visual and IR data, measurement data on toxic gases and radiation levels, use this information for 3D/2D modelling and issue a computer-based advice to the Incident Commander.

3.4.3 Integration with other Concept Cases

CC ASA was integrated through the BRIDGE system with Help Beacon and MASTER.

3.4.4 Features visible in BRIDGE Demo VI

During Demo IV CC ASA showed the UAV, EXPERT System and Modelling on display, as well as the simulated data transfer to the MASTER. Furthermore, the whole ASA system was shown under field conditions and during training with first responders in a video filmed in Austria.

3.5 Concept Case eTriage

3.5.1 Overall Goal

eTriage should support the triaging process without any needs for other communication networks, like mobile networks or internet. I provides overview of all victims including information about their health or injury status.

3.5.2 Main Functionality

The main functionality includes triaging of victims in three classes as well as an ad hoc manner communication of the eTriage devices. Backup system in case of electronics malfunction is simply the colour of the bracelet, which makes the system reliable as the currently existing ones.

3.5.3 Features visible in BRIDGE Demo IV

Triaging, ad hoc communication and also the physical properties of the bracelets like size and weight, colour, usability have been demonstrated.

3.6 Concept Case First Responder Integrated Training System (FRITS)

3.6.1 Overall Goal

In order to improve the emergency actor's readiness and operational awareness, proper training and regular exercises are major activities for all crisis management actors and new systems should have training as an integrated part of the service for first responders to do their training using the system.

The Overall Goal for FRITS is to combine 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 live 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.

3.6.2 Main Functionality

The FRITS system provides tooling which is integrated into the BRIDGE system to support the overall life-cycle of the CTAS training methodology. The Figure under provides an overview of how tools provided by FRITS support the various phases defined.

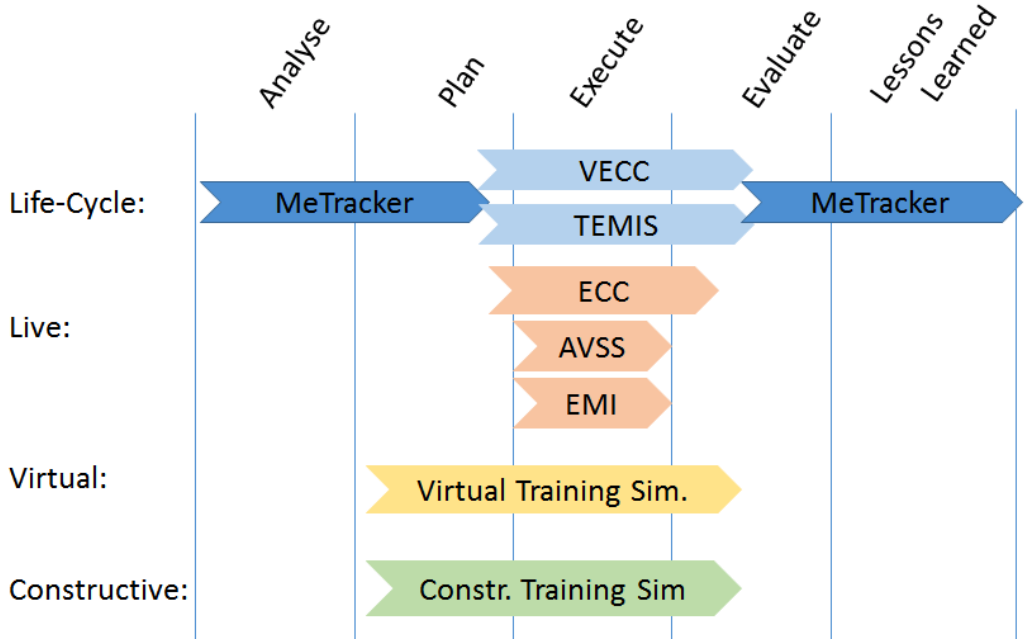


Figure 7: FRITS tooling for CTAS methodology life-cycle support

To support the overall life-cycle of the CTAS Training methodology, FRITS provides a training methodology portal (MeTracker) supporting the exercise managers in their Analyse, Plan, Evaluate and Lessons Learned phases of a training process. To support the Execute phase an observation tool (TEMIS) is supporting in the exercise. VIRTUAL Exercise Control Centre (VECC) is a fairly new concept that should be the central point of interaction between training modules.

For Live Training, besides tools to access and modify the Live Training Data containing training objectives, scenario descriptions etcetera, FRITS provides an Audio-video Streaming service (AVSS) to track and log interactions between training participants, an External Model Interface (EMI) that allows the inclusion of real-life sensors and equipment in the training, and an Exercise Control Centre (ECC) that will support the exercise management with necessary information to control and manage the exercise.

For Virtual Training, FRITS provides a flexible simulation training solution for scenario training and mission rehearsal.

For Constructive Training, FRITS provides a Constructive Training Toolkit that supports multi level training, based on COTS constructive simulators to interact with the training data. Such a toolkit support multi-level training.

3.6.3 Features visible in BRIDGE Demo IV

The main FRITS features presented in BRIDGE demo IV was the MeTracker, the TEMIS observation tool and the Virtual training concept. Demo IV also demonstrated the integration between FRITS and the BRIDGE middleware through receiving relevant information from different end users (position, time and a Unique ID) used for evaluation purposes. FRITS also demonstrated how a virtual simulator can be used as a dynamic input/response tool for end users to train on operational systems.

3.7 Concept Case Information Intelligence

The aim of BRIDGE Information Intelligence is to find automatic analysis techniques to harness (social) multimedia data from crisis-related situations.

3.7.1 Overall Goal

In all emergency management phases (i.e., preparedness, response, and recovery) information about the current situation is vital. People document any situation they are confronted with in social media. The aim of BRIDGE Information Intelligence is to propose data mining techniques that perform an automatic analysis of such data in addition with live data from the field. The results of the analysis can be seen as a sort of situational report.

3.7.2 Main Functionality

The BRIDGE Information Intelligence software comprises three components:

- *Aggregation Component*: This component performs the online aggregation to detect sub-events (= specific hotspots of a crisis). Sub-events are visualized on a map.
- *Data Simulation Component*: It allows the creation of simulation data during a running exercise (e.g., for training purposes). The simulation is based on prepared text snippets and a storyline related to the defined exercise.

- *Data Collection Component*[3]: The component is implemented as an Android App and allows collecting data from in the field. It offers the possibility to send text messages and pictures annotated with text to the aggregation component.

For details on the components, please be referred to D4.4 "Specification of the Multimedia Data Handling Components" and D6.3 "Stationary Command Post and Mobile Devices".

3.7.3 Features visible in BRIDGE Demo IV

The following information about the activities within the concept case has been given:

- Presentation of an overview of Information Intelligence, introduction to the major functionalities, summary of the research activities, and results of the previous demo
- Activities of the last project period related to Information Intelligence, summarized as a poster (major findings on classification with active learning in emergency management)

The following features have been demonstrated in BRIDGE Demo IV:

- Presentation of the online aggregation (i.e., sub-event detection)
- Visualization of the sub-event detection results on a web-based user interface
- Simulation component to generate/simulate data for the BRIDGE Demo Scenario
- Data collection using the Android App (pictures were taken live during the Demo IV)
- Sharing of sub-event information with other concept cases (e.g., integration with the BRIDGE Master)

3.8 Concept Case Master

3.8.1 Overall Goal

The master is the interface to the incident commander first of all. Of course, other persons involved in responding to the crisis have access to selected information provided by the master as well. The main objective of the master is to provide the relevant information just in the right level of details (i.e. all an IC needs but avoiding information overflow).

3.8.2 Main Functionality

Making visible all different kinds of information which is made available through the BRIDGE system in an easy and understandable way.

3.8.3 Features visible in BRIDGE Demo IV

In the BRIDGE Demo, the Master showed an overview of resources including their availability status, victims, availability of hospitals, the dispersion of a toxic cloud – all that displayed on maps showing the incident area. Clustering information depending from the zoom factor of the map was very useful to keep overview of the area currently shown on the screen.

[3] The Android App was developed by BRIDGE colleagues: Amro Al-Akkad (Fraunhofer FIT) and refined by Christian Raffelsberger (Alpen-Adria-Universität Klagenfurt, UNIKLU).

3.9 Concept Case Robust and Resilient Communication

3.9.1 Overall Goal

The main goal of this concept case is to create an ad-hoc networking infrastructure that provides networking services on an incident site. Two interconnected systems are created to achieve this: the BRIDGE Mesh network and the Help Beacons system. The BRIDGE Mesh network allows other systems to exchange data locally or send them to other networks such as the Internet. The Help Beacons system allows people to use their smartphones to signal their need for help via opportunistic networks.

3.9.2 Main Functionality

The BRIDGE Mesh is a deployable wireless ad-hoc network to provide a networking infrastructure to interconnect other systems on the incident scene and provide a gateway to other networks such as the Internet. The Help Beacons system provides a way for people to call for help using their smartphones. It consists of the Help Beacons victim application that runs on off-the-shelf Android smart phones and uses their Wi-Fi capability to advertise short help messages (so called HelpBeacons). No mobile network service is needed for this feature, since the phones create Wi-Fi networks that are used for exchanging data between victim and first responders. The Help Beacons responder application is used by first responders to collect HelpBeacons in their vicinity and locate victims. The collected information can be sent via the BRIDGE Mesh to other systems such as the BRIDGE Master.

3.9.3 Integration with other Concept Cases

The BRIDGE Mesh is a deployable wireless communication infrastructure that can be used by other concept cases to exchange data on the incident site and with external systems if Internet connectivity is available. In particular, the BRIDGE Mesh has been used to send distress messages, collected by the Help Beacons responder application, to the BRIDGE Master. Similarly, the BRIDGE Mesh has been used to send triage data to the BRIDGE Master.

3.9.4 Features visible in BRIDGE Demo IV

The demonstration focused on the Help Beacons application and in particular on features that were added after Demo III. The first feature concerns the recording of short voice messages with the responder application. These messages are sent to the victims' application as soon as a connection between seeker and victim application is available. This feature has been implemented since feedback from the EUAB after Demo III suggested to provide a way for a more personal communication between first responders and people in distress. Before that, the victim application only displayed a simple text message indicating that the distress signal has been received by a first responder. Another new feature is that victims can take photos with the victim application. These photos are sent to the responder application and forwarded to the BRIDGE Master as part of the EDXL report that contains the distress messages collected by the responder application.

3.10 Concept Case SWARM

3.10.1 Overall Goal

BRIDGE SWARM (Situation aWAre Resource Management) 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.

3.10.2 Main Functionality

The smartphone offers insight into the location of an incident, the location of command/control posts, the location and status of surrounding resources, and the location, assigner and status of the current task at hand. Furthermore, it can be used to inform others (commanders, first responders) about the task status, team status and personal status.

The smartphone is connected to the Master via the BRIDGE middleware. On the master, incident commanders can get insight into the location and status of Resources, the ETA for moving resources and the current tasks and their status. In addition, the Master can be used to assign new tasks to resources, either explicitly (direct assignment of a task to a particular resource) or implicitly (assigning a task to a certain amount of resources of the same type).

3.10.3 Integration with other Concept Cases

SWARM has been integrated with the Master concept case, as well as with the Adaptive Logistics and the Advanced Situation Awareness (ASA) concept cases. The BRIDGE middleware has been used to achieve these integrations. Integration with the Master consists of an exchange of resource information to the Master table and exchange of task assignments from the Master table to the appropriate resources. The adaptive logistics concept case, which mainly consists of the collaborative workflow generation and management (CWFGM) services, can assign tasks to resources. Finally, integration with the ASA concept case consists of an exchange of resource locations and statuses to the ASA expert system console.

3.10.4 Features visible in BRIDGE Demo IV

Throughout Demo IV, the SWARM concept case has been demonstrated by using a large-scale simulator which simulates the resource movement and task assignment events. Furthermore, integration with the Master has been demonstrated (task assignment), as well as integration with the ASA concept case (resources moving in the expert system console).

4 Summary

This report documents the final BRIDGE Demonstration in the underground test facility of VSH, in May 2015, with special emphasis on the integration of BRIDGE technology to provide a common operational picture to incident managers in large crisis management.

The Demonstration highlighted the contribution of Concept Cases embedded into the timeline of the Golden Hour with reference to a historical incident, the Toulouse AZF explosion in September 2001. The demonstrated integrated BRIDGE technologies included:

- Adaptive Logistics
- Advanced Situation Awareness
- eTriage – 2 types
- First Responder Integrated Training System FRITS
- Information Intelligence
- MASTER,
- Robust and Resilient Communication

Situation aWare Resource Management This demonstrator combined the three prior demonstrators and included aspects of the 3D visualization and simulation technology. It addressed all relevant stakeholders involved in the crisis scenario.

Figure 8: The BRIDGE Final Demo and Review Team at Hagerbach Test Gallery.

Appendices

Appendix I: Agenda of the final Demonstration

BRIDGE

Bridging Resources and Agencies in Large-Scale Emergency Management
Seventh Framework Programme (FP7-SEC-2010-1) SEC-2010.4.2-1
Interoperability of data, systems, tools and equipment
Grant Agreement No.: 261817
www.bridgeproject.eu

Agenda

Final review
20-21 May 2015

V.S.H. Hagerbach Test Gallery
Polistraße, Hagerbach,
8890 Flums,
Switzerland

Logistics

Travel recommendation: Go by train from Zurich Airport to Sargans (one change at Zurich Main Station). Notify us on arrival time and VSH will arrange a pick-up service at the train station.

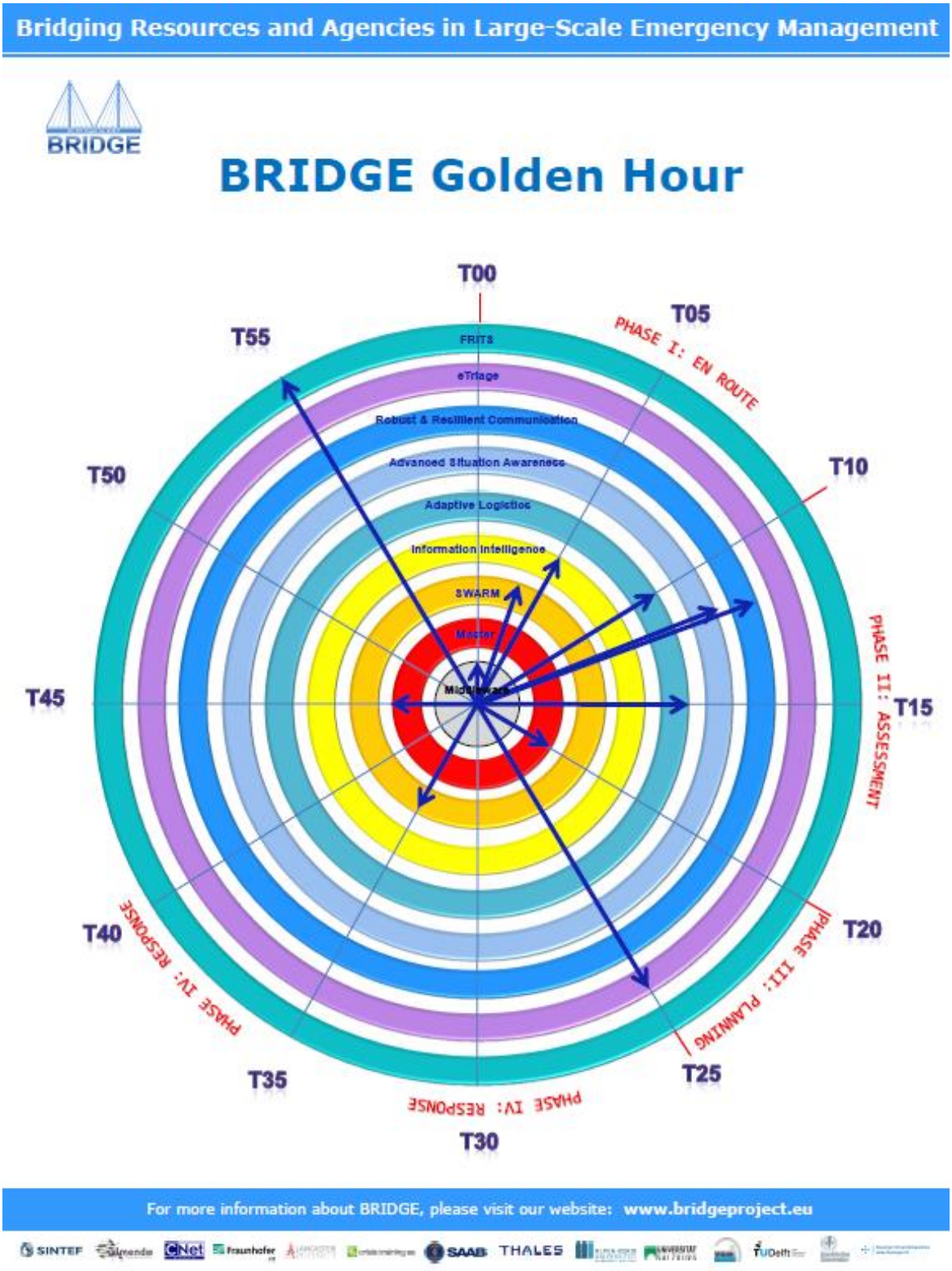
Hotel recommendation: Hotel Seehof Walenstadt, www.seehof-walenstadt.ch

Wednesday 20 May Location: VSH Hagerbach Test Gallery

08:30	Transport from hotels (bus or taxi)			
09:00	Welcome Safety instructions		Dag Ausen Maximilian Wietek	SINTEF VSH
09:10	BRIDGE and the final Demo Scenario description – "phases on the timeline" and links to BRIDGE	D1.8 D9.4	Evangelos Vlachogiannis Maximilian Wietek	Fraunhofer VSH
09:50	*The Golden Hour* – Walk-around demonstration and presentation BRIDGE system of systems: 1. Normal operation 2. En Route 3. Situation Assessment 4. Plan 5. Response	D10.4	Peeter Kool Andries Stam Daniela Pohl Bernard van Veelen Friedrich Steinhäusler Amro Al-Akkad Christian Raffelsberger Jan Håvard Skjetne Erion Elmasllari	CNET Almende UniKlu Thales PLUS Fraunhofer UniKlu SINTEF Fraunhofer
13:15	Lunch			
14:15	Technical integration – how to use the middleware	D5.2	Peeter Kool	CNET
14:40	Training to improve quality of emergency response and crisis management	D7.5b	Morten Wenstad	CTAS
15:00	Domain analysis and Ethical, Legal, Social Issues	D12.3 D12.4	Alexander Boden Monica Bucher	Fraunhofer ULANC
15:20	Summary including "with/without BRIDGE" comparison		Max Wietek Paul Burghardt	
15:45	End-user & Exploitation – Walk-around	D11.2 D13.3 D13.4	Paul Burghardt EUAB / Eivind Rake	Thales Rakos
16:30	Questions & answer session		Panel discussion	
17:00	End of demo. Dismantling of demo			
17:00	Reviewer's meeting		Francesco Lorubbio	EC/REA
17:30	Departure for hotel			
19:00	Review dinner and social program (Römerturm Kerenzerberg)			

	Thursday 21 May	Location: VSH Hagerbach Test Gallery		
08:00	Transport from hotels (bus or taxi)			
08:30	Coffee			
09:00	Welcome and agenda for the day		Francesco Lorubbio	EC/REA
09:10	WP1 – Management report	D1.7	Dag Ausen	SINTEF
09:30	WP2 – Domain analysis	D2.4 D2.5	WP-leader	
09:45	WP3 – 3D Simulation and Distribution of Threat Scenarios	D3.4	WP-leader	
10:00	WP4 – Specification and System Architecture	D4.3 D4.4	WP-leader	
10:15	WP5 – Network Infrastructure and Interoperability	D5.2 D5.3 D5.4	WP-leader	
10:30	WP6 – Interaction Design	D6.3 D6.4	WP-leader	
10:45	WP7 – Collaboration Technologies	D7.4 D7.5a/b	WP-leader	
11:00	Coffee break			
11:30	WP8 – Integration	D8.2	WP-leader	
11:45	WP9 – Demonstration	D9.4	WP-leader	
12:00	WP10 – Validation and Evaluation in the Real World	D10.3 D10.4	WP-leader	
12:15	WP11 – Business Modeling and Exploitation	D11.2	WP-leader	
12:30	WP12 – Social, legal and Ethical Aspects	D12.3 D12.4	WP-leader	
12:45	WP13 – Dissemination and Standardization	D13.3 D13.4	WP-leader	
13:00	Lunch break			
14:00	Overall achievements	D1.8	Evangelos Vlachogiannis	Fraunhofer
14:30	Questions & discussion		Reviewers & PO	
15:00	Reviewers meeting		Francesco Lorubbio	EC/REA
16:00	Feedback from reviewers and remaining steps to close the 3rd period			
17:00	Closing of meeting			

Appendix II: Description of the Golden Hour



Storyboard – The Golden Hour

BRIDGE Final Review Scenario

Standard Operating Procedures for First Responder Organisations in Case of Major Incidents **Response phase**	**BRIDGE contributions** **Concept cases**	**Current Practice 2015**	**AZT Experience 2001**	**ELSI**
<u>Phase -1</u> (T - 24 h) **Routine Operations**	Operator in Bunker, FR unprotected, HAZMAT Tanker monitored Help beacons, Dynamic Tagging, UAV+ Cameras + Sensors, SWARM, Master at OP Centre • Master: Monitoring of key sensors and resources. • Tags ready to use, turned off and packed in triager tag-packs • SWARM is used during routine operations to monitor location and status of local staff. Other local areas also use SWARM during routine operations	Seveso Directive updated, compliance more strictly enforced. Information about dangerous substances must be available. Sub-contracting has to be taken into account as a risk factor. Training. Testing Equipment. Monitoring the plant activity and risks. Emergency services on duty as usual and prepared as normal.	Plant carries 'high risk' Seveso Designation, which requires strict safety procedures. Guidelines were not closely followed (Mayerfeld Bell 2004). Three subcontracting companies worked on the storage of an estimated 390–450 t of 'off-spec' Ammonium Nitrate in the place where the explosion occurred.	Monitoring of sensors and staff (if it includes arrival of 'off-spec' material & sub-contracting staff) could have allowed closer scrutiny of risk and prevented incident - *Prudence*. Training would have heightened preparedness.
<u>Phase 0 (T = 0)</u> **Major Incident**	Chemical Reaction in off-spec ammonium nitrate material leads to explosion at t=0 Primary & Secondary Explosions	Detection of leaks etc. and the following explosion	Explosion (20-40 ton TNT equivalent, 3.4 Richter scale)	
<u>Phase 1 (T + 15 min)</u>	**Bootstrapping BRIDGE System of System:** all services available register with the	***Alarm*** is the time from when the emergency services are	The alarm system at the factory never activated.	BRIDGE tracks and controls

Alarm (Fire, EMS, Police) **En-route (Fire, EMS, Police)** **Arrival (Fire, EMS, Police)**	*Bridge Service Catalogue*, the *BRIDGE QoS Repository*, *BRIDGE Policy Database* and frequently update their status in the *BRIDGE Status Repository*. (For interaction protocols see D05.3 and D07.4 respectively). **Continuously**: arriving organisations dynamically register their resources in the repositories indicated above. *CC Information Intelligence* started to gather and analyse tweets on explosions, damages, traffic, etc. - also on potential terrorist declaration. SWARM & Master show resources arriving. Resources are registered nationally/on European level. Resources can add themselves to the incident. Or be assigned by the incident commander. Or be assigned by entering the local network. The issue of responders arriving unannounced and get in the way is resolved. Master/Middleware enable integration of information from local authority who, according to the Seveso Directive major-accident prevention policy (MAPP) have been provided with information sufficient to identify the dangerous substances, quantity and physical form, activity with it, areas and developments that could be the source of risk. Tags still packed and turned off inside triager's packs. However, triagers are	notified until the first responders are on the way to the incident. The service/commander has normally less than two minutes to process information, assess and make decisions regarding the first response (equipment, personnel etc.) before leaving the station**.** ***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. ***Arrival*** on-scene the accident includes the time when the commander and responders arrives at the scene, parks 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	There was concern this could be a terrorist attack (10 days after 9/11). The shockwaves were so powerful that police were inundated with reports of explosions in different parts of the city. Major traffic problems quickly arose around the site after the explosion, creating difficulties for the emergency services to reach the scene. Besides, extensive damage hindered rescue services in their efforts to reach the factory. Despite major traffic problems, the first rescue team was on-scene 13 minutes after the explosion. A major disaster alarm was triggered in Toulouse 20 minutes after the explosion, signalling for a rescue effort to commence.	access to sensitive personal and risk related information. Access is logged. (Autonomy, DP) Master supports emergency call centres in managing Information overload, other SWARM and Master support communication with media. Concern with terrorism could trigger social sorting data processing. BRIDGE could facilitate this. Major traffic problems become visible through SM sub event analysis. (Efficiency, Agility, Prudence) Digital global

	carrying the packs with them. CC Robust and Resilient Communication: People in distress use their smartphones to signal SOS via the Help Beacon Victim App. The SOS signal contains a message (e.g. 'Help Me') and optionally an emergency profile, which includes the time the SOS call was setup, the phone ID and if available a name and GPS location.	is normally less than two minutes and is affected by the incident area and the level of chaos.		and local volunteers want to contribute to the response effort, and BRIDGE middleware facilitates these contributions. Peeter integrates feed from a hobby UAV. There are legal issues around permissions, data quality and reliability. BRIDGE policy recommendation - work with VOST.
<u>Phase 2 (T + 15 min to + 30 min)</u> **Assessment / Size-up (Fire)** **Area security / Cordons (Police)** **Setting up Incident Command (Police, Fire)** **Planning (Fire, EMS, Police)**	*CC-Adaptive Logistics*: **Need I: Assessment of Safe and Dangerous Areas** : Incident Commander (IC) wants to know where he can safely deploy medical and firefighting resources. **Response I - Area Safety Assessment**: The WF-Generation mechanisms (CWFGM) compute a workflow Safe Area Assessment and kick off the assessment process, including service requests to the Risk Analyzer Modeler (RAM), DEIN, the UAV (Hexa-copter) and available external	The ***response*** phase (phase 2 and 3) 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 damage. The phase is characterised by stressful and complex dynamic environments with time pressure, unique and badly	Rescue work began without a preliminary risk assessment for the rescuers. There was a lack of training The firemen, arriving on scene first, were not protected with adequate equipment for any toxic cloud and with devices to detect those toxic gases. Only after 30 minutes [since the arrival of the first rescue	

	sensors. Result information is to be displayed on the MasterTable. Execution of workflow Safe Area Assessment is monitored by QoS Monitoring Service. **Need II: Assessment of victims**: The IC wants to know where (he can expect the) victims are, an estimate of how many victims there are (to be expected) and the (expected) type of their injuries. **Response II - Victim Assessment**: In response to Need II, the CWFGM computes a workflow Victim Assessment and kicks off the involved services, including RAM, DEIN and PLUS Modeling as a Service (MaaS). Result information is to be displayed on the MasterTable. Execution of workflow Victim Assessment is monitored by QoS Monitoring Service *CC Advanced Situation Awareness*: The first-arriving fire unit flies the *UAV* over the explosion site and sends the first images of the destruction, thermal images of fire, and environmental sensor data from the cloud to the Incident Command. Using the data, *Expert System* provides advice to the Incident Commander regarding self-protection measures for first responders and precautionary measures for the members of public.	structured organisations involving multiple players, critical values at stake, and unclear and competing goals. **Tasks incident commander (IC);** Determining the first incident objectives and strategy. Setting immediate priorities and assigning subsequent priorities. Workings out an action plan. Informing agencies and organisations of the incident status. Establish an appropriate organization.	team] did measurements show that the cloud of dust and smoke caused by the explosion had a “low” toxic content. A local operational centre was set up almost immediately after the explosion. It played a crucial role in the coordination between the emergency medical service (SAMU), general medical practitioners, firefighters and UIISC soldiers.	
<u>Phase 3 (T + 30 min to + 1h30min)</u>	*CC Advanced Situation Awareness*: The *Modelling Module* makes a plume	Long-time response	Search and rescue operations began	

Incident commanding (Fire, EMS, Police) **Information (Fire, EMS, Police)** **Search and rescue (Fire)** **Firefighting / Technical response (Fire)** **Triage (EMS)** **Establishing Casualty Assembly Point (EMS)** **Pre-hospital medical care (EMS)** **Medical transportation and distribution (EMS)** **Evacuation / Sheltering (Police)**	dissipation model for the next few hours based on the available meteorological data and transmits the model to the Incident Command and Police to assist them in the decision-making process with regard to personnel protection, evacuation, and sheltering. *CC Logistiques Adaptive* **Result of Response II - Victim Assessment**: An estimate of the victim distribution becomes available and is presented to the IC. **Need III: IC wants to start a Search- and rescue operation for the victims in the scene**. Found victims shall be triaged and evacuated ASAP. **Response III - Search and Triage**: Deployment of search-and-triage-teams with Triage bracelets. The CWFGM services compute a workflow SAR, and distributes orders to the services involved, including (a number of) SWARM teams of triage-experts. The eTriage information is to be displayed on the MasterTable. Execution of workflow SAR is monitored by the QoS Monitoring service. CC Triage: Triagers start triaging people. Tags turn on and start transmitting data. Data show up in the MASTER table; medics gather the people from the field to the gathering places. Information is updated live on the MASTER.	**Incident commander**; Coordinate the activities for all emergency units. Directs the team performing the orders, the decided tasks. Risk assessment and ensure the safety of the rescuers, the response units and the victims and any threatened residents or inhabitants. Setting the hot and cold zone Continuous situation assessment and monitoring the situation. Adjust incident objectives, strategy and plans. Informing agencies, organisations and media on-scene on the incident status. The IC's role at tactical level is to implement the plans and achieve the objectives set by the strategic level. The tactical level priorities, plans and coordinates actions on the operational level. The strategic level allocates resources and supports the tactical level just as the tactical level supports the operational level. The strategic level is located away	immediately after the first firefighters arrived on scene. The rescue units encountered a stream of dusty, injured persons fleeing the industrial area on foot. The operations were conducted on the premises of the factory and in the adjacent districts. Accident Response Plan and local Disaster Alert (Plan rouge) were activated 23 minutes after the explosion. Emergency response was carried out in accordance with two pre-existing disaster plans: the emergency medical aid plan (known as PPI or "Red Plan") and the plan foreseeing the deployment of a network of emergency medical facilities ("White Plan"). This ensured a quick mobilization of the necessary personnel and equipment to provide medical aid to the victims and minimize possible losses. Having staffed ambulances with doctors who were on	

	CC Adaptive Logistics: **Result of Response III - Search and Triage**: When the search-and-triage teams apply (some) e-triage (ET) bracelets the ET data is coming in. **Need IV : Evacuation of found victims**. The incoming ET data triggers the request for preparation for treatment and evacuation of the victim. So, in response to each new victim, the CWFGM computes workflows that achieve treatment and evacuation of each found victim. **Response IV Evacuate victim**: In response to each new victim found, the CWFGM services compute a **WF Evacuate**, and distribute the appropriate requests to the services involved in the WF. These services include: *Swarm-evacuation teams*, *ambulance-acquisition service* (simulated), *Hospital-bed-claim service* (simulated). Relevant information is to be displayed on the *Master Table*. The execution of the workflow Evacuate is monitored by the *QoS Monitoring Service*. CC Robust and Resilient Communication: 1. In response to the disruption of network infrastructure at the incident site, responders start to deploy wireless network devices in order to establish a mesh of connected devices. The network devices provide different network	from the scene at a command center **Responders;** Search and rescue. Firefighting. Decontamination. Triage and pre-hospital medical care. Security hot and cold zone. Evacuation. Transportation to hospital.	stand-by duty, a lot of medical experts could quickly reach the site, although initially there was a shortage of means of transportation. After a few hours, 60 doctors were present on-scene, most of them performing their duties at an assembly point set up a few kilometers away from the source of the explosion. The assembly point started to receive the first injured at 11:00 and provided medical care to nearly 300 persons. The first aid was administered mainly to the seriously injured victims. About 85% of all seriously injured received such aid. At the initial stage of the response, there was a shortage of material resources. Seriously injured persons were taken to hospitals for special care, many of them - using private cars. During the first day, 862 patients were taken to hospitals. The two largest hospitals in the region—the	

	interfaces (ZigBee, WiFi etc.) to enclose the heterogeneity of available devices at the incident site. 2. The search and rescue team enter the disaster zone. Some responders carry smartphones that run the Help Beacons Responder App, which searches for SOS calls in vicinity. In case a SOS call is found, the responder's phone will connect to the victim's phone in order to notify the person (behind the SOS call) that her/his call has been discovered. If the connection is stable enough the victim's phone will also send an emergency profile to the responder's phone. 3. As soon as the responder's phone gets connected to the BRIDGE mesh, collected SOS calls will be sent to the BRIDGE Master to view them on a map. Siliar to the eTriage CC, transmitting the collected SOS calls to the Master is enabled via the BRIDGE Mesh and middleware services (S2D2S).		University linked Rangueil and Purpan Hospitals— received >1,500 injured persons. Rangueil Hospital received 435 injured persons; more than one-quarter of them were admitted for medical care. In addition, 50 people, who were injured at the hospital when it was damaged, also received care. During the day of the explosion, Purpan Hospital received 1,048 injured persons; one-quarter of them were admitted. Three-quarters of the injured who were received at Rangueil and Purpan Hospitals were able to leave the hospital the same day. Of those remaining at the hospital, 25 had suffered injuries, some of them serious. Four people were evacuated to other hospitals. Injured victims also presented at 24 other medical units, several of them private, or presented to their private general	

			practitioners. In order to cope with the influx of injured persons, the staff at Purpan Hospital improvised, and conducted initial triage at the main ambulance entrance, where they allocated the injured to various injury sectors in the hospital. Within several hours an assembly point with 60 doctors was established several kilometers from the explosion site. [This is conflicting with other references which claims that the assembly point started receiving the first injured already at 11 am, i.e., 47 minutes after the explosion.] Acting in accordance with the two emergency plans, the municipal authorities announced the formation of a 30-km safety zone around the city of Toulouse. They closed the local civil aviation airport, stopped all flights over the city, closed off all motor-ways and the city ring road, shut the railway station, stopped all railway transport, and evacuated the	

			metro system. However, movement on the roads was virtually paralyzed, because so many residents rushed to their cars in order to pick up their children and family members from schools and work places and leave the city. As many citizens attempted to leave the area in their cars, they suddenly encountered police blockades at the main roads to the south and at the central city ring road. Acting upon the order by the municipal authorities, local police closed off all motor-ways and the ring-road. However, movement on the roads was virtually paralyzed, because so many residents rushed to their cars in an attempt to pick up their family members and leave the city.	
<u>Phase 4</u> **Scaling up (Police, Fire, EMS)** **Casualty management / identification (Police)**	*CC Adaptive Logistics*: Continuously calculating responses for newly found victims, based on **Response IV Evacuate victim**.	Planning for long time operations. Decide and approve requests for additional resources or for the release of resources.	Within 12 hours, 1,046 firefighters from 13 different fire prevention districts were on-site. It quickly became clear that the number of rescue staff exceeded	

Evidence protection (Police) **Forensics (Police)**		Demobilizing the emergency services when appropriate. Debriefing of staff, responders and involved persons.	requirements, but this made it possible for them to relieve each other. The phone lines were repaired only late in the evening. The Search and Rescue operation was still ongoing after 20 hours, with around 400 firefighters working through the night. Four bodies were recovered during the night, bringing the total to 29. In the following days of 21st September, 1570 firemen and militaries, 950 policemen were involved in the emergency response and housing monitoring. They reportedly arrived on their own initiative without any plan or any discussion by phone as the classical phone lines were partly destroyed and the mobile phone network was saturated.	