



*Platform for European Medical Support
During Major Emergencies*

D7.4 Trials Final Report



PULSE

***Platform for European Medical Support during major
emergencies***

WP7 Trials & validation

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Abstract:
<p>This document provides a detailed summary of the conclusions reached and future recommendations following the PULSE trials performed on June 2016 and September 2016. The purpose of which was to evaluate the PULSE platform in the context of two realistic emergency management situations: an Emerging Viral Disease (EVD)-SARS-like outbreak in Italy (June 2016) and a Mass Casualty Incident (MCI)-crowd crush in a stadium in Ireland (September 2016). In addition, this document also considers the possible transfer of the results achieved to other domains outside of major medical emergencies.</p>

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1 INTRODUCTION

1.1 Purpose of the Document

The purpose of this document is to summarise the high-level experiences from the viewpoint of the end users and decision makers based on the outcome and results of the PULSE trials performed on June 2016 and September 2016. The purpose of which was to evaluate the PULSE platform in the context of two realistic emergency management situations: An Emerging Viral Disease (EVD)-SARS-like outbreak in Italy (June 2016) and a Mass Casualty Incident (MCI)-crowd crush in a stadium in Ireland (September 2016). In addition, this document also considers the possible transfer of the results achieved to other domains outside of major medical emergencies. It also draws conclusions about the practical impact and the constraints experienced throughout the demonstration work within the project.

1.2 Scope

WP7 ("Trials") dealt with all topics around the two Trials in Rome and Cork and the realisation of the ideas developed inside the project. The Trials were initially designed to provide a flexible and representative test bed for the application of PULSE tools and methodologies in the two key types of major medical emergencies: slow rising emerging viral disease/pandemic type event and a fast, immediate Mass Casualty Incident (MCI)-crowd crush stadium crush event or terrorist attack.

Majority of the planned practical work within PULSE (delivering, deploying and applying tools and running test sets) was done by using the features presented by the Trials actual practical implementations.

1.3 General considerations for the work within the Trials

While working on the Trials, all partners and especially the PULSE consortium end user partners UCSC and IAEMO followed these basic considerations:

Starting from the possible event structures, realistic scenarios and general risk, the actual trials infrastructure and its components were designed and implemented.

Upon that, the use case test steps have been derived by applying the methodology and all the experience of the partners in the project.

Beside the goal of building a realistic Trials scenario, which needed to resemble closely the likely decision making process of health service managers and current infrastructure of the end user partners, the practicability and the realness of event, scenarios and test steps were the basis which influenced all the work in the Trials.



Also, company specific concerns influenced the work, which needed to be properly addressed. As the trials, will resemble the real event in many ways, awareness and active risk management was applied along all the work.

Of course, the availability of existing and developed tools shaped the range of the technically feasible actual work.

Especially at the end of the project practical issues partly limited the envisioned volume and extend of the tests and the implementations being transferred.

2 Common Aspects of the two Trials Sites

2.1 Principal System Architecture of PULSE

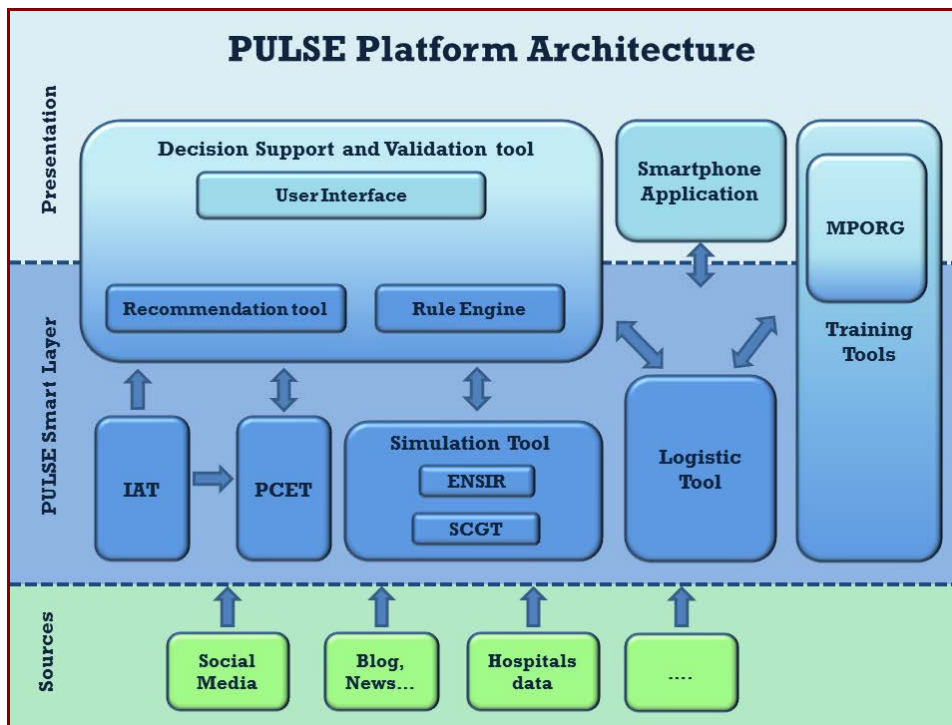


Figure 1: High level architecture

Figure 1 above shows the architecture from a multi-layered perspective. The developed PULSE tools have been grouped in three different layers:

- The **Presentation Layer**: composed of the *User Interface module* (part of the *DSVT*), the *Smartphone Application* and the *MPORG's GUI*, represents the graphical user interface of the PULSE platform. It gives the opportunity, to the different consumers to exploit the features provided by the platform.
- The **PULSE Smart Layer**: it is the core of the PULSE platform. It is composed of all those tools that can analyse, store and elaborate the pieces of information coming from the Sources Layer and to provide enriched crisis management functionalities to the upper Presentation level.
- The **Sources Layer**: it is the bottom layer of the platform. It includes all the external services, data sources providing the medical and environmental information.

2.1.1 Architectural Components

The architecture of the PULSE platform is composed of several software modules/components distributed on a service-based architecture.

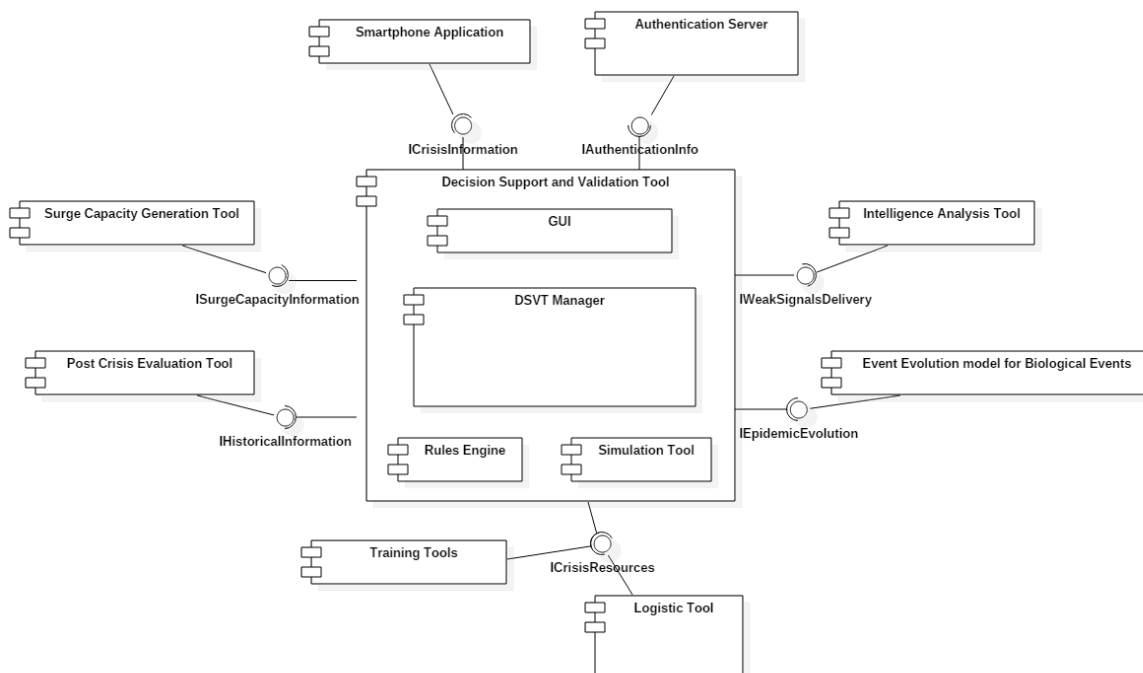


Figure 2: PULSE Architecture – Component Diagram

As shown in Figure 2 above the core of the architecture is represented by the *Decision Support and Validation tool* (DSVT) that acts as the front-end interface as well as the communication backbone of the platform. All the other PULSE tools can:

1. Exploit the interfaces provided by the DSVT
2. Provide functionalities to the DSVT itself.

The PULSE platform is specifically composed of the following tools:

- **Decision Support and Validation Tool (DSVT):** it is front-end interface as well as the communication backbone of the platform.
- **Intelligence Analysis Tool (IAT):** it focuses on weak signal detection to alert decision makers to the occurrence of an unusual biological event.
- **Logistic Tool (LT):** it is used to assess the required stockpiles of any necessary equipment, medications and vaccinations.
- **Surge Capacity Generation Tool (SCGT):** it provides support for the creation of surge capacity in the event of a major health crisis.
- **Training Tools (TT):** these tools include a MPORG training platform for personnel involved in crisis management and a training learning management system (LMS) tailored for the emergency and health services.
- **Post Crisis Evaluation Tool (PCET):** this tool oversees storing and classifying all the resources (including geospatial and time references), events and decisions



that have been taken during the crisis. It allows then the creation of an historical crisis report and the definition of lessons learnt.

- **Event evolution model for Biological Events (ENSIR)**: this tool is the implementation of a mathematical model of epidemics evolution.
- **Smartphone application (SA)**: The Android application can be used to access the PULSE platform.

2.2 PULSE Platform

In the first year of the project, the PULSE consortium has agreed on a functional architecture approach that serves as basis to implement - and enhance existing - preventive and reactive tools and services in ICT systems supporting Major Medical Emergencies.

The Trials implemented the whole framework; in fact, it has been designed to improve the preparedness and response to major medical emergencies.

What the demonstrations did is carry out a concrete test of the PULSE methodologies, tools and services that will help to achieve the desired functionality described in the requirements and use cases identified in the PULSE project.

Furthermore, the results of the demonstration exercise will feed back directly to end users, technology providers and developers who will be able to enhance and improve the technologies going forward.

2.3 Use Case Assignment to the two Trials Sites

For each of the two Trials, and in order to perform the assessment exercise, we developed two very different scenarios

- Slow rising event EVD:
- Fast pace, immediate event Stadium crush:

As already defined and described in D7.2, descriptions for the use cases are available. The planned assignment to the two Trials sites is now subsequently described for Rome and for Cork.

The Emerging Viral Disease (EVD) Trial was conducted as an Extended Table-Top Exercise (TTX2). This means that it was similar to classical Table-Top (TTX), where a realistic emergency is simulated in a meeting between expert members of organizations operating in the simulated scenario, but in addition it was extended, meaning that each member was called to interact with the PULSE platform to evaluate and appreciate the functionalities that it makes available.

The EVD Trial was organised in seven scenes, each of which has a relationship with (1) a specific Pandemic Phase of the National Pandemic Plan and (2) a PULSE Use Case defined in D2.2. All the scenes refer to a wider scenario where a new swine flu virus H1N1 (EAH1N1) originated from pigs, obtains the ability to infect humans and also causes the death of some infected persons.

The following table shows the mapping between the use cases and the scene in which the use case for the EVD is executed.

Table 1: Mapping of scenes to use cases during phases of EVD trial event

When used	Scene	Scene Description	Use Case	UC Description
Pre-Event	Scene 1	An airplane is landing in Frankfurt	UC-02	An airplane is landing in Frankfurt
During Event	Scene 2	ECDC Emergency meeting	UC-06	ECDC recommendations
	Scene 3	Identification of a new probable case in the community	UC-04	Identification of a new probable case in a community
	Scene 4	Weak signal detection and surveillance	UC-04	Weak Signal Detection and Surveillance
	Scene 5	Spread of the infection in Italy - Resources assessment	UC-05	Assessment of the available medical resources during the pandemic phase
	Scene 6	Declaration of phase 6	UC-07	National Authority Periodic Assessment
Post-Event	Scene 7	Post crisis evaluation	UC-08	Post emergency learning at national level.

The following table shows the use cases for the MCI that were executed during the trial and the phase in which the UC is linked. The MCI trial in Cork, Ireland was designed to cover all key use cases, all PULSE tools and all actions of the Stadium Event Medical Plan.

Table 2: Use Cases executed during the MCI trial in Cork, Ireland

When used	Use Case	Description	Participants
Pre-Event	UC-01	Scoring of an event to establish parameters for an event specific medical plan	1. Event Coordinator 2. Regional Authority
	UC-02	MPORG	Not part of this exercise
During Event	UC-03	User wishes to mobilise and coordinate resources	1. Resource Providers 2. Regional Authority
	UC-04	Hospital Surge Capacity Bed Management	1. Regional Ambulance Dispatch or Control 2. Hospital Bed Managers 3. On-site Co-ordinators
	UC-05	Triage in Casualty Clearing Station (CCS) and link to PULSE proposal on ePCR	1. CCS Officer 2. Triage Officer
	UC-06	Input critical data for Recognised Current Situation	1. On-site Co-ordinators 2. Regional Authority
Post-Event	UC-07	Post-Event and Post-Exercise evaluation	1. Emergency Management 2. Regional Authority
	UC-08	Casualty Bureau Operation	1. Police 2. Civil Protection 3. Interpol FASTID (Fast and Efficient International Disaster Victim Identification)



Two of the crowd crush use cases were demonstrated before the incident during the 'pre-event phase', UC 01 and UC 02, UC03 – UC06 were demonstrated during the incident at the 'incident phase', while UC07 and UC 08 were demonstrated at the 'post-incident phase'. Although only a minority of the PULSE platform is aimed at prevention with the majority of the tools being aimed towards the response and post incident analysis, prevention was considered as important.

The MPORG MCI UC 2 was validated in a separate session, before the MCI Trial day, with end-users who also participated to the MCI Trial.



3 PULSE Trials Rome

3.1 EVD Evaluation

The evaluation of the PULSE system and its components was structured into different aspects as follows:

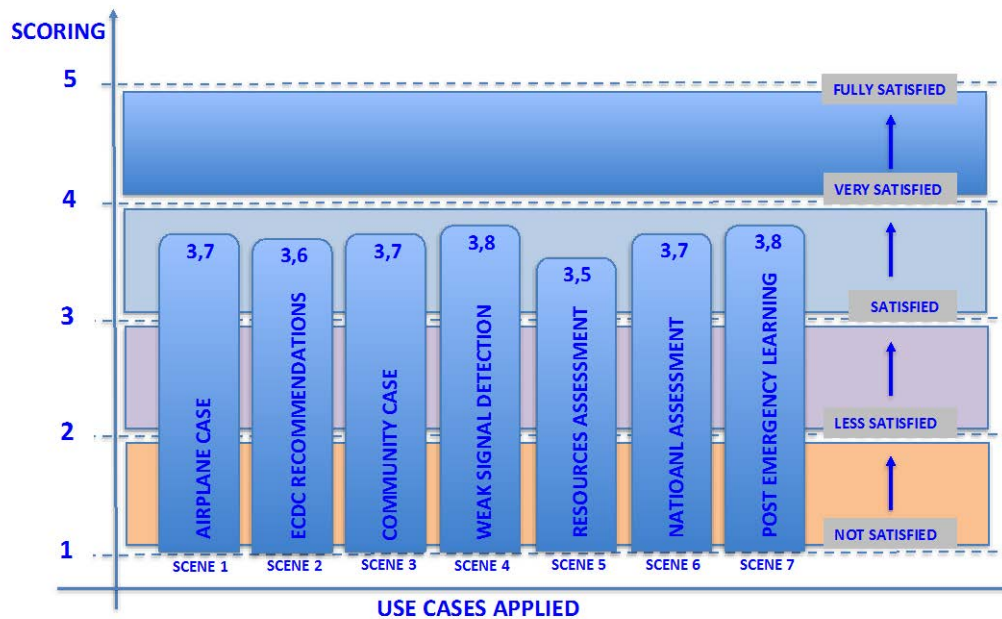
1. The evaluation of the **effectiveness** of the system in terms of benefits created, compared to a situation without PULSE.
2. The second part of the evaluation focuses on the **inherent qualities** of the PULSE platform.
3. The "**socio-political**" evaluation, assessing the system with regard to its expected acceptance and appreciation by society and to the reservations or objections society may have against such a system.
4. The evaluation of the project as a whole, and of **general characteristics of the PULSE trials** comprising a set of criteria addressing trial's preparation and execution primarily.

3.1.1 Evaluation of the effectiveness

System effectiveness was measured by questionnaires, dedicated to individual use cases/scenes. The intent was to demonstrate the PULSE System's functionality and to exercise or practice some of its individual services, which are supposed to facilitate decision making in medical emergency environments.

The seven scenes applied in the EVD Trial were intended to bring about the spectrum of functions founded in the conceptual categories discussed above that would support a better, timely, more comprehensive, more effective decision-making. The summary evaluation result is displayed in below graph.

Figure 3: Summarized EVD Trial Effectiveness



The overall cumulated average rating amounts to 3, 7, which brings the functionality of the PULSE platform close to very satisfied. In summary, it was assessed as an impressive system, extremely useful, and offering a great potential in that PULSE:

- Provides a good high-level communications channel
- Facilitates a rapid and timely situational overview
- Accelerates the information flow
- Ensures immediate availability of relevant data, documents, and literature
- Considers and integrates social media
- Maintains a well-organised data input and data flow structure

Holds a detailed event log and repository immediately accessible

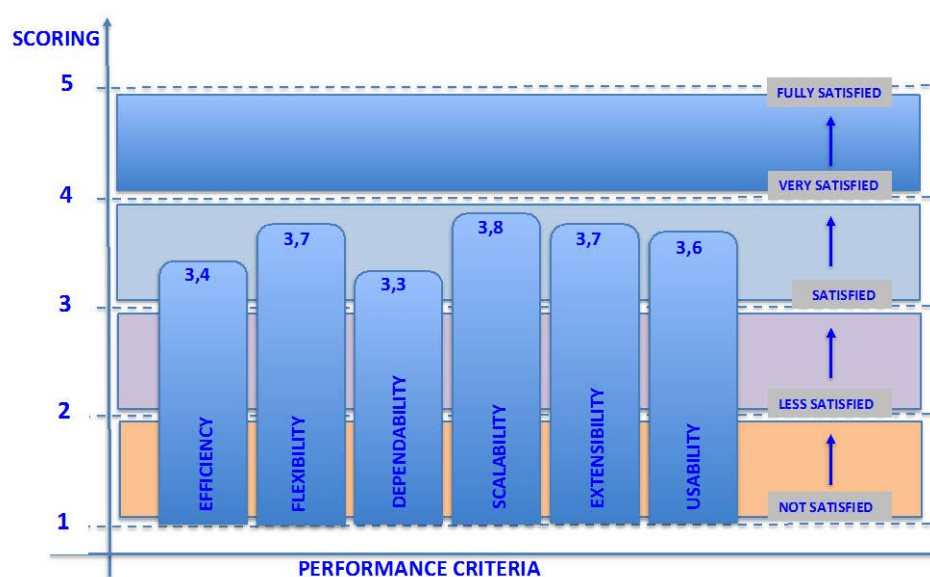
3.1.2 Performance evaluation

The second part of the evaluation is concerned with the inherent qualities of the PULSE platform, comprising a set of characteristics called Measures of Performance (MoP) focusing on:

- **Efficiency** - Human-computer interaction.
- **Flexibility** – Adjustable to new, different, or changing situations and requirements.
- **Dependability** - System maturity and readiness.
- **Scalability** – Smooth improvement of software and expansion/ reduction of functionalities depending on needs.
- **Extensibility** – Facilitating transfer to other crisis management domains and applications.
- **Usability** - Ease of learning, understanding and applying/using the system.

Notwithstanding its prototype status, some initial deficiencies with wireless connectivity and use of tablets issued, PULSE was assessed to be a very good system, very flexible, very useful, offering a great potential primarily because of its adaptability to many other functions, the large number of features interconnected, the repository of information and data saving time and facilitating information sharing. Figure 4 below displays the summarised ratings across the six performance criteria applied.

Figure 4: Cumulated Performance Evaluation



3.1.3 Socio-political evaluation

The third part of evaluation evaluates the PULSE system against the following factors:

- Ethical implications
- Economic factors (Qualitative)
- Legal compliance
- Political relevance
- Societal impacts



The results showed that the vast majority of participants did not think PULSE changes societal ethical values in a negative way. Participants strongly believed that PULSE will help channel medical resources appropriately in a public health emergency.

Economic

The majority of participants in the EVD exercise were unsure about the influence of the PULSE system on economic stability. Moreover there was a strong belief that PULSE would create market advantages for its suppliers, developers and operators.

Legal

The participants agreed that PULSE is compatible with human rights principles and the core values of the Union such as human dignity, freedom, equality and solidarity.

Political

The majority of participants agreed that PULSE fits into related international and EU health strategies and well fits into related national health strategies.

Societal

The participants agreed that PULSE had the potential to increase control over people and/or society and that it would bring direct benefits to people and/or society.

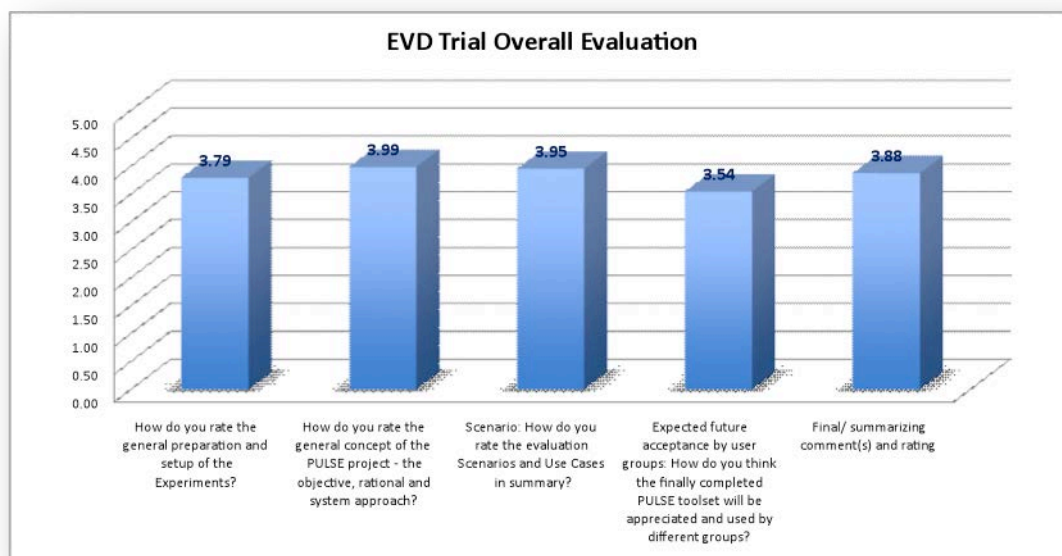
The trial exercise participants also provided additional valuable information via the provided questionnaire. Below is a summary of the comments:

- Some doubts about compliance with national privacy and confidentiality and data protection regulations, rule of law.
- Covering the legal aspects in the (different) EU countries will be difficult.
- Generally, useful in healthcare improvement and crisis management support.
- Information summaries from PULSE to the political/crisis management level will lead to better decisions and better public support and actions.

3.1.4 General evaluation

The objective of this evaluation section was to collect feedbacks related to the general characteristics of the PULSE project as well as a general evaluation of the trials.

Figure 5: An Overview of the General Assessment - Averages



The overall rating average is **3.83**, close to **very satisfying**; highest ratings were received for the trial setup from the perspective of the general concept of the PULSE project (the objective, rationale and system approach) while a slightly lower rating was received for the expected future acceptance of the PULSE system.

Overall, the consortium members gave the higher rates, followed by the actors and the observers; this reflects the consortium members had the opportunity to practice before the trial and have better knowledge of the PULSE platform. The opportunity to use the tablets and to follow practically the experiments gave to the actors a better view over the PULSE platform than to the observers. The difference between the consortium members and the actors is also a reflection of the need for additional training before the trial as discussed further down.

3.2 Future recommendations in the practical work

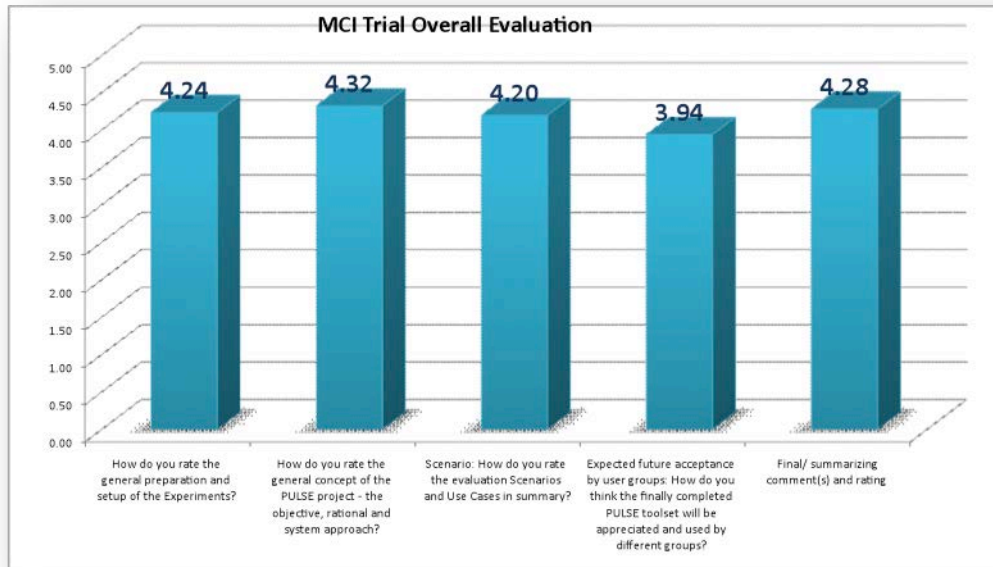
The following are the key recommendations for the future enhancement of the PULSE platform in relation to EVD type events.

- Tailor output to each level of the different stakeholders
- Extend the functionality to other medical sectors (laboratory data, veterinary, support for drugs devices)
- Interoperability with other national and international systems from technical, procedural and legal perspectives.
- Robust mechanism for data validation, especially for the manually inputted data.
- Enhanced user interface and presentation, more graphical output, better top-management reports.
- Multilanguage support.

4 PULSE Trials Cork

4.1 MCI - General Evaluation

Figure 6: MCI Trial - An Overview of the General Assessment - Averages



The overall rating of the MCI Trial is **4.2 out of 5.0**, above **very satisfying** level with highest ratings received for PULSE general concept (objective, rationale and system approach). Very good scores were also awarded to the trial general preparation and the overall evaluation. The lowest (yet high) ratings were received for the expected future acceptance, reflecting legitimate concerns regarding the implementation of the PULSE platform that currently is at the demonstrator state.

Overall, the highest rates were given by the actors followed by the observers and the lowest by the consortium members. So, the highest rates were given by the people involved actively into the trial and having the opportunity to operate the PULSE tools. This reflects a very good appreciation of the PULSE platform as well as its friendliness and easiness in operation. Consortium members involved in the development and acting as facilitators during the trial were even more critical than external stakeholders. This result is also a good consequence of the fact that video presentations were given to the invitees and were publicly available on the PULSE web site before the trial.

The second part of the MCI evaluation is concerned with the inherent qualities of the PULSE platform, comprising a set of characteristics called Measures of Performance (MoP) focusing on the criteria:

- Efficiency - Human-computer interaction.
- Flexibility – Adjustable to new, different, or changing situations and requirements.
- Dependability - System maturity and readiness.
- Scalability – Smooth improvement of software and expansion of functionalities.

- Extensibility – Facilitating transfer to other crisis management domains & applications.
- Usability - Ease of learning, understanding and applying/using the system.

Evaluating the system performance across all use cases and the two additional features (LMS and Mobile App), the performance questionnaire was presented upon the end of the MCI trial.

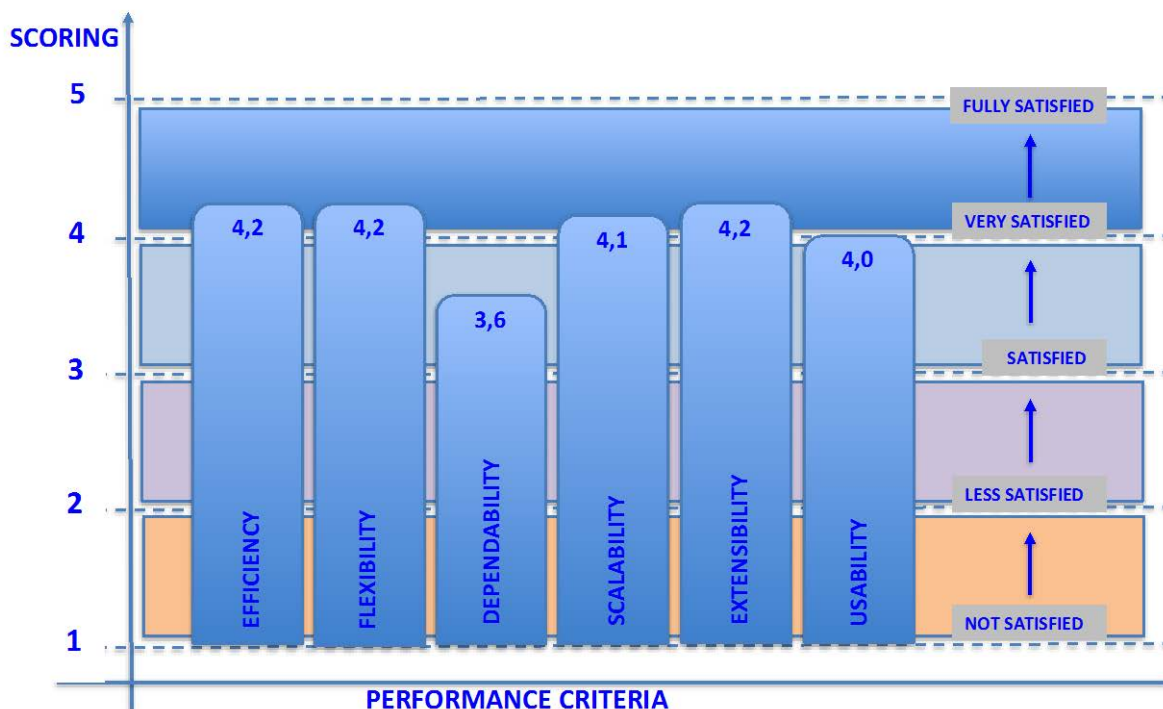


Figure 7: PULSE EVD Trial Cumulated Performance Evaluation

Notwithstanding its prototype status, end-users were pleased with its functions, assessed PULSE system performance as very good, the right tool to better do the job. In addition, the system's flexibility and possibility for expansion was viewed as a capability building tool for organisations, missions and tasks.



4.2 Future recommendations in the practical work

The following are the key recommendations for the future enhancement of the PULSE platform in relation to MCI type events.

- For the MPORG system the integration of traffic conditions typically found in the area in which the scenario is defined.
- Further evolution of the patient modelling in the MPORG system for advanced simulation of patient conditions and effect of different treatments being applied.
- For the smart phone app the following recommendations were identified:
 - Possibility of turning off geo-location until responders confirm availability to support privacy concerns.
 - Integration with other management information systems.
 - Adding a specific barcode to also activate the colour on the screen.
 - Entering data confined strictly to a person/agency with accountable control over the casualty at the moment in time.
 - Support for multiple users operating in parallel or use of new VR/voice activation technology.
- Interoperability with existing national and international systems
- Make PULSE available to all emergency services
- Support enhanced data protection/ legislative barriers; ethical issues of photographing patients, live hospital feeds etc.
- Remove dependence on Internet / public data networks through integration of an independent communication infrastructure e.g. Satellite based communication between scene and C&C centre.

5 PULSE Platform TRL level achieved

On completion of the trials and evaluation of performance, a TRL (Technology Readiness Level) has been determined for each element of the Platform. TRL ranges from 1 to 9 and were based on the EU's definition of TRL.



Technology Readiness Levels

- TRL 0: Idea.** Unproven concept, no testing has been performed.
- TRL 1: Basic research.** Principles postulated and observed but no experimental proof available.
- TRL 2: Technology formulation.** Concept and application have been formulated.
- TRL 3: Applied research.** First laboratory tests completed; proof of concept.
- TRL 4: Small scale prototype** built in a laboratory environment ("ugly" prototype).
- TRL 5: Large scale prototype** tested in intended environment.
- TRL 6: Prototype system** tested in intended environment close to expected performance.
- TRL 7: Demonstration system** operating in operational environment at pre-commercial scale.
- TRL 8: First of a kind commercial system.** Manufacturing issues solved.
- TRL 9: Full commercial application,** technology available for consumers.

Figure 8: TRL levels explained

Based on the above table the PULSE platform elements have the following TRL levels after both trials completion.

Table 3: PULSE platform TRL level achieved

Item	Technology Readiness level
Development of a platform for decision making based on up-to-date web technologies for real-time monitoring of hazardous scenarios and visualization of incident updates.	TRL 5 – technology validated in relevant environment
Smart phone apps	TRL 5 – technology validated in relevant environment
MPORG training tools	TRL 5 – technology validated in relevant environment
On-line learning management system	TRL 5 – technology validated in relevant environment

Development of enhanced screen sharing functionality able to facilitate the collaboration between the platform's users	TRL 5 – technology validated in relevant environment
Development an early warning system that is able to alert decision makers to the occurrence of an unusual biological event based on clinical record and Twitter messages NLP analysis	TRL 5 – technology validated in relevant environment
Definition of an algorithm for the calculation of the optimized dispatch of casualties to hospitals.	TRL 5 – technology validated in relevant environment
Development of innovative approach for post crisis evaluation based on structured storage and retrieval of the incident information	TRL 5 – technology validated in relevant environment
ENSIR model prototype. ENSIR performs the prediction of the spatial-temporal evolution of an epidemic, taking into account different factors, allowing for disease spread with different rates depending on the geographic, social and logistic characteristics of the interested area(the number/density of population in the interested area, the 'natural' connectivity of population, which may depend on the geography of the area, the connectivity by means of transportation, daily flights, etc)	TRL 4 – technology validated in lab (proof-of-concept)
Module for merging publicly available data sources for population distribution and estimation and display of the population density	TRL 4 – technology validated in lab (proof-of-concept)

6 The way forward-Findings from the trial

Based upon end user feedback and overall evaluation results from the trials. A roadmap for the future development of the PULSE Platform is outlined below. This is followed by a review of potential applications for PULSE in other domains.

6.1 The way forward-PULSE methodology

6.1.1 International co-operation framework

One prerequisite for future successful implementation of a system like PULSE will be clear regulations for cooperation among the different stakeholders involved in the use of such a system. That will require the establishment of an international cooperation framework between system providers, health-operators, national governments, the EU, the UN. and /or the modification and application of existing frameworks.

In another project on CIP/ Security (ECOSSIAN, <http://ecossian.eu>), CESS have analysed this and summarized under the term public private partnerships (PPP)¹. That project has developed an IT-system for the protection of critical infrastructure, which is of similar complexity as PULSE. Other than in PULSE, a dedicated analysis was requested in that project, on the conditions and possible models of a PPP. It will be documented in ECOSSIAN D7.10.

Although the security/CI sectors of the two projects are different, we believe that many of the principles discussed there could also be used or modified for a future PULSE operations concept.

Subjects include:

- Lessons from other domains and other nations/ status quo
- Need and rationale of a PPP
- Roles of the different partners involved: National healthcare organizations (public and private); EU; WHO; ...
- Sharing of resources for system implementation and operation
- Legal framework
- Harmonization, common standards
- The role of insurances
- Sharing models and incentives for future operation and cooperation on the basis of PULSE, including
 - information sharing
 - sharing of resources
 - sharing of tasks and responsibilities
 - sharing of risks (e.g. of failures)
 - Incentives for implementation and cooperation
- Joint operations models, including
 - joint "command and control", based on PULSE
 - closed user groups

¹ Public-Private Partnership



- rules on privacy and IPR
- joint decision making procedures
- lessons learned and best practices procedures and supporting tools
- joint training and exercising

6.1.2 PULSE Best practices and SOPs

Within WP5 considerable work was undertaken to clearly define and understand the the operation and healthservices acorss four very diverse European countries, Germany, Romania, Ireland and Italy. Together, they form a small representaitve group of the diverse countries that form the EU. The outputs of the research highlighted considerable simiarlities and differences in the operation of major emergency management across Europe. The key role that ECDC and other International Health organisation highlighted that a cohesive approach to major health emergency planning and management is possible across countries. Pulse highlighted that

- The Intelligent Analysis tool is the cutting edge of Epidemiological Surveillance. If it is integrated with existing systems and implemented by adequate models it will help in forecasting epidemiological risks worldwide.
- Logistic and Surge Capacity Generation tools are an upgrade of existing single agency Information Repositories. They must be tailored to the end users and implemented in National and Regional Emergency Medical Systems.
- The Post Crisis Evaluation Tool must be upgraded to the applicability in international Authorities. The possibility of having a lessons learned tool is fundamental in major emergencies to identify further gaps and needs towards major preparedness. Lessons Learned from emergencies are usually very generic in that it is sometimes impossible to identify exactly the moment a decision is taken and what data were available at that moment. The PULSE system reports exactly the moment the decision maker has taken the decision and the data available for him/her at that moment. Lessons learned with this methodology will surely enhance Preparedness and Response systems of every type of responder especially of high level authorities such as WHO and ECDC.

6.2 The way forward-PULSE Tools and Technology



6.2.1 Pulse platform Reliance on Wi-Fi

The PULSE platform has initially been designed to operate within a web-based environment. During the trials, it emerged that Wi-Fi may not always be available and/or of a sufficient quality to support the PULSE platform. The consortium believes that the platform needs to be extended to support KA satellite communication and other communication options. This will ensure that PULSE will operate effectively in major emergencies. As outlined in the Pulse exploitation plan, Skytek's proposed REACH project in association with the American Red Cross will address this limitation of the current system and seek to ensure that the PULSE platform has a robust communication system.

6.2.2 Improvements in the Triage process

Currently, during the triage process, the first responder documents on paper the casualty and the condition of a casualty, usually acting alone. During the trial, it emerged that two first responders working together allowed them to very quickly and effectively triage and record patient details via the platform. Feedback was extremely positive from the first responders, as it allowed one individual triage, while the other used the PULSE system. First responders believed that first responders' working together was a more efficient process. A time and motion study would be an interesting activity to access the validity of the findings from the PULSE MCI trial

6.2.3 Inclusion of Management reporting

The PULSE platform was designed to support senior managers and key decision makers during major medical emergencies. During and post a major medical crisis preparing Government and Media updates and reports is a central and critical management task. Key end users who attended both trials suggested that the PULSE platform should have a management reporting function where decision makers can easily prepare and transfer information to third parties. The ability to log activities to allow post event analysis was also identified as potential valuable addition to the system.

6.2.4 Extension of the Casualty Bureau Functionality

The Irish Police force attended the trial and were very impressed with the user friendly nature of the system. Immediately, they suggested that the casualty bureau app could be integrated with the triage app to allow a more powerful 'intelligent' system that could effectively try match casualties with missing person reports filed for example by ethnic group, hair colour, distinctive body marks, tattoos etc. The casualty bureau and triage apps are stand-alone products that can operate independently of the PULSE platform. The involvement of a police service in a follow on research project would enable the development and integration of these two applications, with strong commercial potential. Skytek is currently exploring this possibility.



6.2.5 PULSE broader medical users

Each one of the PULSE tools may be further refined and better adapted to the end-user who is going to use it, through customization and tailoring of the user interfaces. The performance of the trials, in particular the EVD trial in Rome, consented to identify new possibilities in terms of end-users, such as for example the Airport Medical Authorities (targeted during the end user requirement gathering) and the National Veterinary systems (not targeted during the end user requirement gathering), the Epidemiological Surveillance Systems in case of Mass Gatherings (i.e. Jubilee in Rome 2016) (not targeted during the end user requirement gathering). The PULSE Platform for the slow rising medical events was exercised on the scenario of a new influenza epidemic, but it is also customizable to practically every infectious disease epidemic. In particular, the same tools will be adapted and upgraded for a new project REACHING OUT (started October 1st 2016) in which an Ebola Epidemic in Guinea Conakry is studied.

The PULSE platform was considered interesting also by the OSDIFE (Osservatorio sulla Sicurezza e Difesa CBRNe), the Italian Center deputy to the reporting of CBRNe threats in Italy who identified in the DSVT a possible good platform for regular reporting of CBRNe threats.

6.2.6 PULSE as a training tool

The PULSE platform is also utilizable for many a Table Top exercise with adequate previous data input. Table Top exercises played out with the Platform may consent to identify needs and gaps not only of the system, but also of the systems that are being analyzed. Aside from the MPORG tool that may be tailored to different end users, the Platform itself prepopulated with specific data, taken from historical sources or hypothetical scenarios can be used as a Living Laboratory for Table Top Exercises.

6.2.7 Linking to external systems

From the outset, the consortium designed the system using open standard and COTS technology that would allow the platform be easily integrated into the diverse IT systems in operation across Europe. During the trial, several key systems were identified as priorities for the PULSE platform to link to and these were successfully interfaced with for the retrieval of information during the trials. These system were:

- **Open Data for real-time access in the emergency department of Lazio**
 - This dataset allows PULSE to acquire the status of the emergency department of all the hospitals located in the Lazio Region (in Italy). For each hospital it is possible to see the number of patients under observation, under treatment or that are waiting to be examined by a doctor. The number of patients is in turn divided among four different categories (red, yellow, green, white) depending on the priority code assigned to each individual patient.

- The system is currently used by the Emergency coordinator operating in the Lazio Region and it is publicly accessible through the Lazio Region web site: <http://www.regione.lazio.it/accessiprontosoccorso/>. The PULSE platform integrates the functionalities provided by this dataset by invoking the API accessible at this link: <http://dati.lazio.it/catalog/en/dataset/pronto-soccorso-accessi-in-tempo-reale>
- The functionality has been integrated into the DSVT GUI and allows any emergency coordinator using the PULSE platform to have a real-time access to the Lazio Hospital emergency department information.
- **ProMED** - the Program for Monitoring Emerging Diseases.
 - ProMED is dedicated to the rapid dissemination of information on outbreaks of infectious diseases and acute exposures to toxins that affect human health. It is also able to provide up-to-date and reliable news about threats to human, animal, and food plant health around the world. The system is accessible at the website <http://promedmail.org/>
 - The PULSE platform allows a user to select a specific event, can see the communications related to that selected event and can visualize it on a map.
 - The PULSE platform provides also an alerting system that periodically checks the ProMED website and sends an alert whenever a new ProMED communication has been added to the system. This allows the decision makers to have an always updated status of epidemics all around the world.
- **HealthMap**
 - HealthMap brings together disparate data sources, including online news aggregators, eyewitness reports, expert-curated discussions and validated official reports, to achieve a unified and comprehensive view of the current global state of infectious diseases and their effect on human and animal health. The system monitors, organizes, integrates, filters, visualizes and disseminates online information about emerging diseases.
 - The system is accessible at the website <http://www.healthmap.org/en/>
 - The PULSE platform integrates the search widget and the results generated by HealthMap directly into the DSVT general overview map. In this way, a decision maker can easily access to the HealthMap-related alerts by simply selecting the HealthMap layer on the DSVT GUI.

As well as integrating data from external emergency response system, PULSE also provides an external interface to facility the integration of PULSE generated information into third party applications. Third party applications can easily integrate with the PULSE platform by simply invoking the RESTful API provided by the PULSE tools. For example, as described in D4.2, D4.7 and D4.8, the Logistic tool exposes a standard RESTful interface and provides set of methods that allow to create, read, delete and update the crisis resources. These methods, are used by other PULSE tools (e.g., DSVT, Smartphone app and MPORG), but the same integration can be performed by other authorized external systems that can exploit the Logistic tool functionalities and then retrieve and update the crisis resources handled by the PULSE platform.

The PULSE partner Leonardo is currently exploring the possibility of linking PULSE with key health service systems currently within their extensive portfolio of products.

6.3 The way forward- PULSE LEPMI

In both trial exercises, results showed that the clear majority of participants did not think PULSE changes societal ethical values in a negative way. In both cases, participants strongly believe that PULSE will help channel medical resources appropriately in a public health emergency. Similarly, there was a strong belief that PULSE would create market advantages for its suppliers, developers and operators. This is a positive sign for the future development and uptake of the PULSE system. A resounding majority of participants in both cases confirmed that PULSE would bring direct benefits to people and/or society; this confirms that PULSE could be highly beneficial to health crisis management and the enhancement of emergency preparedness and response by facilitating better decision-making and resource allocation.

Most participants in both trial exercises agreed that PULSE fits into related international and EU health strategies. This is a positive indication that the platform is suitable for use across the EU. The majority in both exercises also confirmed that PULSE fits with related national health strategies. However, industry, NGOs involved, policy-makers/ crisis management and possible other end-user groups should collaborate in the development of effective, shared strategies and promote discussion on reducing any potential legal complications in cross border co-operation and collaboration in emergencies.

In both the exercises, participants agreed that PULSE is compatible with human rights principles and the core values of the Union such as human dignity, freedom, equality and solidarity. Policy-makers should continue to foster respect for fundamental rights in the implementation of public health emergency measures. The risks to privacy and personal data were highlighted; these can be eliminated or minimised by adopting technical measures and organisational practices to support privacy of personal and sensitive information, respecting the data protection principles, making health managers accountable for the use and processing of personal data (e.g., by conducting a data protection impact assessment). More importantly, as PULSE would form a part of critical infrastructure, the **security and integrity** of the system must be safeguarded at all levels, **against internal compromises and external attacks**. Further, in the future if the threat profile, technical specifications of the PULSE system and/or its utilization profiles change, we recommend a revised assessment of the performance in future scenarios and of the ethical and socio-political impacts of the system (see next chapter).

6.4 The way forward-Implementation Support

Beside the need for continuous adaptation and improvement, and the needed regulatory framework mentioned above, the PULSE project results include a set of evaluation methodologies that can (and should) be applied to future implementation and operations. The methodology is described in D7.3 and its application and the evaluation results documented in D7.3.

In summary, the evaluation methodology facilitates the assessment of the PULSE system under three different views, and a considerable number of associated criteria:

1. The evaluation of the effects of the system, measured in MoEs, Measures of Effectiveness. Examples of criteria: better use of resources; reduced reaction time.

2. The evaluation of the qualities inherent in the in MoPs. Measures of Performance. Examples of criteria classes: Usability; interoperability.
3. The evaluation of the socio-political effects, possible appreciations and reservations in EELPS² criteria. Example criteria: risks of privacy violations, fairness of distribution of resources.

The breakdown of these criteria comprises a total of more than 80 different criteria.

The methodology, however, allows for easy reduction or amendment, for adaptation to different types of application of PULSE in different scenarios and cases of use, and assessments from different perspectives (e.g. of technology, first responders, hospital operators, political priorities or preferences).

6.5 Transferability to other domains

6.5.1 Summary of current potential customers

The PULSE tools, models and methodology were designed and developed considering the requirements from a large domain of end-users, from medical and emergency management domains.

The main target customers for PULSE are:

- Emergency Management Agencies,
- Public Health Authorities,
- Public Sector Decision Makers,
- Medical Officials and Scientific Community,
- Software development companies,
- Organization ensuring humanitarian protection and assistance for victims in response to major emergencies.

PULSE offers support for the improvement of the health services in both preparedness and response stages of a major medical incident, leading to a more efficient emergency management. PULSE provides validated procedures, adequate to improve the operation and success of the healthcare system in challenging disaster situations where combined operations are required at local, regional, cross border and international levels.

Public Sector Decision Makers includes institutions and authorities working in crisis and emergency management at technical or solution level, as well as decision makers in the different government bodies and authorities (e.g. health care, crisis and emergency management, etc.). PULSE supports key decision makers, by integrating a suite of models/simulations and analysis tools able to provide insights into the collective behaviour of the Health Services.

Although PULSE was designed to support the above organisations and institutions, the consortium have identified two other domains for the PULSE platform:

² Ethical, Economic, Legal, Political, Societal

- NGO staff protection
- Non Medical First Responders for Emergency Response Scenarios
-

6.5.2 NGO (Non Government Organisation) Protection

The PULSE platform provides a range of tools designed to assist with effective decision making and resource planning. The PULSE platform can be adapted to be a very effective tool to address the **protection of NGO workers**. Recent data from the Aid Worker Security Report 2015 suggests that violent attacks have increased dramatically against aid organisations over the last few years. Since 2004, the number of incidents involving the killing, serious wounding or kidnapping of humanitarian staff has increased by just over 300%. The number of staff kidnapped has increased by over 540% since 2000. In 2014 alone, 120 aid workers were killed and 121 kidnapped, highlighting their acute vulnerability, especially in conflict contexts.

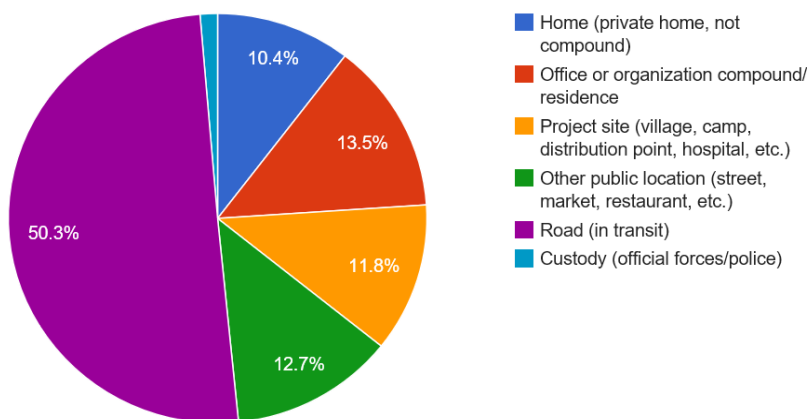


Figure 9: Categorisation of attacks on aid workers

Since more than 50% of attacks take place either during road transport to or from programme areas or while in those programme areas, it is widely recognised that this is the area of greatest vulnerability and the area upon which greatest focus is needed to enhance aid worker security. The application of emerging and beyond state of the art technology offers a genuine opportunity to change the pattern of vulnerability facing aid organisations. With over 450,000 aid workers deployed in the field, it is essential to provide a better means to protect civilian humanitarian personnel from attack and provide a more efficient means of offering a safer infrastructure for them to work within. The application of emerging and beyond state of the art technology offers a genuine opportunity to change the pattern of vulnerability facing aid organisations, especially if it is tightly integrated with novel and efficient information sharing and operational procedures. Currently 8 countries account for the vast majority of attacks against aid workers that are recorded on the Aid Worker Security Database (AWSD) – Afghanistan, Syria, South Sudan, Central African Republic, Pakistan, Sudan, Somalia, and the Democratic Republic of Congo.



PULSE could offer significant advantage in terms of the ability of NGO's to sustain a programme presence in insecure areas. Key PULSE features:

- **Tracking of ambulance:** the tracking of ambulances can be adapted to track NGO convoys in the field
- **MPORG:** The MPORG tool can provide a valuable training tool to allow key NGO decision makers and field operatives prepare and train for Kidnap and his risk situations
- **Situational awareness:** A single interface could be made available to display on a detailed map, the real time position of all asset and personnel in transit or in field locations, highlighting planned versus actual routes and all information on potential or emerging threats

If PULSE was successfully adapted, deployed and integrated into an aid organisation's infrastructure, **the PULSE system would provide an immediate step change** at all stages of transport operations from the initial planning, real-time monitoring and tracking, automated alerting and coordination of a response to an attack, carjacking or kidnapping attempt.

6.5.3 Management of Fire Fighting Support

Recently fires in Europe and worldwide have resulted in tragic consequences with examples of mega-fires including the loss of Spain of 149,300 hectares in Summer 2012 and fires in Russia in 2010 which killed 54 people and destroying many thousands of homes. Mega-fires happen when multiple fires across a large geographic area merge into one. In many EU countries, vulnerability to fire is due to climate changes, to increased urbanization and expansion of the wildland-urban interface areas. Fires have a high social and economic impact. As direct consequences of fire, millions of hectares of forests burn, causing the loss of human life (civilian and fire fighters), livestock, damage to private properties and to the environment.

Civil Protection and Fire Fighting organizations, have summarised the lesson learnt from the recent mega files disasters into the following categories, all of which can be supported by the usage of PULSE developed technologies and concepts.

- **Detection, Monitoring and C4I:** an effective and fast coordination is essential. It is vital to have detection, monitoring and control over the affected area as well as the capability to broadcast immediate alerts and instructions to the population. People now increasingly turn to social media as their first choice of communication in emergency situations, because they believe them to be the quickest way of getting help. The PULSE system social media tools can support the above requirements using the social media and mobile applications for the pushing of alerts and instructions not just to emergency response personnel but to the public in general.
- **Good planning and fast response** influence the effectiveness of fire fighting and the outcome of the intervention. The PULSE systems can have a tailored decision support system to propose the best usage of fire fighting equipment and resources over the mega fire fighting area. The tailored system would include elements of the DSVT, the logistic tool and the surge capacity tool for the

generation of the optimal use of fire fighting resources, the allocation of personnel to tasks and the requirement for additional equipment as the scale of the fire escalates. The pre-planning system within PULSE currently applicable to risk management for medical personnel for a major event such as a concert can be adapted to cover risk definitions and calculation for a range of potential fires such as in parks, mountains and cities.

- **Adequate sensors and sensor networks** can aid to improve global situation awareness and control the operations, guided by a well visualized real-time risk analysis for responders. The PULSE set of tools for IAT (weak signal detection) and range of mobile apps are ideally suited for use in enhancing the deployment of sensor networks in parks etc. to enhance fire detection and response. Due to this the analysis of social media tweets, images and information captured from the mobile app would allow the public support information gathering through the submission of details on the fire evolution, allowing for early detection for response and offer an enhancement to the range of dedicated sensors deployed.
- **International Coordination:** coordination of fire fighting activities is highly requested at national and international level. The presence of several agencies sharing the responsibility for fire management within the same country is the first sign that cooperation has to be pursued and then extended at international level, facilitating the adoption of common procedures and interoperable devices using widely accepted standards and protocols. Multi-cultural aspects also play a relevant role and should be harmonised. The results from PULSE in relation to the mechanism in how to and the following definition of Standard Operating Procedures can be applied to the fire fighting agencies in particular cross border situations.
- **Training:** lack of simulators and training of fire crews and others involved in fire management was seen as a need, especially the necessity for further training in more sophisticated techniques of fire detection and suppression. Specific forest fire-fighting training is recommended in order to coordinate on site international and local intervention teams. The MPROG and learning management system (LMS/LRS) developed within PULSE is ideal to provide the training of mega-firefighting scenarios in particular the coordination of activities on site.

7 Abbreviations

Abbreviation	Meaning
DSVT	Decision Support and Validation Tool
ECDC	European Centre for Disease prevention and Control
EVD	Emerging Viral Disease
ENSIR	Event evolution model for Biological Events
FASTID	FASTID (Fast and Efficient International Disaster Victim Identification)
IAT	Intelligence Analysis Tool
LT):	Logistic Tool
MCI	Mass Casualty Incident
MoP	Measures of Performance
PCET	Post Crisis Evaluation Tool
PPP	Public-Private Partnership
SCGT	Surge Capacity Generation Tool
TRL	Technology Readiness Level)
TT	Training Tools
UC	Use Case
WHO	World Health Organisation