PROJECT FINAL REPORT

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1. FINAL PUBLISHABLE SUMMARY REPORT

1.1 Executive Summary
The IMPRESS project (http://fp7-impress.eu/) has been a three-year research & development project co-funded by the European Commission’s Seventh Framework Programme, Security Theme, Topic: “Development of decision support tools for improving preparedness and response of Health Services involved in emergency situations”. IMPRESS started in May 2014 and has ended in April 2017. There exists a huge variety in the occurrence and characteristics of major incidents. Incident management stakeholders and in particular emergency health service providers have to deal with two basic challenges: The disproportion between the needs and the available human/material resources in the response capacity and the inherent time constraints of an emergency. These critical factors play a seminal role in the decision-making process during a crisis event, which affects all levels of command & control (strategic, operational, tactical). The drawback with current health emergency management systems lies with the command & control operations that should coordinate the actions of the separate services and turn them into an effective, multi-faceted crisis response mechanism.

In this respect, IMPRESS, for effectively managing health emergencies, provides an end-to-end operational system and respective services to effectively manage medical resources, prepare and coordinate response activities among diverse agencies involved, supported by a dynamic Decision Support System, using data from multiple heterogeneous sources, to facilitate timely and more informed decisions during critical situations. The devised solution facilitates communication between Health Services (and Emergency Responders) at all levels of response and the crisis cycle with the necessary health care systems support, supervision and management of participating organizations. The offered solution assists health services in becoming more proactive, better prepared and interoperable with other emergency response organizations. Thus, medical emergency teams are transformed, using IMPRESS, into one coherent force. IMPRESS thus aims to improve the efficiency of decision making in emergency health operations, which will have a direct impact on the quality of services provided to citizens.

Further from the operational end-to-end IMPRESS system for multi-agency communication and collaboration, effective medical resources management, decision support and situational awareness system, IMPRESS further developed the conceptual framework and HEMS approach, the domain taxonomy and ontology (semantic reference model), taking into consideration existing domain specific standards for interoperability purposes, as well as a suite of training tools and respective material for health emergency responders and decision makers. It also analyzed all influencing factors ranging from psycho-social, ethical, legal and data protection and privacy ones.

IMPRESS will thus catalyze a dramatic and durable impact in the way in which Health Services are provided in crisis situations, and will help improve the integration of health care actors and volunteers with other Crisis Management stakeholders, providing also an overall competitive advantage of CM-related SMEs and large businesses in Europe.

1.2 Project Context and Objectives
Countries are facing major challenges to protect their populations from an increasing number of potential health threats in the future. Preparedness and prevention plays a significant role in ensuring an efficient response to national and international crises. Emergency Medical Services (EMS) systems
form an integral part of any public health care system: their primary function is to deliver emergency medical care in all emergencies, including disasters and crises. It is widely recognized that an effective disaster response is heavily dependent on pre-existing local system capacity and capabilities than on external assistance. In the early stages of a health crisis, the ability to respond depends on the level of preparedness of the local community (citizens and volunteers) and health services. An efficient and well-structured EMS system ensures the achievement and maintenance of the skills necessary to deal with disasters, while disaster preparedness not only helps to identify organizational gaps but in many cases helps to minimize the consequences of a hazardous event so mitigate the risk and avoid potential crises.

*There exists a huge variety in the occurrence and characteristics of major incidents.* In general, an adequate major incident management system has to deal with two basic challenges. First, there is a **disproportion between the needs and the available human and material resources**: limitations in the response capacity (coordination, triage teams, search & rescue, Advanced Life Support and transportation squads, ground vehicles, and other health and psycho-social interventions), not only with respect to the number of people affected (quantity) and the time constraints (emergency) but also concerning the nature of the needs (quality). In disasters, characterized by disruption of infrastructure, facilities and/or services, this imbalance is even more serious and long-lasting. Secondly, very often there is **inadequate information**, low levels of **risk perception** and possibly scientific uncertainty or public concern and awareness with respect to the causes, nature and extent of the health issues involved and the risks that they may represent. The field on which this situation is more dramatic is that of medical rescues where every minute of delay can mean death and suffering for numerous victims. In a society that regularly reminds us of the vulnerability of man in the face of natural or man-made events, one of the major tasks for governments and crisis managers is to ensure attentive prevention and an appropriate response to disasters.

On the other side of the spectrum, the critical factors are more related to analysis and decision-making. A situation e.g. where there is an actual or potential risk of a major exposure to an unusual serious health hazard for a community (or which is perceived as such) can result in a public health crisis.

A Decision Support Tool (DST) needs to be capable to deal with the whole scope of health emergencies, from a single accident, over multi-casualty and mass-casualty situations to the most complex disasters. For health professionals to be able to use this tool in extra-ordinary situations, they must have experience in using its functionalities in daily practice. The extra-ordinary approach and special arrangements, does not only relate to the emergency response, but must be implemented for all phases of the management cycle.

*IMPRESS aspires to provide a consolidated concept of operations, for the health sector to be able to effectively prepare and coordinate response activities, which will be supported by a Decision Support System (IMPRESS DSS), operating at the different command levels. The goal of IMPRESS will be to aid in the guiding of health services becoming more proactive, better prepared and interoperable with other emergency response organisations, while at the same time integrating volunteers and cross border assistance teams more effectively into the process.*

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All types of emergency situations require – from a health perspective - extra-ordinary competencies, skills and attitudes, and thus specific education and training, the broader scope of which is commonly called ‘disaster health’. Mass emergencies, like major accidents and classical disaster, must be dealt by a structured mobilization of additional or specialized material and teams, combined with a more efficient use of the available resources (e.g. using methods of noria and triage, improved coordination, etc.). Public health crises require surveillance with early detection and early warning, extra-ordinary (often cross-border) decision making and control strategies, follow-up research & structural measures, all of which relies on timely (pro-active) and adequate exchange of information and communication.

Also, after a major emergency it is essential to provide on-going assistance, restore key services and infrastructure, organize socio-economic recovery, reconstruction and development as well as integrate lessons learned in future risk management and preparedness. In a nutshell, previous incidents confirmed the need for a “whole of community” approach in planning and responding to a disaster, and confirmed that a healthcare preparedness program must address the entire healthcare community in its preparedness activities. Regardless of the threat, an effective medical surge response begins with robust hospital-based systems and effective Healthcare Networks to facilitate preparedness planning and response at the local level. Simply put, strong and resilient Healthcare Networks are the key to an effective state and local emergency response to an event-driven medical surge. In addition, trauma Centers, Hospitals, and Healthcare Systems face multiple challenges daily in addition to the growing list of man-made and natural threats. Emergency department overcrowding, the rising uninsured, and an aging population all inhibit the healthcare system’s ability to respond effectively.

All in all, IMPRESS aims to advance the preparedness of emergency medical services (ambulance dispatch centers, hospitals, volunteer communities, etc.) in numerous ways, including planning for all-hazards, increasing surge capacity, tracking the availability of beds and other resources using electronic systems, and developing systems that are interoperable with other response teams. The IMPRESS general objective is to provide preparedness and response capabilities through guidelines and tools where ultimately, the routine use of these capabilities will sharpen their application in larger disaster scenarios.

In order to realize the IMPRESS concept, the project aims to satisfy the following core objectives:

**Objective 1: Re-balance the disproportion between response needs and capacity**
IMPRESS aims to support decision makers of the health emergency domain through structured mobilization of additional resources regarding material, logistics and health personnel. Also, it will provide a general picture of special resources, both teams and equipment, and finally it will improve the efficiency and efficacy of available resources through organizational measures such as e-triage, avoidance of unnecessary initiatives and enhancement of cooperation and communication of various health services at regional, national and international level.

**Objective 2: Remediate the information deficits and decision making problems with respect to the nature, scope and causes of crisis events that threaten the Health Status of a Community**
This objective will be addressed through rapid and adequate collection and exchange of data and information, fast, transparent and truthful communication of facts and interpretations, extra-ordinary decision making and swift reactions. The IMPRESS DSS, procedures and methodologies will provide a long-term structural improvement of emergency health services.

**Objective 3: Health services response and preparedness improvement**

The IMPRESS solution aims to enhance response and preparedness of emergency health services through efficient planning, training and decision making, tracking and allocating resources using electronic systems, and developing interoperable tools and systems. Moreover, the IMPRESS DSS solution will provide a training module that will provide decision makers and health emergency personnel with considerable experience and it will strengthen their skills and know-how regarding not only day to day operations but also crisis events, by increasing surge capacity.

**Objective 4: Enhancement of Intra- and Inter-Organisational interoperability in EMS**

The IMPRESS project will provide a framework which enables the exchange of data and information by establishing a common ground for interoperability between stakeholders in the emergency response domain through a taxonomy and operation framework. Based on the above, the DSS will provide a layer of abstraction that will ensure cooperation of relevant agencies and information exchange needed for strategic level decisions which may include scenario analysis, definition of operational procedures and resource allocation.

### 1.3 Main Scientific and Technological Results

The IMPRESS project has resulted in the following main scientific and technological results:

1. **a core taxonomy for the health services involved in emergency management**, as well as a semantic reference model (ontology) for the specific domain, taking into consideration current standards and specifications for interoperability purposes.

2. **a HEMS approach** which is most suited for European countries deployment, taking into consideration current adopted approaches and providing a comprehensive overview of the role, responsibilities and interactions of clinical and public health providers, given proper attention to the requirement of cross-border and multi-cultural implementation. Abstraction has been made from the country-specific legal formalities and organizational traditions, and the typology and categorization of the health services has taken a more generic format of operational functions and responsibilities.

3. **a new operating framework** based upon a distributed, modular, scalable system, that is able of connecting systems from different organizations into a common advanced holistic response framework, catering for the necessary interconnection and interoperability layers

4. **an integrated and interoperable multi-agency coordination and collaboration, COP, reporting and Decision support** system to effectively and timely manage and respond, as well as optimize available resources during the management of large scale health emergencies.

Those solutions help the different health agencies to share and combine information and resources, which in turn will help them to act in concert rather than as independent organizations. At the same time, the information sharing and combination help all Health Emergency Units to build a more complete picture of the crisis response from the fragments of
data available to them. As a result, they are better able to coordinate and distribute resources across the event, increasing the efficiency and effectiveness of a Health Emergency response.

5. **training component and associated training material as well as lessons learnt collection tool** that both facilitate the easy deployment, use and know-how of end user operators and decision makers.

In more detail, after extensive state-of-the-art investigation of existing most accepted data and taxonomic structures and international standards in the health emergency domain (specifically the Extra-ordinary Public Health Challenges – EOPHC) for reporting on healthcare activities and health problems, including the WHO Family of International Classifications (WHO FIC) and the European Committee for Standardization CEN CWA 15931 standard for disaster and emergency management, developed in view of shared situation awareness between first responder agencies, and which is crucial for the interoperability between health and non-health services, an integration of their definitions and models has occurred to define the IMPRESS binomial core and health determinant model, as shown in Figure 1.

![Figure 1 - The Projected Integration of WHO FIC and CEN CWA 15931](image)

Thus, the **IMPRESS defined taxonomy** has been based on an original integration of the relevant elements of ICD-10 in the structure of the CWA 15931 standard, as indicated by the subcategories // or ///, and of external databases in the ‘context’ class, as shown in Figure 2.
In addition, the IMPRESS Reference Semantic Model has been defined that represents the semantic information model of the IMPRESS architecture and builds upon the IMPRESS taxonomy. It consists of an ontology, the IMPRESS Ontology which is represented in OWL and represents semantically the domain of the health emergency management. The upper layer of the IMPRESS Ontology contains four main concepts: EOPHC, Person, Resources and Activities, as shown in Figure 3, following the structure of the IMPRESS taxonomy.

The vertical models cover various domains such as disasters, emergency stakeholders and agents, casualties, health status, equipment and rescue activities. The data facet includes various sets of code lists described in SKOS. In addition, the ontology captures the evolution of events and their temporal attributes. Apart from the representation of the activities and the functionalities of the health emergency management, the need has been addressed to represent specific information necessary for the support of the envisioned pilots, as well as to support other technical requirements, such as the semantic interoperability between the components that has been necessary for their smooth integration into a complete platform. As an example, the IMPRESS Semantic Reference Model has been extended to import data about the EDXL family of protocols which have been used for the integration and the interoperability of the IMPRESS Incident Management Tools. Moreover, EDXL
data have also been stored into the WARSYS database throughout the lifecycle of an event supported by the IMPRESS Platform. These cases are supported by the defined IMPRESSEDXL HospitalBedCapacityStatus class, as shown in Figure 4.

![Figure 4 - IMPRESSEDXL HospitalBedCapacityStatus Class](image)

Furthermore, a **generic Health Emergency Management System (HEMS)** has been proposed by the IMPRESS project, by synthesizing the main elements common to HEMSs existing in several European Union States and in the United States. This approach has been followed to take into consideration all Extra-Ordinary Public Health Challenges (EOPHC), which include mass emergency (ME) situations and encompass a wide spectrum of hazards and threats, including HAZMAT scenarios. The Lennquist approach has been followed to describe the generic HEMS for handling EOPHC. In Table 1, always in terms of the EU-Lennquist approach, the key roles in a generic scenario of mass casualty incident from the field to Hospital and from gold/strategic to operational functions have been summarized. The third column presents an instance/exemplary case of Italian organisations fulfilling the respective roles.

### Table 1 – Generic HEMS Key Roles in a Generic Scenario of Mass Casualty Incident

<table>
<thead>
<tr>
<th>Scenario: generic mass casualty incident</th>
<th>Role</th>
<th>Description</th>
<th>e.g. in Italy/notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High level command</td>
<td>Representative of the Political Authority at local level; this role is not directly involved in emergency management, but has the authority to solve coordination issues</td>
<td>Government authority at Provincial level (Prefetto; in Italy there are 109 Provinces)</td>
</tr>
<tr>
<td></td>
<td>Local Coordination Unit (on site)</td>
<td>Members are identified once the event is scheduled. They come from all the agencies involved (EMS for Healthcare). The unit has the full responsibility to ensure readiness and to coordinate the</td>
<td>Members come from EMS (118), Fire Brigade (Vigili del Fuoco) and Police forces (in Italy different Police forces, e.g. State Police, Carabinieri or Local)</td>
</tr>
<tr>
<td><strong>Final Report</strong></td>
<td><strong>Grant Agreement No. 608078</strong></td>
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<tr>
<td>response (out of the hospitals). Each member contacts his/her Agency to mobilize needed resources</td>
<td>Police) are responsible for the same duties in such contexts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCS (Casualty Clearance Station)</td>
<td>It is located at a safe distance away from the incident, to safely manage casualties delivered from the scene. It serves as a point for secondary triage and for provision of life saving treatments to safely package the casualties for transport to hospital.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On site manager</td>
<td>Coordinates pre-hospital response in the field. He/she is in contact with the Local Coordination Unit to provide information and to get instructions. In many EU countries this is a manager from the EMS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMS (Emergency Medical Service)</td>
<td>Agency that coordinates every medical emergency intervention outside the Hospitals in a given territorial area. It has a call centre, has visibility and command on all available resources (transportation and hospital capabilities) both public and private (volunteer) In Italy EMS has regional responsibility. Call centre number is 118 (it will soon become 112)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital Emergency Management Unit</td>
<td>Multifunctional Unit that each Hospital activates in case of emergency. It has responsibility on the Hospital resources. It is in contact with EMS In each Italian hospital the Unit’s role is defined in the PEIMAF (Piano di EmergenzaInterno per MassiccioAfflusso di Feriti), the internal Protocol for the management of mass incident situations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital Disaster Manager</td>
<td>Coordinates hospital response on the field. He/she is in contact with the Hospital Emergency Management Unit to provide information and to get instructions. Medical Doctor, activated according to the PEIMAF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication Officer</td>
<td>Officers in charge for communications with media and public information roles</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Having defined the generic IMPRESS HEMS, the IMPRESS end-to-end integrated operational system to manage mass-casualty health emergencies has been designed, developed and tested in three pilots, two real-life and one tabletop exercise. The IMPRESS system is composed of, as shown in Figure 5.

- **Front-end user-oriented tools and systems:**
  - INCIMAG – Multi-Agency Coordination and Incident Management System
  - INCIMOB – Mobile Application of Medical First Responders

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- **INCICrowd** – Mobile Application of Volunteers Citizens and NGOs
- Hospital Information System Interface of WARSYS

### Backend Decision Support and Data Management tools and services:
- **DHC** – Data Harmonization Component deploying the defined IMPRESS Semantic Reference Model
- **WARSYS** – Data Storage component
- Decision Support System Tools
  - **SICKEVO/PATEVO** – predicts patient physiological evolution
  - **LOGEVO** – predicts emergency logistics evolution
  - **SORLOC** – locates multiple infection sources
  - **Recommendation Engine** – manages other DSS Tools and recommends optimal dispatch to hospital

In addition, IMPRESS has resulted in training tools and content to facilitate effective training of first responders and IMPRESS system operators on using the IMPRESS system but also understanding the fundamentals of health emergency management. These are:

- The **IMPRESS training suite**, allowing online self-learning capabilities to trainees
- The **IMPRESS Lessons learnt collection tool**, that analyzes gathered IMPRESS system data after the management of a health emergency, to extract relevant KPIs and enable the reflection on what could be improved in the response actions, as well as facilitate training.

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**FIGURE 5 – A CONCEPTUAL VIEW OF THE IMPRESS OPERATIONAL SYSTEM AND TRAINING TOOLS**

The **INCIMAG System** presents a multi-Agency generic software suite for **Integrated Emergency Management** that unifies in a single User Interface, the following functionalities:
- Call-Center Operations Management
- Operational Resource Management
- Incident Management & Computer Aided Dispatch
- Operational Resource Tracking
- Rostering
- Situational Reporting
- Radio over IP Communication
- Mobile Data
- Sensor Data
- Geographical Information System

INCIMAG additionally provides the following functionalities for Health Emergency Management (as shown also in Figure 6):

- Emergency Patient Tracking
- Hospital Availability
- Decision Support Tools
  - Patient Status Evolution (interfacing with PATEVO)
  - Logistics Evolution (interfacing with LOGEVO)
  - Biological Agents Source Localization (interfacing with SORLOC)
- Patient Evacuation Recommendation (interfacing with the Recommendation Engine)
The INCIMAG Suite is compatible with Emergency Management Interoperability Standards such as EDXL-CAP (Common Alerting Protocol), EDXL-RM (Resource Messaging), EDXL-HAVE (Hospital Availability), EDXL-TEP (Tracking of Emergency Patients), EDXL-SitRep (Situational Reporting), EDXL-DE (Distribution Element). It invokes and interfaces with all backend decision support tools and data management components and interacts with INCIMOBs operated by first responders, connected over mobile networks, as shown in Figure 7.
INCIMAG system editions may reside in diverse agency premises and operated by the respective agency during a health emergency to facilitate, through the innovative Emergency Message Content Router (EMCR) of the INCIMAG Suite of Tools, the sharing of information and operational picture, as well as the collaboration of the various agencies involved in handling the emergency and in decision making. This is illustrated in Figure 8, demonstrating the communication and sharing of information among an INCIMAG EMS Edition, an INCIMAG Civil Protection Edition and an INCIMAG Hospital Edition. Interoperability of data and information exchanges is achieved through the use of the EDXL family of standards.

The main objective of the INCIMOB mobile application is to provide responders in the field access to information from the INCIMAG Command & Control system. INCIMOB provides functionalities that facilitate:
• Patient tracking, i.e. functionalities related to
  a. registry of found patients,
  b. facilitate the triage of patients and to
  c. update patient data, whenever new information becomes available.
• Communication and situational awareness, i.e.:
  a. send situational reports from the field to the control center,
  b. receive information on events, manage tasks and update status on their completion, and
  c. exchange messages with the control center.

When initiating INCIMOB, Figure 9 shows the listing of all functionalities together with short explanations.

![INCIMOB Main Menu]

The patient tracking functionalities ease the handling of patient information through the in-situ registration of patient information as for instance physical characteristics like gender, age, eye color etc. Also, the responder can register symptoms, treatment information or specific requirements, for instance if a patient needs intensive care. Patient information can be updated at any time and as often as is needed.

Patients are registered and identified by a unique ID, that can be either (as shown in Figure 10):

1. read from barcodes, such as from paper-based triage-tags,
2. obtained from triage-bracelets with an NFC-chip or
3. entered manually.
INCIMOB has further implemented two triage algorithms as a sequence of dialogs – an example is presented in Figure 11. It allows to carry out the triage within few seconds for each patient. Alternatively, you can also directly select one of the triage categories. Finally, the app can be used to continuously update patient data, for instance if new symptoms appear or their severity changes, or if treatment must be documented.

Furthermore, INCIMOB supports status update functionalities, as shown in Figure 12, the purpose of which is to:

- allow first responders to declare or refuse responsibility for a specific task allocated by the control center and
- receive information about events and tasks
- inform the control center about the progress of the response activities (as shown below)

FIGURE 10: REGISTRATION OF PATIENT: 1) READ BARCODE FROM TRIAGE TAG 2) READ NFC FROM WRISTBAND 3) ENTER PATIENT CODE MANUALLY 4) SEE PATIENT CODE AFTER SUCCESSFUL REGISTRY

FIGURE 11: PATIENT TRACKING SUBMENUS: 1. STARTING THE MENU WITHOUT PATIENT INFORMATION 2: CHOOSE TRIAGE METHOD, 3: ENTER PATIENT CHARACTERISTICS, 4: SEE TRIAGE CODE (“DELAYED”) AND GCS.
Another important feature of INCIMOB is that field staff can send situational reports (SitReps) to the INCIMAG control center. Situation reports are concise information about observations, casualties or special needs. According to the nature of the report and the situation, different types of information can be transferred, such as:

- characteristics of incidents,
- required emergency medical services,
- characteristics of fire and HazMats incidents.

A further mobile application developed within IMPRESS is INCICrowd, targeted to volunteers and NGOs assisting rescue services during an emergency. The architecture of the INCICrowd application is similar to the architecture of INCIMOB, but with a reduced set of modules and functionalities. Furthermore, it is not directly connected with INCIMAG. Data comes from and is sent to the IMPRESS Message Bus, managed and bundled by the Crowdsourcing Server, which acts as gateway between all the INCICrowd instances and the Message Bus. INCICrowd allows volunteers or even the wider public:

- to submit situational reports to the control center (INCIMAG),
- receive alerts for a selected area, and
- exchange information on offers & needs of goods and man-power.

The first functionality is identical to INCIMOB. The second and third functionalities are newly implemented ones for INCICrowd. Users can subscribe to receive alerts for alerts from the control center and thereby select any area by clicking on a point and entering a radius. Further, during a crisis, while some people are in need of resources or work force, other that are not affected may able to share their resources. This module gives citizens the opportunity to offer their resources or to search for resources they are missing. Therefore, this module serves more as intercommunication tool for citizens and not for exchanging information between crisis management and citizens. Figure 12 presents a number of capabilities in visual form of INCICrowd.
Going further, IMPRESS has resulted in a number of **Decision Support System Tools**, operating as backend services that analyze incoming operational and victims data to facilitate better and more informed decisions, combined with data and information that originate from data management components.

The **SICKEVO/PATEVO** DSS Tool allows to **follow the victim** and predict the evolution of his/her physiological state, from the very beginning of the crisis event to the end of the patient's observation period (due to death, discharge, assignment to definitive care or conclusion of the simulation), in order to alarm for any critical anticipated change in his/her condition and expedite, if needed, dispatch to a hospital. Figure 13 demonstrates the invocation of the PATEVO/SICKEVO backend functionalities through INCIMAG and the Recommendation Engine on a victim, for whom triage data are collected using INCIMOB.

![FIGURE 13 MENUES OF INCICROWD.](image)

**FIGURE 13: MENUES OF INCICROWD.**

FIGURE 14: **PATEVO – PATIENT PHYSIOLOGICAL STATE EVOLUTION PREDICTION**

![FIGURE 14: PATEVO – PATIENT PHYSIOLOGICAL STATE EVOLUTION PREDICTION](image)
The LOGEVO DSS Tool forecasts the evolution of the provision of resources to the hospital and to the field (Hospital Surge and similar) determining the time-curve of the amount of resources that can be provided to the system by exploiting the incremental capacity of the health structures involved in the crisis. Figure 14 demonstrates the invocation of the LOGEVO backend functionalities through INCIMAG and the Recommendation Engine.

The Recommendation Engine produces recommendations/suggestions on how to distribute the patients over hospitals, based on:
- patient physiological status and on its foreseen evolution (PATEVO outputs)
- available resources (ambulance vehicles and hospitals bed availabilities in different hospital categories) (WARSYS – DHC outputs)

The recommendation is about:
- the order (prioritization) of patients
- the destination hospitals, and
- the optimal routes to the hospitals.

Figure 14 depicts the workflow of the optimization provided by the Recommendation Engine and the connectivity to the related IMPRESS components.
FIGURE 16: RECOMMENDATION ENGINE - WORKFLOW

The SORLOC DSS Tool, given sufficient information, provides answers to fundamental Emergency Response questions in the case of covert biological agent release, such as:

- When the release occurred
- How many cases will occur (with and without mitigation)
- What area is affected with probably the spatial source (so long as travel history is provided)

A simulated example of the output of SORLOC in case of a biological agent release is shown in Figure 15.
The **IMPRESS Data Management components** include WARSYS, which is the IMPRESS Data Warehouse, as well as the **Data Harmonization Component** (DHC), that is using the Semantic Reference Model, described earlier, in order to homogenize multidisciplinary and heterogeneous data as well as align data, so as to have the same representation, so that they can be used seamlessly by the various IMPRESS system components. Upon request, it transforms the data to the format requested by each module. Both of these components cover the need for the interoperable usage (through relevant data standards and the Semantic Reference Model) and management of data originating from various heterogeneous resources, such as:

- Information from Incident Management Tools
- Information from citizens – volunteers (crowdsourcing)
- Hospital information from other health care facilities
- Data from external sources
  - Geographical data: other critical infrastructures, the coordinates of critical infrastructures etc.
  - Demographic data: population for specific areas
  - Codelists for disease classification, etc.

The main services that are provided by the Data Harmonization Component, interoperating with WARSYS and INCIMAG, for the purpose of facilitating more enriched information visualization and better and more informed decision making, are:

- **Bed Availability**: information can be retrieved regarding available beds for a hospital from external resources and transform the data to EDXL HAVE format for the Incident Management
Tool. Figure 16 presents the workflow process for bed availability information retrieval and use within the IMPRESS system.

- **Weather Data**: information can be retrieved about the current weather conditions in an area, or the weather forecast in an area and offered to Incident Management Tools. Figure 17 presents the workflow process for bed availability information retrieval and use within the IMPRESS system.

- **Population of an Area**: the total population in an area can be retrieved (using Geonames & DBPedia data)

- **POIs of an area**: information can be retrieved Points of Interest of an Area using DBPedia data

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**FIGURE 18**: USE OF HOSPITAL INFORMATION FROM OTHER HEALTH CARE FACILITIES – BED AVAILABILITY

**FIGURE 19**: USE OF OTHER INFORMATION FROM OTHER THIRD PARTIES – GEOGRAPHICAL AND DEMOGRAPHIC INFORMATION

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The **IMPRESS Training Suite** is a Moodle-based online learning system with the appropriate digital training material, which provides decision makers / health emergency personnel with the ability to develop competences and skills (both in terms of domain processes and the use of the IMPRESS platform) relevant to the efficient and effective handling of health crisis incidents. Figure 18 illustrates the structure of the IMPRESS e-course and provides the target learning groups and an example of available online training material on INCIMOB use.

The **domain** covered in this course is the emergency preparedness and response of the health services to extra-ordinary public health challenges (EOPHC).

The **target audience** of this course relates to the operators of the health emergency response management system (HEMS) (excluding potentially affected persons or communities as such). These operators are divided over the following six target learning groups:

1. Prehospital Emergency Medical Services (EMS) first responders / field medical staff;
2. Personnel involved in medicalized transportation (ambulance, medivac helicopters, planes, trains, ships, etc.);
3. Staff of Emergency Call and Dispatching Centres (EMCCD);
4. Accident and Emergency Department (A&E) staff and personnel involved in hospital services for acute healthcare;
5. Members of Regional (RMCC), National (NMCC), or International Medical Coordination Centres (IMCC);
6. Staff of Public Health Agencies (PHAs)

**INCIMOB video**

The video shows how INCIMOB application is used in reality. All the steps that are needed to input vital information in the system are depicted to guide the users on the proper use of the application.
The Lessons Learnt Collection Tool, shown in Figure 19, after a health emergency incident, provides an interface to the expert to search in the database for similar incidents or retrieve past lessons learnt reports if existent. The ability to create a new lessons learnt report for the incident is given by more than one experts, using a form with predefined fields to enter. KPIs for a past incident are further measured.

![Lessons Learnt Collection Tool](image)

**FIGURE 21: LESSONS LEARNT COLLECTION TOOL**

### 1.4 Potential Impact

Countries will face major challenges to protect their populations from an increasing number of potential health threats in the future. Preparedness and prevention will play a significant role in ensuring an efficient response to national and international crises. An efficient and well-structured EMS system ensures the achievement and maintenance of the skills necessary to deal with disasters, while disaster preparedness helps to identify gaps in professional standards, organizational structures and coordination mechanisms which vary widely across European Union (EU) Member States. The IMPRESS DSS provides enhancement of interoperability, effectiveness and optimal allocation of resources during emergency and crisis situations is needed for Health Services across jurisdictional and national levels. A proposed solution needs to combine connectivity between Health Services at all
levels of response and the crisis cycle with the necessary medical information systems support, supervision and management of every participating state and health sector organisation during a crisis. IMPRESS has targeted to develop a solution which advances the preparedness and response of emergency medical services using electronic systems and develop communication systems. One of the objectives has further been to communicate the various achievements of IMPRESS in related organizations as a mean to include it in governmental programs, health services and emergency response programs, public awareness and contingency management activities.

IMPRESS has thus envisioned to catalyze a dramatic and durable impact in the way in which Health Services are provided in crisis situations, and to help improve the integration of health care actors and volunteers with other Crisis Management stakeholders, providing an overall competitiveness of SMEs and large businesses in Europe.

IMPRESS, through its solution offering, will assist in improving the efficiency of health services operations in both preparedness and response stages, which have a direct impact on the quality of services provided to citizens, better and more direct provision of emergency pre-hospital medical care, reducing the cost and speed of providing these services. All of these simply translate into more lives saved during health emergencies.

Moreover, on a European level, emergency operators welcome the opportunities to receive international help in large-scale disasters when needed. However, this international assistance lacks full practical applicability since interoperability issues on several levels – from organizational, procedural down to technical levels – are not yet resolved. IMPRESS further boosts interoperability in crisis events.

1.4.1 Socio-economic Impact

Reviewing the history of accidents, disasters and crisis, one cannot but conclude that much of the collateral damage caused by these events was made possible by the lack of effective first responder action stemming from incomplete information. The IMPRESS solution focuses its use cases around the view that crisis impacts are shaped by the size and structure of the receiving socio–economy, as well as the nature of the triggering event. Small and poorly diversified economies with spatially concentrated productive assets are highly vulnerable to exogenous economic and disaster shocks alike. Through IMPRESS case studies, it is possible to show the socio-economic benefits that will be derived from the implementation of the IMPRESS system. Disasters and crisis, be they man-made (industrial accidents, terrorist attacks) or natural (hurricanes, fires, floods, earthquakes, etc.) are, almost by definition expensive occurrences. They invariably result in loss of life and the waste of thousands of man-hours and assets. Thus, societies literally cannot afford to ignore the possibilities of disasters and crisis, and must do their utmost to limit their economic impact. IMPRESS contributes significantly to ameliorate the high costs of a crisis, since it can be said almost without fail that an effective health emergency response and timely decision making also translates to substantial monetary savings. These savings may be realized in a myriad of ways: direct crisis costs may be reduced through the reduction in medical costs by dispatching emergency units in accordance to the distance from the crisis location and through the effective allocation of patients in accordance with the capacity and specialization of each hospital. Often, however, the true costs of crisis are indirect and can only be measured some time after the event. Crisis may result in a loss of confidence not only for the civilians but also for medical
personnel, leading to social disappointment; mishandling of crises may lead to a decline in health domain investors’ confidence in the municipality/nation. An effective system for emergency health response will be able to allay fears following disasters: while people realize that many unpredictable events are indeed just that—unpredictable—it is the handling of such events, regarding the response and preparedness, that dictates their level of confidence in the authorities. The IMPRESS solution provides a viable and effective approach to secure much more effective and timely management of health emergencies and thus increase in the level of confidence to the system.

1.4.1.1 Improved Command and Control Decision Making
Command and control operations stand to gain the most from the IMPRESS system. At present, individual European health emergency services are some of the best in the world, and enjoy the use of the latest technological means and operational protocols to conduct their work. The drawback with existing systems lies with the coordinated command and control operations that should coordinate the actions of the separate services and turn them into an effective, multi-faceted crisis response mechanism. Thus, medical emergency teams that currently use outmoded or no mechanism to interface with each other will be turned, using IMPRESS, into one coherent force, eliminating the duplicate application of force, sharing intelligence and information as it becomes available. The IMPRESS contribution, however, will not be limited to this—its decision support features will help decision makers at command and control centers not only to exert more centralized control over their units, but to use this control in better ways in order to make better and more educated decisions. Better decisions, in this context, can be characterized as decisions that are based less on assumptions that need to be made in the absence of concrete information.

1.4.1.2 Better Coordination of Health Emergency Services in Real Time
IMPRESS targets to solve force coordination problems in an effective fashion. Through its developed common operating framework and health emergency management system, IMPRESS promotes the sharing of information — emergency unit capacity, hospital capacity, etc. – during times of crisis. Correspondingly, the benefits will be realized in real-time: IMPRESS disseminates and shares the most up-to-date information it accumulates immediately, and thus gives more actionable information to decision makers to make a situational assessment. Thus, it helps them determine the best ways to respond to a crisis. In turn, this helps save lives, cost and time when addressing a crisis situation.

1.4.1.3 Improved health emergency services preparedness
It should be kept in mind that health emergency services cannot just react to situations as they arise; rather, training is a major aspect of the readiness of any city-wide or country-wide emergency response scheme. In order to address this need, IMPRESS has created new possibilities for preparing towards crisis events during normal times. IMPRESS has achieved this by providing KPIs for emergency or crisis response and recovery as well as historic data after the crisis for assessment and possible redefinition of emergency plans. IMPRESS does not focus solely on the reaction during the crisis or emergency event – on the contrary, it will cover the whole life cycle of the event. This will increase emergency services preparedness, by defining rules for emergency management and providing essential experience and skills to health emergency personnel.
1.4.2 Technological Impact

1.4.2.1 Data collection
First and foremost, IMPRESS has aided in the development of advanced data collection technologies. Currently, there are several limitations to health emergency data collection—health operational documents are usually awkward and time-consuming, so first responders forget to fill them in or do so hastily. IMPRESS has generated smart mobile applications (INCIMAG mobile version, INCIMOB, INCICROWD) that can be used through portable terminals by users on the field (smart mobile and tablet devices, etc.), which handle this issue reliably in the emergency response phase. These tools and applications allow a by far more efficient integration of data at the scene of emergency.

1.4.2.2 Data fusion
In addition, IMPRESS has changed the way data is gathered and handled during times of emergency and crisis. Current European efforts have resulted in the definition of a number of data access and processing services and provided access to critical information databases or static or historic data sets; it is of paramount importance, however, that means are developed to integrate these data in real-time, and deliver them effectively and in an actionable fashion to end-users. The development of the IMPRESS system components for data storage and data harmonization, as well as the definition of the domain taxonomy and semantic reference model (ontology), and the development of interfaces with existing Hospital Information Systems or other Legacy Systems, which facilitate the aggregation and thus combination of data regarding patient information, medical history, equipment and consumables needed and in hospital capacity (beds, medical personnel, consumables, etc.) significantly contribute to the effective fusion and interoperable use of respective data for informed decision making as well as situational awareness purposes. In this way, the IMPRESS system has paved the path towards providing fully interoperable solutions to these problems.

1.4.2.3 Decision support
Another important impact has been brought about by IMPRESS has been the development of novel methods for decision support. The development of such methods is recognized worldwide as very important. In crisis situations, it is often difficult to attach proper values to the different issues comprising the crisis as they evolve, e.g. making the correct decision, regarding changing status of in-hospital doctors and consumables, in order to transport the patient to the most efficient hospital. In such events, each branch of the decision tree carries with it severe implications, both positive and negative, that are not immediately apparent to decision makers. The IMPRESS DSS tools have provided the decision makers with decision support systems that will be also usable in the post-emergency analysis phase to evaluate the decisions made. The IMPRESS impact becomes obvious when making decisions by providing further analysis and integration of the available data, allowing decision makers to better understand the implications of their potential decisions. Thus, decision support modules developed within the IMPRESS solution may find their way into a wide variety of management tools, both in private enterprise and government. It has to be stated that the decision support systems will not take over making the decisions, but will ensure maximal availability of data sets describing the scene of interest. The general principles of decision-making do not apply to emergency management exclusively. IMPRESS will make an impact on – potentially distributed - planning and execution processes in both the private and governmental sector.
1.4.2.4 Contribution to Standards

Interoperability of health services is a key priority in Emergency Management, and this consequently requires the use of interface standards to the greatest possible extend. Since the key stakeholders with an interest in the IMPRESS results usually have a common background but come from different hierarchical levels or nationalities (which implies different information and resource needs) an extensive use of standards has been conducted in order to have the best result with respect to information/data interoperability. To maximize its usefulness and impact, the IMPRESS project has ensured that the data that is collected is operationally useful and standardized and that the framework’s outputs are practical and expedient to the agencies and organizations responsible for crisis management and health emergency first-response. Moreover, since IMPRESS approaches health and emergency response issues, standards on the above two domains have been taken under consideration from the design and development of the DSS to exploitation of use cases and disseminations of results (EDXL family of standards, etc.). Through all the above activities and the implementation of the IMPRESS envisioned pilots and demonstrations, the used standards, have been additionally disseminated and made widely known to Public and especially the interested Organizations and Agencies at an international level.

1.4.3 Wider Societal impact

The predominant societal security needs addressed by IMPRESS are Life and Health. The intention behind the outputs of the project are to improve preparedness and responses to major incidents that threaten life and health of citizens, irrespective of ethnicity, beliefs, economic status. The tools developed improve the speed, efficiency and prioritization of the health response reducing preventable deaths and reducing the consequences of delayed assistance/treatment on the future morbidity of casualties. This has been effectively demonstrated by the executed real-life and table-top exercises and pilots in the timeframe of the project, and evaluated by a significant number of relevant stakeholders and end users.

The IMPRESS solution focuses specifically on addressing the following threats to society: terrorism, pandemic, natural and man-made disasters, through early detection of covert events as well as more rapid and efficient health response to overt and covert events. The solution addresses large-scale crises, independently from their nature and root cause. The solution reduces uncertainties in the public concerning the secure provision of medical services and medicaments. This is especially relevant for regions that were affected previously by severe large-scale crises as e.g. floods or earthquakes. The project has developed solutions for better service even in case of isolation of certain areas.

The major beneficiaries of the IMPRESS project results are the population – citizens and society as whole. Emergency Responders and Health Sector professionals also benefit significantly by being better prepared, better equipped, and more able to concentrate on saving lives since the offered technological solution greatly assists in, and reduces the burden of, the management of the response.

Furthermore, IMPRESS strengthens community engagement through enabling the participation of citizens and volunteering groups in the emergency response concept, by using INCICROWD. It further facilitates social and territorial cohesion through the consideration of cross-border cooperation and operations and good governance through a system that consistently guides an optimized health response.
The results of the IMPRESS project benefit the entire community - the developed solutions are targeted towards organizations, volunteers and the public – independent from their societal or economic status.

1.4.4 Main Dissemination Activities

The following outlines the main dissemination activities that have been performed by the IMPRESS partners during the course of the project. IMPRESS has adopted a multiple concurrent dissemination approach geared towards different stakeholders to the project. The main IMPRESS dissemination activities have been the following:

- **Online communication through:**
  - the IMPRESS Project web site, publicly accessed at [http://www.fp7-impress.eu/](http://www.fp7-impress.eu/)
  - the IMPRESS Blog: [http://fp7-impress.blogspot.gr/](http://fp7-impress.blogspot.gr/)
  - Social networking in Facebook, LinkedIn, Twitter, Slideshare
  - Youtube channel: [https://www.youtube.com/channel/UCnogtr427SoYtfERSXBAcUg](https://www.youtube.com/channel/UCnogtr427SoYtfERSXBAcUg)
  - Research Gate IMPRESS project
  - Articles and posts to other web sites or online media (e.g. INTRASOFT’s, KEMEA’s or CNR web sites and internal dissemination channels)

- **Face to face meetings and events organization**
  - Organization of IMPRESS Stakeholder Advisory Group Workshops, one per year of the project lifetime
  - Clustering with other projects and IMPRESS results presentation at workshops of the MELOGIC project, the Cluster of EPISECC, SECTOR, Broadmap, REDIRNET, SecInCore projects, the EU-TOXI TRIAGE project
  - IMPRESS presentation at the Innovation Theatre of EENA 2016 and EENA2017, and IMPRESS exhibition at the EENA 2017 Conference
  - IMPRESS results presentation at CMDR annual conference INTERAGENCY INTERACTION IN CRISIS MANAGEMENT and DISASTER RESPONSE of 2016 and 2017
  - Publications to relevant domain specific journals
  - Training and Awareness-Raising workshops (for the three pilots that have been conducted but also during the last period of the project to relevant stakeholders)
  - Pilots (Palermo, Montenegro-Athens, Greek-Bulgarian TTX)

- **Written communications**
  - Formulation and distribution of IMPRESS newsletters, brochures, leaflets
  - Posters and banners
  - Press releases for all conducted pilots

- **Collaboration with Medical Schools (Greek and Cypriot) has been achieved, aiming to provide workshops, courses, training, to current experts, future medical staff and wider public**

1.4.5 Exploitation of Results

A number of awareness-raising activities (SAG Workshops and stakeholder events, exhibition and presentation of IMPRESS results to key events (EENA 2016, EENA 2017, cluster events, NATO CMDR COE conferences, etc.) have been pursued to enable discussion with relevant stakeholders and end users, promotion of IMPRESS project results and activities towards take up of results. This has been further pursued from within the end users of the consortium (CNR, MoH/EKEPY, KEMEA) and their own network of stakeholders, through events and bilateral discussions. Interest has been shown on the IMPRESS proposed solution by both Italian stakeholders as well as Greek ones that participated.
in the respective IMPRESS piloting activities, acknowledging the added value and imperative need for the capabilities offered by the IMPRESS solution.

Activities towards the exploitation of IMPRESS Results has been pursued in two paths: i) exploitation of the integrated IMPRESS DSS Platform and ii) exploitation of individual components / tools and produced knowledge. The exploitation planning for the IMPRESS integrated DSS Platform is defined by the Exploitation Plan of IMPRESS (D6.10) while exploitation planning of the individual components / tools is defined individually by the project partner who owns the IPR of each output. The exploitation of the IMPRESS outputs is expected to start within 2018 since the partnership needs to further work on the market readiness of the outputs before launching them to the market.

The IPR for the integrated IMPRESS DSS Platform is defined within the Joint Ownership Agreement. Further to the IPR, the Joint Ownership Agreement defines exploitation partners, objectives, contributions to the final solution, rights and royalties for each project partner. Thus, within the Agreement the partners that are willing to participate in the exploitation of the joint IMPRESS DSS Platform are presented. The IPR for individually owned components / tools is defined by the owner of the component / tool even when this component / tool is used within the IMPRESS DSS Platform.

Since where possible open standards were used, individual components can be exploited individually or as a complete solution. There are areas which can be explored with more research. These areas are easier or autonomous use of mobile data terminals by field personnel and incorporating telecommunications in disaster-areas.

Regarding further research and potential exploitation of distinct components / tools, IVI has already initiated discussions with County Görlitz (Freestate of Saxony) to further develop the INCIMOB mobile application. For this, adaptations to the German emergency procedures are needed (e.g. choice and order of patient details to be registered) and interfaces to the existing digital systems must be implemented. Both are feasible due to the flexible architecture of INCIMOB. Fraunhofer IVI envisages to transfer INCIMOB from the prototype into a readily usable, commercial product and daily usage (respectively usage in mass-casualty incidents) by multiple organisations.

Furthermore, Fraunhofer IVI currently discusses with Friedrich-Löffler-Institut (Federal Research Institute for Animal Health) to connect patient data registration with data registered for animal production, transport and symptoms since diseases between human and animal populations are transmitted between them. So far, data is collected only separately for either human or animals. An integrated database may provide a global view and may help to prevent and control diseases. It is foreseen to undertake this development in the frame of an interdisciplinary research project.

The EMCR router is an output which has been initialised during the IMPRESS project by STWS but requires further research in order to take an exploitable form and more specifically to be integrated in the STWS product suite. It has been already adapted recently and used in the frame of a commercial project delivery of STWS that concerned the IMS/CAD system of Fire Brigade in Greece at National Scale.

Last but not least, a pilot implementation of the IMPRESS solution in Cyprus is foreseen. An extended pilot implementation by ADITESS is foreseen as the next key milestone for the IMPRESS solution in
Cyprus. An end-user pilot would help in testing the scalability of the solution, its robustness, identifying further development requirements and most importantly acting as a key reference site for exploitations. ADITESS is in the discussion with a department of the Ministry of Health of Cyprus which showed interest in the IMPRESS solution, in order to agree on this collaboration and to proceed with the further steps of the pilot implementation.

1.5 IMPRESS Project Details

1.5.1 Project web site, e-mail and social media accounts

Project website: www.fp7-impress.eu
E-mail: info@fp7-impress.eu
Twitter: @Impress_FP7
LinkedIn: “IMPRESS FP7 Project” group
Facebook: “IMPRESS FP7 Project” page

1.5.2 IMPRESS Project Coordinator Contact Details

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1.5.3 Project Logo

1.5.4 List of Beneficiaries

Twelve partnering organisations form the IMPRESS project consortium, bringing together expertise in research and development that is required in order to achieve the project objectives. In the sequel, short names of partners will be used as indicated in the following Table:

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