Technology Handbook for Emergency Medical Response

D1.5

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NIGHTINGALE

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PROJECT PARTNERS

Partner No.	Logo	Partner	Short name	Country
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2		TOTALFORSVARETS FORSKNINGSINSTITUT	FOI	Sweden
3		LEONARDO – SOCIETA PER AZIONI	LDO	Italy
4		C4CONTROLS LTD *[TERMINATED]*	C4C *[TERMINATED]*	UK *[TERMINATED]*
5		INTRASOFT INTERNATIONAL SA	INTRA	Luxembourg
6		INOV INSTITUTO DE ENGENHARIA DE SISTEMAS E COMPUTADORES, INOVACAO	INOV	Portugal
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LIST OF ABBREVIATIONS (ALPHABETICAL ORDER)

Abbreviation	Definition
2D/3D	2/3 Dimensions
AED	Automatic External Defibrillator
AML	Advanced Mobile Location
AMP	Advanced Medical Post
API	Application Programming Interface
BLS	Basic Life Support
CBRN	Chemical, Biological, Radio-Nuclear
CCP	Command and Control Post
CODU	The Urgent Patient Guidance Centers
CPR	Cardio-Pulmonary Resuscitation
DOA	Description of Action
EMS	Emergency Medical Services/ Support
EMT	Emergency medical technician
EOC	Emergency Operations Center
ETSI	European Telecommunications Standards Institute
FA	First Aid
GA	Grant Agreement
GIS	Geographical Information System
GPS	Global Positioning System
IED	Improvised Explosives Devices
IoT	Internet of Things
IR	Infra-Red
MCI	Mass Casualty Incident
MMU	Mobile Medical Units
MRD	Director of Medical Rescue
MTC	Medical Transport Capacity
NG112	Next Generation 112
OC	Operations Center
PDA	Personal Digital Assistant

PEMEA	Pan-European Mobile Emergency Application
PSAP	Public Safety Answering Point
SALT	Sort, Assess, Lifesaving Interventions, Treatment and/or Transport
SOCMINT	Social Media Intelligence
START	Simple Triage And Rapid Treatment
UAB	User Advisory Board
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
USA	United States of America
VIC	Disaster Intervention Vehicle
VMER	Emergency and Resuscitation Medical Vehicle
WVSM	Wireless Vital Signs Monitor

Executive Summary

The management of a Mass Casualty Incident (MCI) evolves through several key activity areas. First, receiving the notification of the event, dispatching response units, alerting and providing guidance to the public, creating and updating a real-time common situational picture, sharing information with other response organizations and authorities. Second, performing the triage of patients (on several instances – for treatment on the field, for treatment and the patient collection point or Advanced Medical Post (AMP), for transportation). Third, delivering treatment to victims (considering the resources available on the scene – human and material and fourth, determining the transportation of casualties to definitive care, matching the right hospital with the right resource and considering the severity and nature of the injury, (such as neurological injuries, severe burns), the treatment capacity of the hospital and the time to destination).

Significant advances in technology, especially in the areas involving – Command & Control, increased dramatically the capacity to address issues described under the First item – Public Safety Accesses Point (PSAP) centers, using NG112 system to have the capacity to receive the location of the caller, receive footage from the scene, and send the closest response resources based on accurate location. Dispatchers can see images from the scene using dashboard cameras on response vehicles, cameras on drones and Close Circuit Television. In addition, they can widely share this information using dedicated apps within their organization, with other organizations, and with the public, as appropriate using the different apps available and social media accounts.

On the other hand, triage is still performed using paper-based tags, a reality creating many challenges when it comes to real-time information on the location of the victims and the severity of their injuries (something that should be translated into the real-time allocation of resources). Though technology exists to a degree to allow "electronic triage tags" that transmit data on location and the patient's condition, these technologies are not used in real life. Some reasons include the dependency on connectivity (which may be affected after a large scale incident due to the overload of usage of the cellular network), reliability (e.g., limited battery life rendering the tag useless), lack of "working hands" of medical responders (who would treat the casualties first, only then deal with technology), and the reluctance of organizations to implement technologies that will start providing information "at some point during the incident", with the risk of providing partial information to decision makers, leading to wrong decisions.

The solution suggested is looking for technologies to be used daily, thus ensuring they will be in good operational order to be used during the emergency operation. It should also be as automatic as possible, so no additional time is taken from medical personnel when conducting for their task, and very little training and no licensing are needed.

These challenges are specifically crucial in a "sudden onset MCI", as a major accident in a large European urban setting, where technology should be a support to the operation, not a factor that delays (due to time to deploy and operate on the field) the treatment and evacuation of casualties.

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Introduction

The NIGHTINGALE project focuses on developing technologies and procedures that are expected to benefit Mass Casualty Incident (MCI) handling. From a technological perspective, medical and non-medical responders, when responding to an MCI, rely on tools, services and systems for retrieving information and triaging victims within and around the incident scene, for performing transport, for exchanging information and collaborating among participating agencies and for making available the needed resources to respond to the incident. From a procedural perspective, medical and non-medical responders follow defined workflows that nominate participating agencies and teams to a given incident and the chain of command, which dictate the triage, evacuation, and transport process to be followed and indicate the collaboration and coordination framework in place.

As NIGHTINGALE has the purpose of enhancing all abovementioned aspects, acknowledging at the same time operational differences among agencies in different countries, this deliverable does the first step towards better comprehend technology and procedures in place of the consortium's medical and non-medical responders as well as of selected organisations/countries of the members of the User Advisory Board (UAB). Such descriptions will allow on one hand to inventory operational technology and procedures and, on the other hand, to permit the identification of gaps and shortcomings that existing systems have.

Furthermore, in this deliverable, we perform a technology watch concerning state-of-the-art technologies, tools, and services available in the market to support the MCI handling processes. Again, gaps and limitations of modern systems are to be highlighted better to understand the innovation pathway of the NIGHTINGALE project.

This document is structured as follows:

Section 1 provides a concise description of the connection of the contents of the deliverable to the related tasks of the NIGHTINGALE grant agreement (GA).

Section 2 set the scene of the document and defines the main categories of responders, the important milestones within an MCI response and the categorisation of tools, services, systems and procedures that are dominant in an MCI response.

Section 3 presents the technology and processes in place for the consortium's medical and non-medical responders and for selected members of the UAB. In this section, we also present the results of a public questionnaire that has been completed by various practitioners. This section also addresses advantages, gaps, and limitations of the systems and processes described. It also presents a market watch describing the state-of-the-art technology for an MCI response available in the market. Gaps and limitations of such systems, tools or services also described.

Finally, the conclusions of the deliverable are presented, raise issues to be solved and suggest the best optional solution to handle the issue.

1. Addressing the NIGHTINGALE Description of Action

The following table presents the connection of the contents of the present deliverable to the NIGHTINGALE Description of Action (DoA). D1.5 is a direct outcome of T1.3 - Technology Watch for emergency medical services (EMS) - Gaps and Limitations and it informs T1.4 and T1.5 on Scenarios/Use Cases and on functional and non-functional user requirements respectively.

Table 1 Contents of the present deliverable in relation to GA requirements

NIGHTINGALE GA requirements	Corresponding Section(s)	Short description
This task will be focused on delivering the most updated, state-of-the-art situation regarding operational technologies for Emergency Medical and Non-Medical First Responders. The purpose of this task will be twofold: to provide a view on the technologies currently used and accepted by the practitioners when handling MCIs, their benefits and their limitations…	Section 3	The requiered information is detailed in this deliverable.
…and to identify the latest and upcoming technology tools on the market potentially to be adopted by practitioners whilst analyzing possibility to be integrated with NIGHTINGALE Toolkit as well as gaps and shortcomings preventing adoption by practitioners.	Section 4	The requiered information is detailed in this deliverable.
Such in-depth Technology Watch and acceptance/adoption dynamics (i.e. strengths and gaps) for emergency medical responders and non-medical CP agencies that are operating in mass casualty incidents, shall provide the most useful insight for the challenges NIGHTINGALE Toolkit will need to surpass towards succeeding its envisaged adoption pathway as well as will deliver substantial input for the definition of technical requirements, specification, Toolkit design and validation KPIs	Section 3 and Section 4	The requiered information is detailed in this deliverable.

2.Setting the scene of MCI

2.1. Mass Casualty Incident (MCI)

"Mass casualty incidents (MCI), generate more casualties at one time than the locally available resources can manage using the routine procedures, highlighting that resource scarcity becomes a critical decision-making issue. MCI triage aims to prioritize casualties according to the severity of their injuries, often keeping available resources in mind" [1].

A Mass Casualty Incident is a collection of circumstances when the treatment needs and the capacity on scene is significantly misbalanced (MDA definitions), for example plane crashes, large road accidents, building collapses or security related incidents like the 09/11 attacks in 2001. A multiple casualty incident is one in which there are multiple casualties; however the amount of available resources is enough to deal with the situation. The definition of MCI can be different for each agency and sometimes can be classified into different levels, depends on the number of causalities or the entity of response in terms of resources. When the supply of resources does not meet the demand of the patients injured, regardless of the cause, the emergency classified as a MCI and it cannot be managed by normal procedures.

There are many facets to responding to a mass-casualty event. There is the initial scene assessment and setup, triage, movement of patients to casualty collection points, treatment and ultimately transportation for definitive care. A well-designed and well-practiced system will provide for both the safety of the responders and the efficient triage, treatment and transportation of victims. It is important that all EMS responders have a good fundamental understanding of not only the various aspects of triage, treatment and transport, but also the principles and concepts pertaining to the management and coordination of MCIs. There are several organizations and responders involved in those kinds of occurrences, which means that agencies with different type of training and structure respond with a different type of task.

1. The general public:
   Bystanders are the first on the scene. They are the ones who call the incident in, provide the Public Safety Answering Point (PSAP) with essential information on the situation (even providing photos and videos to next generation 112 (NG112)), Initiate rescue operations and provide first aid (FA) to the injured (in NG112, PSAP operators can remotely provide FA instructions to callers on critical issues, such as bleeding control, that are part of the call reception protocol).
   The attitude towards bystanders on scene differs among public safety organizations (i.e., Blue Lights Services): while some services consider them a valuable resource to provide support, other services believe they should be removed immediately from the scene, and many services

entertain in-between approaches (e.g. ask bystanders to support in specific activities performed away from the immediate scene).

2. PSAP – Public Safety Answering Point:
   PSAP refers to the emergency call reception center, having different implementation models in European Member States. As per European directive, it is universally accessible in public telephone networks in Member States[1] using the number 112. This is where the initial information, originated from mostly citizens' calls, on the incident is collected and evaluated. The information is then sent to the appropriate dispatch center (depending on the emergency response structure in the jurisdiction), who dispatches response resources and activates the MCI protocol. As the PSAP call takers receive additional information, it is forwarded to the appropriate dispatch center.

3. Emergency Operations Center (EOC)/Field Command Post:
   Based on the local MCI protocol, the following structures may be activated:
   a. Emergency Operations Center (EOC), which may take over the management of the incident, or just exercises an oversight role. Depending on the size/complexity of the incident, additional EOC may be activated at the more senior levels – silver/gold/elected officials.
   b. On-site command post – in some systems the on-site command post will take over radio communications and incident management, while in other systems, it is just the technical infrastructure for the organization's commander to fulfil one's tasks (meaning the radio operators are still at the dispatch center).
      On-site command post can be a single command post per organization (e.g. police command post, EMS command post, fire command post), or a joint command post where all organizations sit around one table. Any combination of both applies, as per the local incident management structure.

4. Incident Commander:
   The incident commander is the person responsible for the overall coordination of actions on the scene, aiming at – saving lives, containing hazards, minimizing the impact and restoring normality. Different incident command systems have different designations – from one agency being the incident commander (regardless of its nature) e.g. civil protection, while others will change as per the nature of the incident (usually between the fire and rescue services and police).

5. Public Safety organizations commanders:

[1] https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31991D0396:EN:HTML

Besides the "incident commander", each response organization has a designated commander, who is the senior on scene, and has the overall responsibility of the organization's functions on scene. Each blue light organization may have a different command structure, as per their internal structure.

6. Police:
   Police (with its different sub divisions – national, local, armed police) has some or all the following tasks:
   a. Security of the scene
   b. Crowd control
   c. Management of suspected objects and possible IED (Improvised Explosives devices), search of victims and objects to ensure no IED are present (bombs technicians)
   d. Cordoning of the area
   e. Traffic control
   f. Collecting evidence and investigation
   g. Identification of the injured and decease (liaison with forensic medicine)
   h. Registration of those on the scene

7. Fire and rescue services:
   Have some or all the following tasks:
   a. Containment of hazards on the scene
   b. Search and rescue (including from collapsed structures)
   c. Rescue of victims from the epicentre of the scene, including FA
   d. Identification of the presence of toxic substances on the scene, and risk assessment
   e. Decontamination of victims
   f. Provide professional advice on stability of damaged structures, toxic situations, flammability of the situation

8. EMS:
   Have some or all the following tasks:
   a. Triage of patients (for rescue, initial treatment, advanced treatment, transportation)
   b. Initial life saving measures, advanced medical care
   c. Removing patients from the scene, from patient clearance point
   d. Transportation of patients to the appropriate care facilities
   e. Coordination with the receiving care facilities, and being constantly updated on their capacities
   f. Formally pronouncing the death of the deceased on scene
   g. Coordination the transportation (means and destination) of the walking wounded
   h. Registration of victims being treated and transported.

9. Public Information Officer (in different system different agencies have these functions):
   This function is conducted on multiple sites with multiple channels being used (see also 17. Media). These functions are active long after the scene has been cleared.
   a. Providing information and updates to the general public on the situation
   b. Providing warnings and guidance to the public as needed
   c. Providing information to the relatives of the injured about their location and situation
   d. Providing information to the relatives of the deceased and supporting their identification.
   e. Restoring family links

10. Mental health and psychosocial support:
    (In different systems, different agencies have these functions): This function is conducted on multiple sites with multiple channels being used. These functions are active long after the scene has been cleared.
    a. Providing support to the relatives and friends of the deceased.
    b. Providing support to the injured, their relatives and their friends.
    c. Providing support to the by standers who were on the scene (special needs of those who treated the injured)
    d. Providing support to the affected community/ies
    e. Providing support during ceremonies

11. Hospitals and other health care facilities, who received casualties from the incident:
    Provide specialised healthcare to victims delivered by EMS.

12. Health authorities :
    As in many systems, EMS / hospitals are not necessarily under the national health authority, the local regional or regional health authority is detached from real time information on the number of casualties, their condition, and distribution.

13. Civil Protection:
    In different systems, Civil Protection has different roles and mandate, thus might be or not considered a "blue light organization".

14. Local Authority:
    In some systems, the head of the local authority is the top authority of the blue lights services, thus is the "ultimate incident commanders" and delegates the power to the field commander. In other systems, the "blue light services" depend on other structure, and the local authority role is more dedicated to supporting the affected community.

15. Public authorities (higher in the hierarchy than the local authority, as governor, perfecturate):

Are the ones responsible to bring additional support to the scene, from sources outside of the local jurisdiction. This will be done upon request of the local commanders when resources available locally are not sufficient. These administrative levels are also those responsible to monitor the situation and inform the higher authorities.

16. Elected officials:
    At the different levels of the political system, are the ones expecting real time information on the situation.

17. Media:
    Broadcasting from the scene and any point of interest and requesting immediate updated information. Traditional media includes television and radio, while some organisations have started to explore the use of social networks.

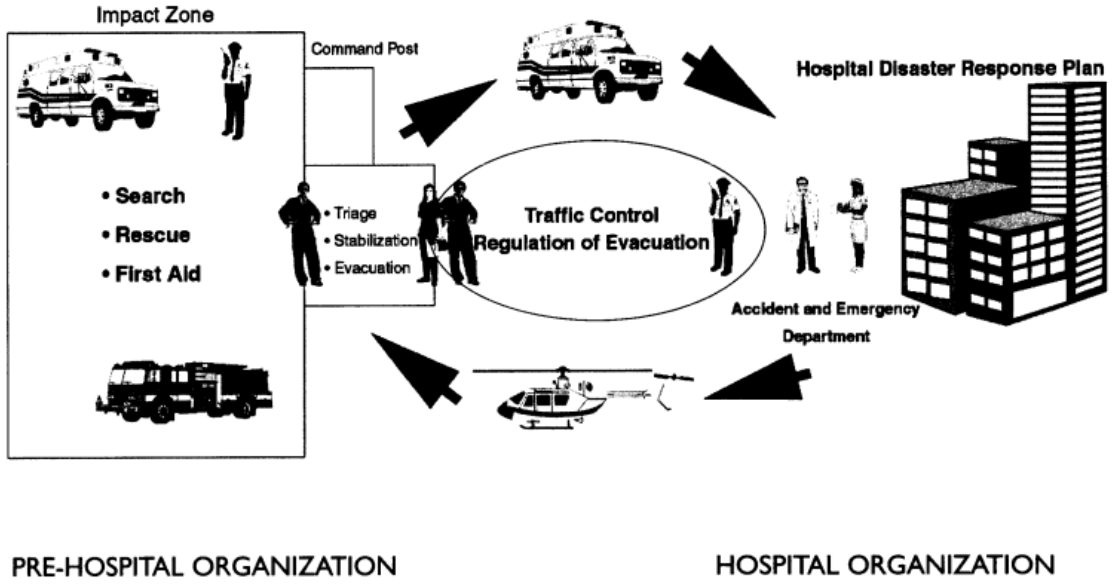


Figure 1 MCI management system [2]

2.2. Basic workflow of an MCI response

The MCI management starts with the alerting process, which includes initial warning, assessment of the situation and dissemination of the alert message. The core of the alerting process is the PSAP; an emergency all center that receives emergency calls from citizens and is linked by radio and phone to all services involved in emergency management. At this point, a quick initial assessment is required, which will be the main difference between a poorly run MCI scene that risks poor patient outcomes and a well-run MCI scene that gives victims their best chance for survival. The purpose of this procedure is to identify the immediate extent and the potential risk of the problem; to know exactly what happened and what may happen, to mobilize adequate resources and to correctly organize the field management. As part of the initial assessment, the PSAP needs to identify the exact location of the event, time and type of the incident, estimated number of casualties and added potential risks.

In case a MCI is declared, the PSAP alerts the local emergency and health care services, informing specific persons and institutions, mobilizing necessary resources to scene and creating a common operational picture. The first arriving EMS team is responsible for creating the operational picture by performing an initial scene assessment (using similar principles to those of the PSAP assessment) and immediately reporting to the dispatch center before any further action is taken. If first responders start their work in the field before reporting, there may be a delay in the mobilization of resources, or critical information may be lost.

The Emergency services widely use the METHANE acronym to build a report for alerting others about a major incident.

METHANE stands for:

- Major Incident Declared
- Exact location
- Type of incident
- Hazards
- Access
- Number and type of casualties
- Emergency services present and required

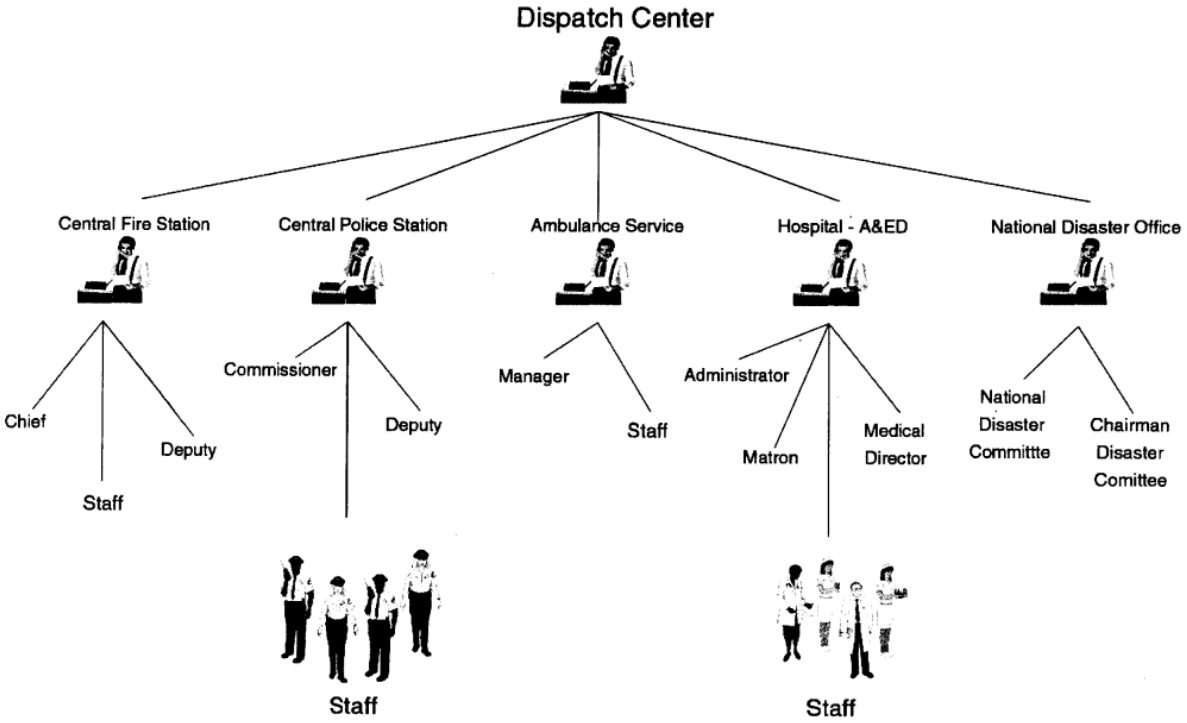


Figure 2 Cascade alerting system [2]

The second role of the first arriving responders is to identify the field areas to be established (access roads, evacuation area). The pre identification of these areas will allow various incoming resources to reach their specific areas rapidly. The field management of the event may require the mobilization and coordination of sectors, which do not routinely work together, therefore a multi- sectoral control unit, could be formed in order to supervise victim management. The main principle for an effective command post is radio communication that can be implemented from any sort of structure, like an ambulance vehicle or specific mobile command post.

The next objective in field management is the rapid triage of the casualties, identify those who needs immediate treatment and transport to health care facilities and the victims who can be delayed. This primary triage is mainly based essentially on urgency and likelihood of survival, criteria followed by several of the popular triage systems described in the following chapter. The field triage process is conducted at three levels:

- On- site triage (primary triage)
- Medical triage (secondary triage)
- Evacuation triage (last field triage)

The variety of equipment used while responding to MCI is unlimited, although the basic requirements of resources are globally well- accepted and includes:

- Identification devices for area and responders
- Triage tags
- Area lightning devices

- Stretchers
- Blankets and survival blankets
- Gloves, flashlight, stethoscope
- Medical disaster/ MCI kit (Airway equipment, cardio-vascular equipment, pneumatic equipment)

After the process of triage and life- saving medical treatment, the evacuation procedures begins. Strict control of the destination and/ or rate of transportation is crucial to avoid overwhelming the health care facilities. Keeping the scene in order and controlling the victim flow is essential, for victim movement must be in one-way direction and without crossing. From impact zone site to collecting point, from collecting point to the advanced medical post (AMP) entrance, from the AMP entrance to evacuation area, from evacuation area to hospital. The efficiency of each successive in between levels is maximized by ensuring that the circulation follows in a one- way, controlled rotation. Non-acute victims are typically evacuated only at the end of field operations.

When pre- hospital victim management is efficient, the controlled flow of victims arriving at the hospital will allow immediate dispatch of victims to the appropriate care area. In a well- established MCI management system, constant communication must be maintained between the hospital and the Field Commander Post/ PSAP. Beds should be made available in the hospital to accommodate victims of the MCI. The reception capacity of a hospital is not only linked to the number of beds available, but to its capacity to deliver care. At this time, additional medical staff members are required to come in duty and support treatment efforts. The hospital treatment areas usually are sorted to five main categories:

1. Read treatment area
2. Yellow treatment area
3. Green treatment area
4. Hopeless victim area (patients needing only palliative care)
5. Deceased victim area

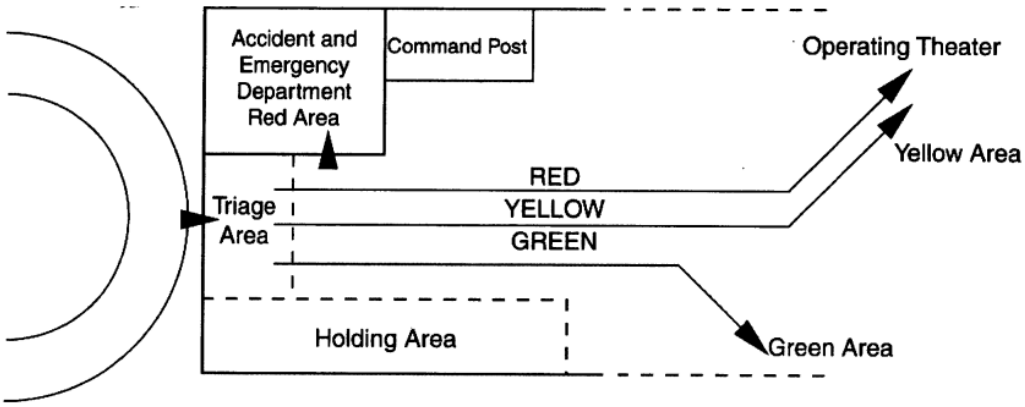


Figure 3 Flow of victims [2]

2.3. Inventorying systems and processes currently in use- an example from Italy

2.3.1. Processes currently in use in Italy in case of declaration of an MCI

What herein described for Italy is what happens in most European countries were health systems are based on Regional afferences. Before starting an overarching excursus, which may be tailored for other European Member States or Regions, we must remember that [3, 4, 5, 6, 7]:

Processes are divided to the following categories:

1) **Receiving the call, creating and initial understanding of the incident (including next generation 112)**

The Italian model for MCI foresees the involvement of a Single Response Centre which is accessed by a 112 call and to which the 112, 113, 115 118 lines are channeled. This center has the task of receiving and assessing emergency requests, as well as to activate the most suitable response (State Police, Fire Brigade or Medical Rescue). This center is usually on regional or loco-regional basis.
Structurally, a functional and efficient Operations Centre (OC) must possess characteristics of operational autonomy at all times, have internal areas dedicated to the administrative, nursing, technical and management offices and for relations with staff and the public. The OC assolves the task of management, coordination, planning, organization and control functions, as well as training activities.
In addition, there must be warehouses/storage facilities for equipment and materials and vehicles.
The Operations Room must only be accessible to the staff and the posts of the control center operators must be arranged to allow functional autonomy without interference and, at the same time, facilitate integration and exchange of information.

Available technologies must include audio communication and data transmission equipment, audio recording systems and all the necessary technology, including adequate power supply and the presence of uninterruptible power supplies.
The informatics software must facilitate the management of operational process by having data updated in real time, it must allow the recognition and location of the calls, it must use a mapping system and it must improve the monitoring capacity through the collection, analysis and evaluation of data and information.

The telephone system must provide backup options that are automatically activated in the event of a flow interruption. It should provide a double circuit:

- A closed circuit that connects the control center with all the territorial posts and with the structures involved in emergencies;
- An open circuit with the outside world for sharing information.

The radio system must use its own frequency pairs made available free of charge and exclusively by the Ministry of Health to Emergency Services on a national scale and must have adequate coverage of the reference territory.
The phonic recording system, integrated with the computer system, must allow the immediate replay of the conversations that must be archived.
The operators in charge of assessing telephone calls should have standardized and computerized interview protocols that allow for the immediate re-listening of conversations and enable them to identify the circumstances of the incident and the best resources to activate.
In addition, the call-receiving center must be able to provide useful instructions before the arrival of first responders, so that first aid maneuvers can be facilitated and self-protection guaranteed while waiting for the arrival of the medical responders.
Finally, a multilingual telephone interpretation service must be provided for rapid activation.

2) Alerting and dispatching resources

Once the necessary information has been acquired, the Territorial Operations Centre must

- Mobilize men and resources
- alert all the health structures in the area concerned (in particular the hospital emergency departments);
- alert and link the competent authorities and other civil protection structures according to municipal, provincial and regional planning.

The available emergency vehicles will be sent to the site of the event where they will join the assessment teams that may have been sent beforehand.
A doctor, designated by the OC will take charge of coordinating operations while waiting for the Medical Rescue Director to arrive.
His task will be to coordinate the medical recovery operations and, with the available personnel assist in complex extrication and recovery operations carried out by the fire brigade, implement primary triage, define areas of triage, define the collection areas of the injured and the optimal route to the Advanced Medical Post.

In the meantime, the OC will send personnel and vehicles to set up the AMP outside the area, previously perimetered and guarded by the police forces. The tasks of AMP will be secondary triage, stabilization and evacuation of previously recovered victims.
The OC will have to organize a command post (Mobile Command Post) headed by the Medical Rescue Director who will be responsible for the management of the whole medical intervention system with the task of connecting the operators involved in the recovery of victims, the AMP, the OC and the persons in charge of other services (Fire Brigade, Police, etc.).
If the event affects a small area, a single reception and command area for the available forces.

If the event affects a big area, this will be divided into several sectors, which may refer to several AMPs or to more complex field medical structures such as Mobile Medical Units (MMUs) or field hospitals.

3) Resources management

The 118 Health Emergency Operations Centre is the main interlocutor in the health field in case of MCIs and will guarantee the coordination of territorial and hospital structures, public and private organizations involved in the emergency response (Act of Agreement between the State and the Regions published in the Official Gazette on 17 May 1996).
The immediate response phase by the 118 emergency services will be carried out by the activation of "**first departure" teams** with the task of carrying out the:

- reconnaissance of the site;
- sizing of the event;
- identification of the main type of event and its consequences on people;
- identification and signaling of access possibilities to the area (definition of viability);
- identification of the most suitable places for the possible setup of the elements of the "rescue chain" AMP and MMUs;
- subdivision of the area into sectors assigned to rescue teams;
- first triage, as soon as the above tasks have been completed.

The deferred response phase will consist of:

- mobilization of local resources foreseen for maxi-emergencies;
- setting up the various elements of the rescue chain.

The "second departure" rescue teams will carry out:

- the second triage and primary stabilization;
- evacuation of injured people coordinated by 118 emergency services.

The first ambulance with the first police car and the first fire brigade "departure" constitute the first command and control post (CCP).
At the scene of the event, the person in charge of OC 118 or a doctor delegated by the 118 medical director will act as Director of Medical Rescue (MRD).
It is necessary that the MRD have specific training in the management of MCI. They will interact with similar representatives of the fire brigade, the police and other institutions in charge of emergency management. The MRD must be able to operate immediately in order to dispose and coordinate resources need to set up the “rescue chain”. He/she will assume responsibility for every medical

intervention device in the area of operations, maintaining a constant link with the Doctor of the 118 Operations Centre.
The figure of the MRD is related to:

- the Triage Director, a doctor or, in his/her absence, a professional nurse, in charge of coordinating triage operations on victims;
- the Transport Director, a nurse or technical operator in charge of manage the movement of medical transport vehicles according to the priorities triage operations, with the help of a telecommunications technician.

The OC 118 will set up the chain of medical assistance (AMP; MMUs) disposing the local resources provided for maxi-emergencies, if necessary.

The "first-start" or "rapid response" medical teams are different from the tasks and equipment of 'second departure' or 'delayed departure' teams.

- First departure teams are those usually contained within the ambulances.
  - Second departure teams have customary equipment reinforced with "disaster lots" marked with the four colors according to the criteria adopted at international level:
    - non-medical equipment (yellow);
    - cardiovascular support equipment (red);
    - respiratory support equipment (blue);
    - other materials (green).

The AMP is located at the outer edges of the safety area or in front of the event with respect to the safety area. The AMP can be a structure or a functional area for gathering the victims; concentrate first treatment resources; carry out triage; organize medical evacuation of injured to hospital centers.
The AMP, located in fixed structures (existing premises) or in tents, must include 4 zones:

- triage area where the injured are assessed and directed to the destination area;
- absolute emergency area or red/yellow area for pre-hospital resuscitation and stabilization of severe injured;
- "relative emergency area" or green area for non-severe injured;
- a separate area for the recognition of the deceased by the judicial authorities.

1st LEVEL AMP:
The 1st LEVEL AMP has the following characteristics:

- ordinarily managed by the 118 emergency service;
- limited treatment capacity (10 patients);
- rapid deployment (set up within 1 hour);
- limited duration of intervention (maximum 12 hours).

It is set up when the impact of the event does not compromise the integrity of the existing rescue structures (hospitals) and the need for emergency response is expected to be temporary limited.

2nd AMP:
The 2nd LEVEL AMP has the following characteristics:

- it is the treatment facility in the event of a major disaster (emergencies type c) thus those situations that go beyond the possibilities of the existing rescue structure (Art. 2 Law no. 225 of 24 February 1992);
- it must be ready for use as soon as possible after the alarm (3-4 hours);
- it is able to treat 50 patients with a red-yellow code of severity within 24 hours and for three days;
  it has 72 hours of operational autonomy.

In case of catastrophic events that go beyond the possibility of local response and impair hospital structures, an “extraordinary medical rescue chain” is activated with other field structures, such as mobile medical and surgical units (MMSUs) and field hospitals.
The MMSUs are intermediate structures between the disaster area and the field hospitals, setup for events involving a vast coverage of the territory and impairing hospital structures. It is equipped with a reception area, triage area, operating theatre, emergency room, maternity ward and must be self-sufficient in terms of health and logistics for at least 48 hours. It is a mobile structure equipped to function as an AMP, including 2, maximum 3 pneumatic tents, stackable stretchers for 50 injured persons, power generators (electricity and oxygen), medical equipment divided into "disaster lots". Pending the setting up of field hospitals, medical aid (personnel and vehicles) that arrive in the affected area can be referred to the nearest hospital where it is presumed that the wounded will be transported spontaneously by the rescuers and first responders.

4) Creating, updating and sharing a common operational picture

Facing MCIs, it is foreseeable that ordinary tele-radio-communication systems may be compromised. Therefore, it may be necessary to use impromptu networks operated by the Radio Emergency Services of radio amateurs and police, which will establish communications between operational centers, hospitals and field facilities using differentiated and exclusive channels. As soon as possible, the medical RT station of each sector should be placed alongside the respective RT stations of the other units deployed on the territory (fire brigade, police, army) for better control of the information distributed to the various contacts. It is essential that the regional radio networks of the 118 OC system be structured to allow communications in emergency conditions through the use of mobile repeaters to be activated in the event of a disaster.

5) Triage

The triage systems referred in the National Emergency Plan do not foresee the employment of devices for primary triage. During the first triage, performed by first responders, the injured person is firstly identified by a “color code”. After that, a triage card needs to be filled indicating the class of severity. The second triage will be done at the AMP for each victim involved and a triage card, which will accompany him/her until arrival at the hospital, is filled out.

The first triage protocol considered is the START (Simple Triage And Rapid Treatment) and it is aimed at rescue teams.
The second protocol (CESIRA) is similar in approach, but it is aimed specifically at rescue teams that do not have a medical component and therefore it does not include the possibility of making death determinations in the field. The acronym (CESIRA) represents the sequence of pathophysiological conditions to be identified (Consciousness, Hemorrhage, Shock, Respiratory failure, Bone fracture, Other) in order to be able to classify patients, as can be easily seen in the following diagram.

6) Patient care

Circulation Management

For the purposes of planning for the deployment of resources (MMSUs, AMP, field hospitals), all classes of complexity must be represented.
In contrast, the tables identify in the first classes of effectiveness (I and IIa) the procedures and equipment that enable rescue teams, AMP personnel, or those working at the initial stages of the rescue chain to carry out assistance maneuvers with the most favorable cost/benefit ratio.
A similar operation can be carried out for other items relating to materials of "generic" use, thus obtaining a list of equipment essential but sufficient to cope with the various problems encountered in a maxi-emergency scenario.

Classes I (essential)

- Stretchers;
- Towels for casualties;
- Thermal protection material;
- Water;
- Battery operated flashlights.

Class IIa (useful)

- Batteries;
- Lamps;
- Immobilizers for limbs;
- Cervical collars;
- Spine immobilizers;
- Basic surgical instruments;
- Megaphones;
- Radio telephones;
- Plastic bags for waste.

Class IIb (useful but redundant or with logistical problems)

- Vacuum mattresses;
- Air compressors;
- Current generators;
- Battery charger;

- Shelter heating devices (pneumatic curtains or other);
- Supports for stretchers;
- Mobile phones with fax.

7) **Patient tracking and monitoring**

The triage operations take place simultaneously with stabilization maneuvers useful to keep the patient alive at least half an hour. This allows patients to be sent to the red area or to the hospital:

- In the red area, therapeutic maneuvers are carried out to allow survival of at least three hours. This allows for a longer wait for definitive hospitalization.
- In the yellow area, therapeutic maneuvers are carried out to allow the patient not to evolve to a red code. This allows for a longer wait for hospitalization.
- In the green area, the main activity is the observation of the victims.

An example of an indicator useful for evaluating the resources to be deployed and for analyzing the real scenarios is:

a) Medical Transport Capacity 1 (MTC1):

It is an indicator developed to evaluate the number of ambulances theoretically necessary to transport all patients from the place of the event (evacuation time) within a certain period of time. Depending on the selected time interval, we speak of MTC1 if the time interval is 1 hour, MTC2 if the time interval is 2 hours and so on. Usually the parameter is considered 4 hours (MTC4) or 6 hours (MTC6).

Medical Transport Capacity MTC = (N * t) / (T * n)
MTC = Number of ambulances needed
N = number of patients to be transported
t = average transport time for each single round trip rotation
n = number of patients per ambulance
T = time limit set for site clearing (1 h - 2h - 4h - 6h)

8) **Sharing information with the public**

It is necessary to program a room, away from the rescue areas, where the Medical Director of the Presidium informs the media about the progress of the rescue. This room must be equipped with fixed telephony with internal and external lines, effective network coverage for mobile telephony and free Wi-Fi network.

2.4. Technologies and solutions supporting MCI declaration and resources dispatch

2.4.1. New generation emergency medical centres

The everyday person is not using the emergency lines often, and when they do, one would prefer not to. However, the stress and uncertainty are significant distractions that can lead to difficulties collecting important information over the event. Significant progress has been made to develop the

EMS command centers in the last decade to make the PSAP operators' and the dispatchers' work more efficient and the crises more manageable.

When a person informs the PSAP centre about an emergency, it is often difficult to describe the event's exact location, even if the caller knows the place. The time wasted in these situations can be easily avoided by locating the caller's mobile phone. A Geographical Information System (GIS) [8] is used to map the location of callers and determine the location of the various field first responders. Many agencies are operating advanced technologies allowing them to send photos and video live from the scene, a capability that could enable a better understanding of the field and even the possibility to guide the caller to triage and treat the victims before the help arrives. There are also new next-generation communication devices that operate on 4G\5G technologies that provide reliable and secure communication.

One of the best examples of the advanced MCI management software is called the **"Panacea's Cloud"** [9]. The product provides an effective communication and coordination tool in disaster situations, allowing the Incident Commander to deploy resources at suitable locations, reduce triage time, and manage the situation more efficiently. The system's features include:

1. Responder Theater Dashboard
   - Map of patients and first responders, providing location and status of each person.
   - Ability to enter new patients and staff into a database.
   - Ability to create and maintain an incident, receiving updates in real-time.
   - Video and audio feeds of first responders to provide instructions.
   - Messaging system to provide constant and up-to-date communication.
   - Data storage after the incident for review and documentation.

2. Heads up display

With Heads up Displays (Google Glass and Recon Jet), Panacea's Cloud can share audio and video feeds between first responders and Incident Commanders. This communication allows for real-time instructions and gives the Incident Commander mass amounts of information that can aid in making more informed decisions.

3. Virtual beacons

Panacea's Glass utilizes Virtual Beacons to document patients' location and statuses in an emergency. With low energy Bluetooth, these Virtual Beacons can communicate with our system and place patients on a map for the Incident Commander to see.

4. Network

Panacea's Cloud is composed of a mesh network that runs independently of Wi-Fi and other outside networks. This fault-tolerant network and mobile cloud allow for deployment anywhere and eliminate failures that take down the whole system.

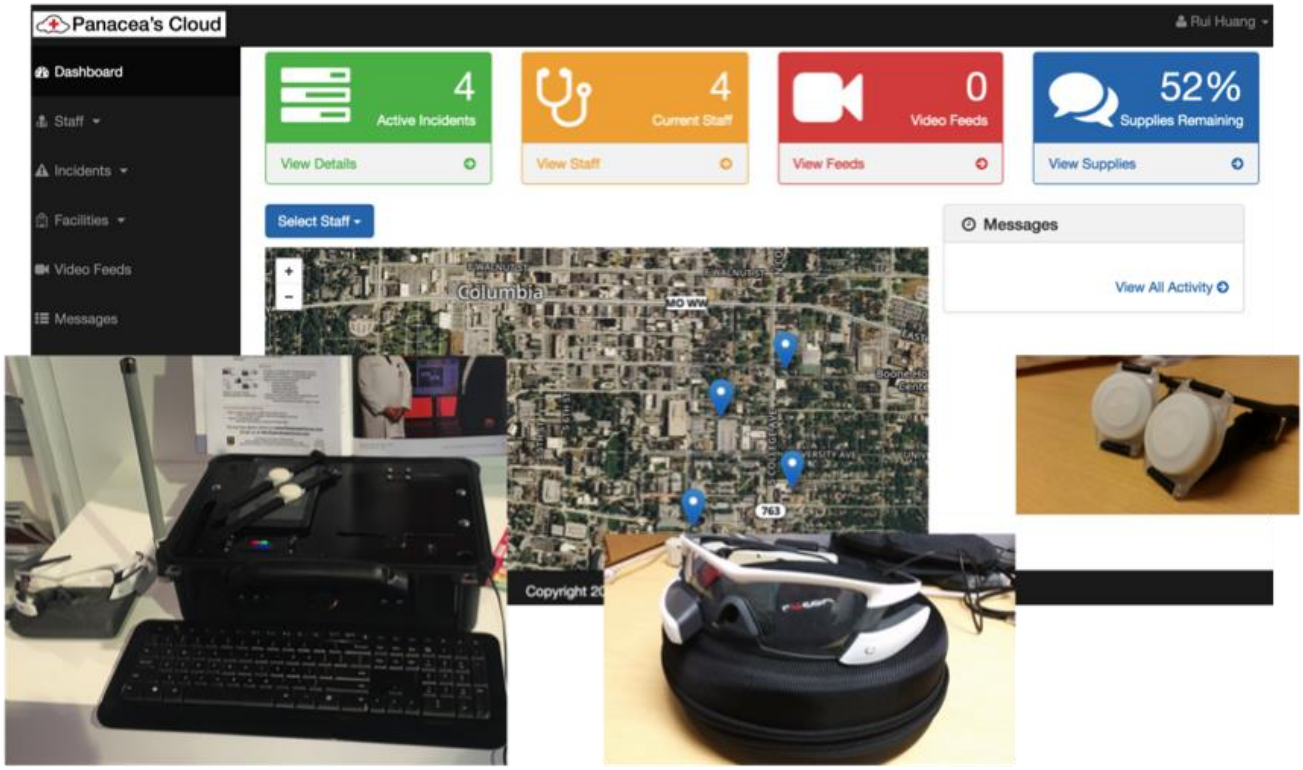


Figure 4 Panacea's Cloud- The tools [9]

2.4.2. MDA Command and Control system

MDA Command and Control system allows for efficient, real time response to tasks on the field (e.g. people in need for medical assistance), by allocating the site, allocating the resources needed and available, tasking the resources and following up the accomplishment. This can be achieved for large number of incidents simultaneously and for large number of resources to the same task, grouping them if needed. The systems receives and disseminates information to dedicated apps both used by the general public as well as by the team members and volunteers. The system is built to cope with the management of thousands of different operational events in real time, while putting an emphasis on the optimal use of the organization's resources.

The system contains and supports the following options:

- Operational Event Management
- Mission Management
- Vehicle Management
- Office Management
- Logistics Management
- HR Management
- Coordination of Intricate Missions
- End User Interface – Tablet / Cellular application

The system handles approximately 40,000 devices at any given time. In addition, dashboard cameras have been installed in all rescue vehicles to allow the dispatcher to watch a live video feed from the field. Many times, this ability is a decisive factor in managing an incident, allowing the dispatcher to understand the true nature of the medical emergency and to call additional MDA teams or security forces to the scene.

Operational Activation

The system works online from a central database and a central geographic information system. The Control and Command System receives operative information, processes it, and creates an update of the situation while suggesting possible treatment options to the decision makers. The system offers the operational system manager maximum information including classification of the event, type of rescue vehicles, staff, and equipment relevant to the event. All this takes place while evaluating variables ensuring maximum efficiency and quality of treatment for the patient. The system supports several layers of information. Some appear automatically (such as medical information regarding a patient recognized by the system) while some layers of information come to support the decision making process of the team. Using these tools the system manages thousands of medical emergencies a day while maximizing EMS abilities and minimizing response time. Dispatch uses different platforms at its disposal in order to save lives. The Control and Command System enables a wide and comprehensive view of the situation while identifying potential "bottle necks" both in routine work processes and in complex emergency situations.

- Receiving the call (including managing 'caller file')
- Analysing the call based on medical, demographic, and geographic facts.
- Managing a computerized event log reflecting current updates on all events allowing the dispatcher to manage events and create an update on all events and resources.
- Managing the vehicle fleet

The system manages all resources and platforms at its service. Based on the system manager's input the system optimizes resources as per events, taking into account event needs and prioritizing needs and resources.

The system's archive module reconstructs and audits events. The system records every action performed during the event and presents the auditor with a full, accurate, and realistic picture of the event as it was. Additionally, the archive module records all vehicular movement on its GIS layer and presents the location of dispatched vehicles and their respective routes on a built-in time scale. Also displayed are the locations of emergency vehicles that had been in the vicinity and where not dispatched thus enabling an effective audit of the event.

The system includes a form-managing module that manages all medical and logistical computerized forms as well as an archive of these forms.

The information managing system can warn of bottleneck situations in the workflow using a scale ranging up to the highest-level employees. The system uses display screens and active notices to teams' apps.

The system includes options for video conference calls

Multi Casualty Incident Management

The MCI module is rooted in the command-and-control system, allowing one or several MCI scenes to be simultaneously managed quickly and efficiently using an automated process, enhanced control capacity in the dispatch center, and the dispatcher's monitoring capabilities. Multi-casualty incident module has an interface that is identical to the system used during "routine" emergencies, providing the dispatcher with a system they're already intimately familiar with at a time when the stakes are highest and when it is crucial that he make educated decisions based on real-time informational analysis. The MCI module optimizes resources based on the geographical information it receives in real time and assists in assigning the appropriate resources to respond quickly to the multi-casualty incident while maintaining the ability to continue routine work throughout the country. The module includes many automatic and semi-automatic procedures, including:

- Dispatching rescue vehicles.
- Marking the arrival status of rescue vehicles.
- Dispatching announcements to PA systems in the stations.
- Sending updates to mailing list managers.
- Sending relevant information to the hospitals that patients are to be evacuated to.

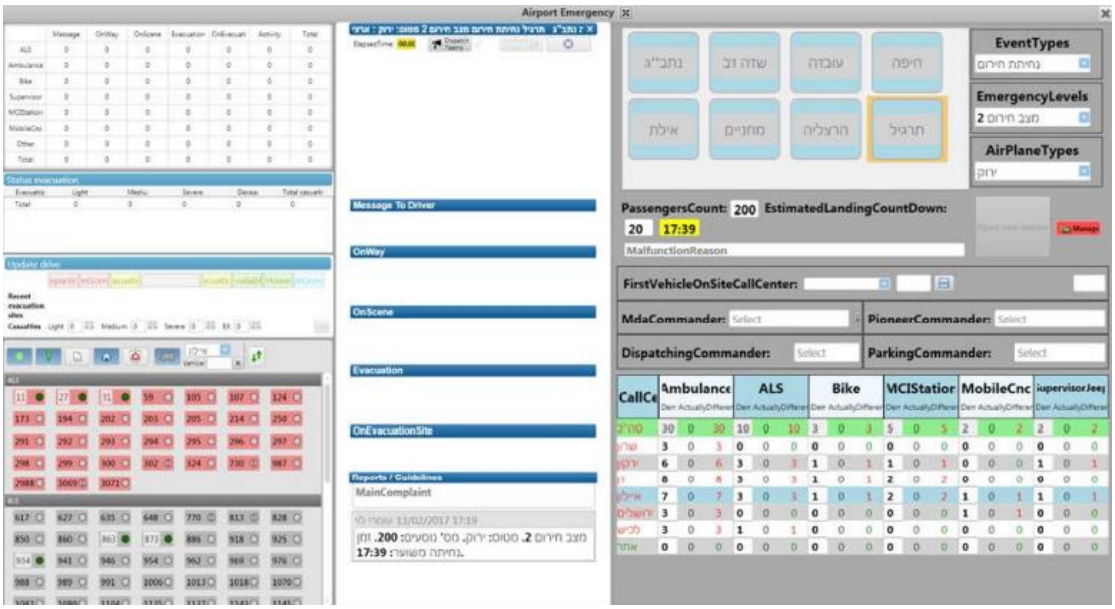


Figure 5 MCI Command and Control System

The system translates the data received into real-time information and sends it to the dispatcher and relevant decision-makers, while presenting the information in an easy-to-understand way. Another advantage of this smart system is its ability to provide a real-time report of the scene,

providing the dispatcher with an exact number of rescue vehicles dispatched to the scene, the number of injured civilians, and number of people who have already been evacuated. MCI module has proven itself on countless occasions over the years, assisting in the management of complex incidents throughout Israel.

Instant Geolocation

Locating the patient within seconds of receiving a call dramatically improves patient outcomes. That is why finding the patient's precise location is critical during a medical emergency and why it is the first step of a successful treatment. Thanks to the advanced technology, we are able to automatically locate a patient, even when they are in remote areas, such as forests, beaches, or the desert. When a caller can only provide an estimated location (and does not use any smartphone app, which instantly geo-locates callers), the dispatcher sends him an SMS text link. After clicking the link, the precise location of the caller appears on the GIS screen in the command-and-control system and EMTs are immediately dispatched to the scene.

Photos and live footage of emergency

It is crucial for dispatchers to get a clear understanding of an emergency scene to provide the optimal treatment to the patient. Dispatchers need to determine the kind of treatment a patient requires, the type of incident (terror attack, accident, disease), the nature of the injury (trauma, cardiac event, labour), and the scope of the incident (one patient or a multi-casualty incident). Using this information, the dispatcher can determine what type of rescue vehicle should be dispatched to the incident (Basic Life Support Ambulance or Mobile Intensive Care Unit, police unit or fire fighters), how many EMTs and which kind of medical teams, whether there is a need for security forces (such as police or the fire department), and which hospital the patients are to be evacuated to. Even if the caller is not using any unique smartphone app, he can still send files and photos to the dispatcher by clicking on a link sent him via a text message from the dispatcher. Opening the massage allows the caller to take a picture of the scene using his cell phone and send it to the dispatch center's command-and-control system. Every file is proofed for viruses or other malware and examined before entering the system for security purposes. Photos usually reveal the type of injury, making it easier for the dispatcher to consult with doctors either at the dispatch center or in hospitals about the recommended treatment. Frequently, receiving a photo from the scene makes it possible for the dispatcher to diagnose the severity of the injury and call hospital personnel, who will already be waiting with blood units and surgeons. This capability has proven to be very effective and has been instrumental in saving lives.

Live video feed from the scene

The command-and-control system can receive live video feeds from emergency scenes, which the dispatcher can view while simultaneously speaking to the caller and dispatching teams. This is possible through the use of unique app, which simultaneously opens a video feed to a dispatcher when a caller contacts emergency services in an emergency. Because of this function, the dispatcher can assess the type and extent of an incident and the condition of a patient before the first team even arrives. The dispatcher is also able to provide phone guidance to the caller, if necessary. Having the ability to watch what a caller is doing can tremendously improve the way he follows instructions,

especially since the caller is usually an untrained civilian who for the first time is being asked to stanch a patient's bleeding or to begin Cardio-Pulmonary Resuscitation (CPR) until first-responders arrive. In addition, based on what the dispatcher observes, he can make the most accurate diagnosis possible and decide whether to call for a medevac helicopter team or ask the hospital to prep an operation room or catheterization room.

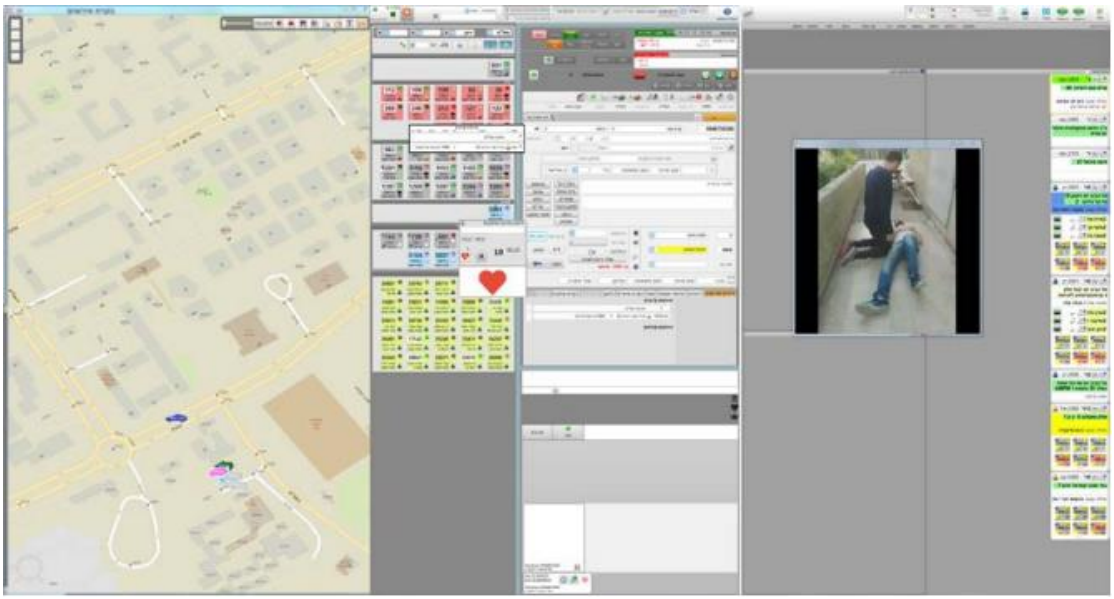


Figure 6 MDA Command and Control System features

2.4.3. MCI supporting Apps

Mobile applications of all kinds have become an integral part of our lives in many aspects, including emergency (and non-emergency) medical apps. There are many apps on the market for different medical purposes, for civilians and professionals.

Civil population dedicated App

The emergency app for the public should allow informing the PSAP about an emergency, regardless of the position of the caller. For example, an application called "My MDA" [10] allows the caller in need to access the PSAP within a few seconds, simply by entering the app and clicking on "call 101"

Figure 7 MDA app- Home screen

Other useful features of the App are:

- Emergency chat for people with disabilities;
- Sending and receiving photos and live video;
- Dispatcher locates the phone by Global Positioning System (GPS);
- Provides guidance and information about medical emergencies.

The Romanian Special Communication Service developed a similar mobile application. The 112 Call ("Apel 112") application is an application for mobile phones operating on Android and iOS systems, capable of reading location information generated by existing location services on the caller's phone and transmitting the geographical location of their phone to the 112 National Emergency Service.

The application uses Internet data connection and the mobile phone's location service to transmit to the 112 Emergency Service the location information in the Advanced Mobile Location (AML) format, containing the geographical coordinates of the mobile phone.

When the caller opens the application, the phone will display the latitude and longitude corresponding to their exact geographical location. Location accuracy is limited by the GPS features, the typical error interval being 10 meters.

Another platform that can support the communication between the person in need for help and the PSAP is the GeoHub Advanced Location Entity (GHALE) platform [11], developed by DEVERYWARE. This system allows the communication between Pan-European Mobile Emergency

Application (PEMEA)-compatible [12] 112 Apps and PSAP through the European Telecommunications Standards Institute (ETSI) PEMEA network, aimed at increasing and improving the communication capabilities between emergency centres (Private and Public Safety Access Points) and European citizens using Internet Applications to communicate. The PEMEA network is a EU standard that defines protocols and rules allowing emergency Apps to use Internet communications and reach European 112 emergency centres, supporting multimedia (e.g., voice, video and text) and data exchange (e.g., caller location).

The **GHALE Platform** is a middleware platform compatible with the ETSI PEMEA technical specification (Pan-European Mobile Emergency Applications ETSI TS 103478) and the ETSI NG112 technical specification (ETSI TS 103.479) ,specially designed to enable and control the multimedia communication between the emergency centers (PSAPs) and the online communication platforms on the Internet (Apps and IoT Hubs).

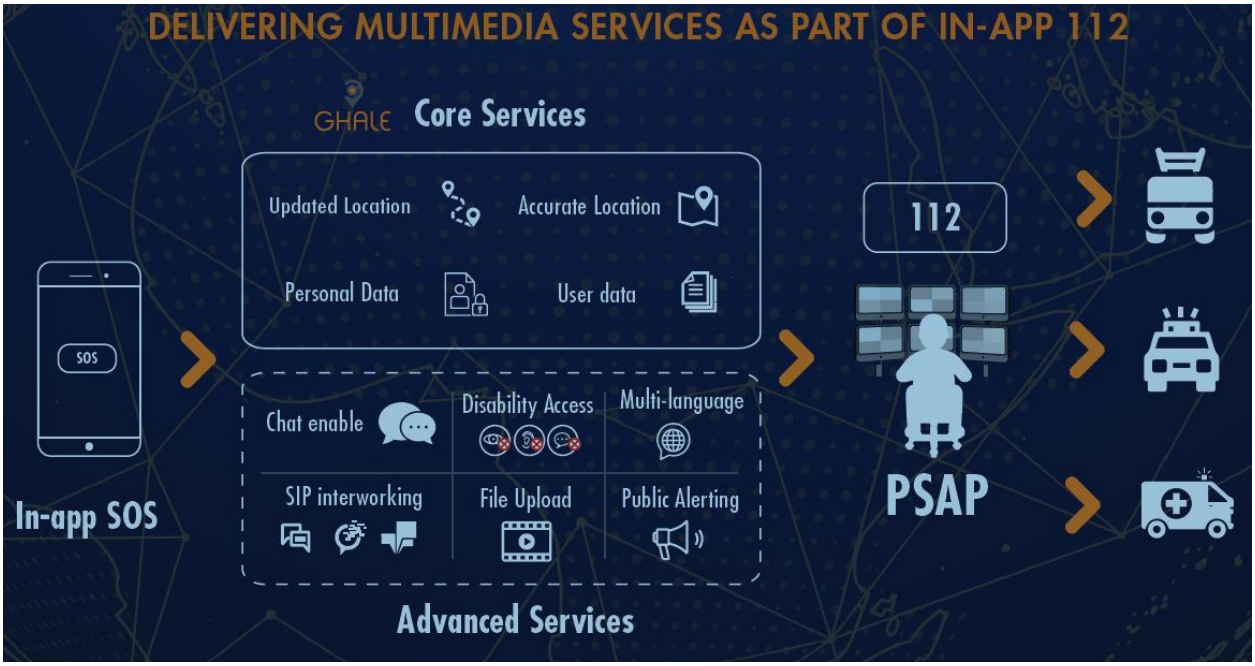


Figure 8 GHALE – Delivering multimedia services as part of IN-APP 112 [11]

Main advantages:

- **Main advantage for Citizens**, Citizens could leverage the full set of communication solutions available in the Internet (Apps) to get in contact with the regional and national PSAPs in a secure way, when they suffer an emergency situation. Internet applications (typically web-based or based on Apps running on Android/IOS devices) are able to leverage the capabilities of the citizens' portable devices and wearables to communicate with emergency services, providing:
  - Information to properly attend the emergency, as the GPS location, heart beat monitoring, historic medical info, spoken language, contact data of relatives;

    - Improved communication capabilities, as video, real time text, photo exchange, provision of data from wearable devices.
- **Main advantages for PSAP** would be able to monitor their citizens, not only by calls and by messages as it is traditionally done, but also through the full set of communication capabilities that internet solutions are offering today: video, chat, Real Time Text, file exchange, data streaming, alerting, etc. PSAP could also leverage the full set of solutions and data coming from new devices available in the market to better attend the emergency:
    - Data coming from the citizen's mobile phones e.g.: videos, photos, accurate location, personal info stored in the device;
    - Data from wearable and medical devices used by citizens e.g.: Real time heart beat monitoring, breathing frequency, victim movement status, blood pressure;
    - Data coming from Internet of Things (IoT) Devices inside the area of the emergency e.g.: indoor and outdoor devices as video cameras, fire detectors, pressure equipment, weather condition measurement devices, flood detectors, local weather station;
    - Data coming from devices used by agents on the fields e.g.: GPS devices, sensors on drones as video and Infra-Red (IR) cameras, data from wearable devices;
    - Data coming from public warning systems.

GHALE offers routing and aggregating service capabilities, and provides a host of services to the PSAPs through a choice of Application Programming Interfaces (API) that best meet the needs of the specific PSAP operating procedures.

2.4.4. Civil protection Apps

Every country wants to protect their citizens and alert them in case of a possible emergency. The civil protection Apps allow authorities to inform and alert the citizens about a recent incident in real time and provide indications on how to avoid injuries. The Federal Office for Civil Protection of Switzerland developed a civil protection app named Alertswiss [13] that can create an emergency plan that can be used in case of a disaster, send warnings and push messages about the incident including valuable tips and instructions on how to stay safe.

Another example of a civil protection app is the Romanian Emergency Situations Department's (DSU) App [14]. The app has four main functions:

1. Information - in this section, users of the application can find the latest news in the field of emergencies, directly from the source. The Inspectorate for Emergency Situations, the General Aviation Inspectorate, the Ambulance Services and Mountain Rescue Department are able to provide information of interest to the users of the "DSU" application. Also, based on a partnership concluded with a National Press Agency, in the News Feed section of the "DSU" application, users have the possibility to read the latest news in the field of emergencies or related to this field. Moreover, the user has access to interactive maps with useful information regarding the location of emergency shelters, 24h Pharmacies, Hospitals, Emergency Departments, Fire Stations (Figure 6).

2. Alert - weather alerts, flood alerts, blocked roads are found in this section. "DSU" users receive push notifications every time an alert appears in their area of interest.

3. Reporting - the public has the opportunity to come to the aid of emergency personnel. Anyone witnessing an emergency, whether it is floods, landslides, fire or road accidents, is able to send photos and videos to the Emergency Department. In this way, the action of the emergency services can be improved by the access from the first moments to images on the spot. However, the reporting is not a call to 112 and will be used by “DSU” staff to support the response teams.

4. Learning - knowing how to deal with an emergency is essential. Therefore, in this section of the "DSU" application, users have access to dozens of articles on behavior in the event of an earthquake, flood, fire, first aid and quick rescue measures that can be taken, if facing an emergency. As a novelty, the lessons also come with tests, where the knowledge gained by reading the articles can be verified.

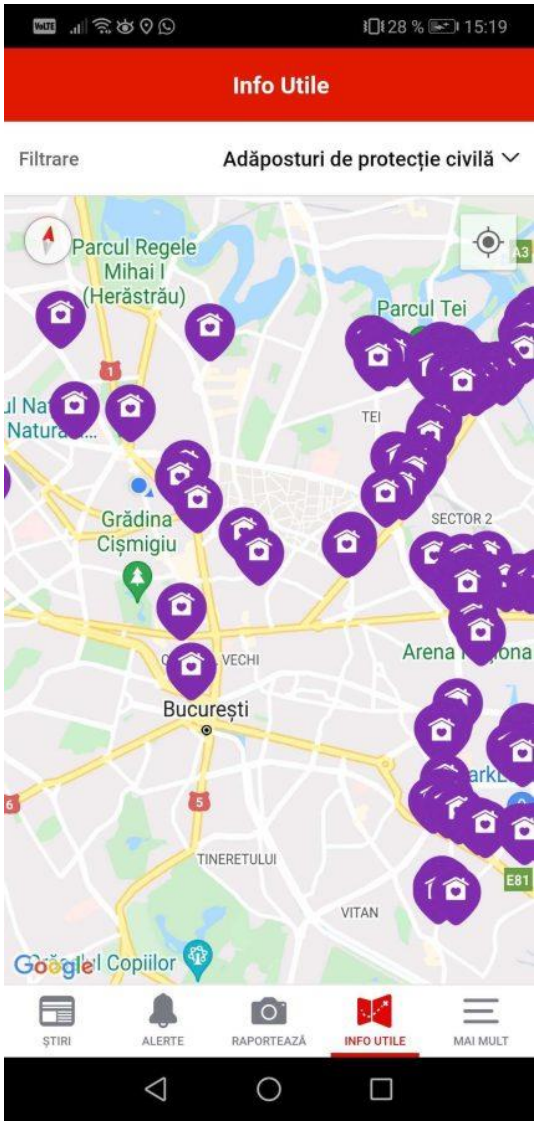


Figure 9 Interactive map of emergency shelters [14]

2.4.5. EMS dedicated App

Application for EMS crews became standard in the world of EMS. MDA's crews App, as an example, offers much more than just the shift-schedules of the worker, which were provided just a few years ago. The main features of the application are:

- The App receives an automatic notification in case of a disaster/ MCI.
- Agencies with off-duty first responders on call can send the medical details (like address, patient name and complaint) to a nearby first responder who can provide lifesaving treatment before the ambulance arrives

Figure 10 MDA app- Notification about an emergency call

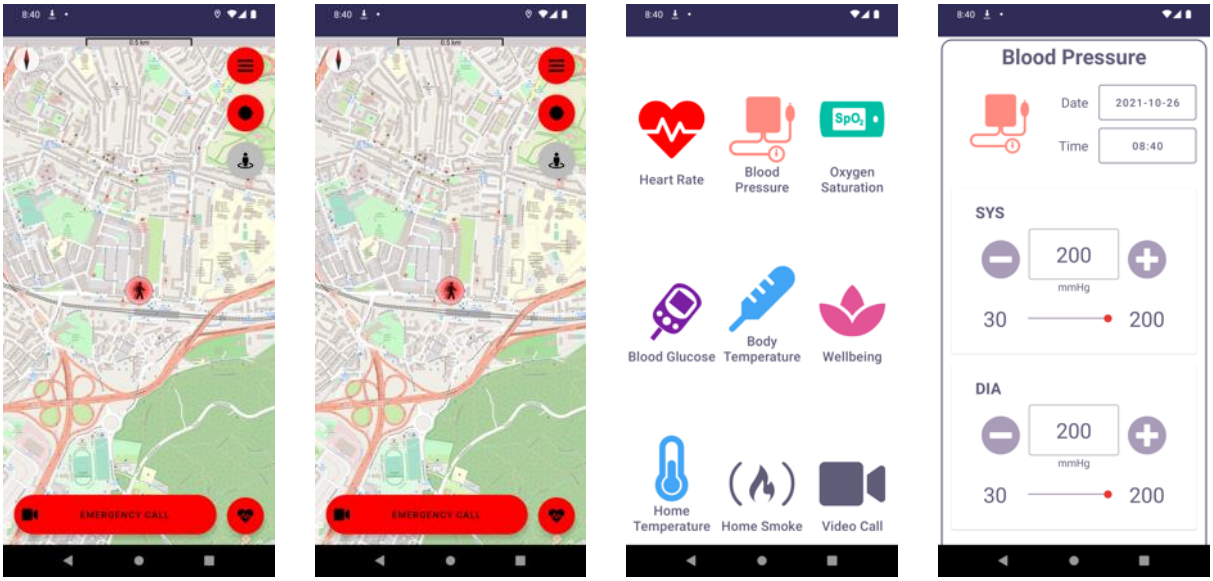
Another platform for both the general public and the EMS is called AWARE [15]. The **AWARE Platform** and Apps supports the next generation security and emergency response services. This platform is a situational awareness tool for security practitioners and emergency response services that provides an intuitive and comprehensive incident/event management system, displaying georeferenced events, associated with multimedia data (photos, videos and text), that clearly identify the incident's type, severity, location and time, as well as its status (open, closed, waiting for dispatch, dispatch sent). All reported incidents present a trustworthiness factor (verified vs. non-verified) to determine the degree of trust in the information source. The AWARE Platform enables the dispatch of assistance and the monitoring of the response effort, as well as the dissemination of public alerts, through the interaction with accompanying mobile Apps

AWARE System: Web view | AWARE System: Situation Awareness | AWARE Responders App

Figure 11 AWARE - Situational awareness tool for security practitioners (overview) [15]

AWARE includes a mobile application for public security authorities while responding to emergencies and incidents, in patrolling and "on-the-move". It allows first responders to receive alerts, dispatch notifications and use the smartphone to easily view and acknowledge reported incidents on a map.

AWARE also includes a mobile application for citizens, enabling them to report incidents/emergencies, using multi-channels such as messaging, images, video and automatic location. Upholding responsible citizenship, the AWARE App includes social functions, such as one-to-one (e.g., officer to citizen private message) and one-to-many (e.g., officer to citizens geo-cast message), thus supporting notifications and alerting from public authorities on specific incidents.



AWARE Citizens' Emergency Reporting | AWARE IoT and Medical Data Exploitation

Figure 12 AWARE Citizens App (overview) [15]

The AWARE Platform connects citizens, first responders and staff involved in emergency management and response. Emergency incidents can be created using the following inputs:

- Inputs from emergency management staff (including PSAP and dispatching), used when creating emergency incidents.
- Inputs from citizens, via the AWARE Citizens App, that can include personal information (e.g., name), medical information (e.g., blood type, allergies and conditions) and location.

Moreover, additional information such as notes, photos and videos can also be included. Information from wearables and medical devices is also part of the citizens' report.
- Inputs from responders, via the AWARE Responders App.
- Integration of wearables and IoT (e.g., fire detectors) into automated emergency reporting.

2.5. The triage

The term triage in medicine is a practice of sorting patients for care when resources (staff, equipment) are limited. This procedure should secure the prioritisation of medical care to those who are most in need of immediate care, often instead of severely injured patients who have lesser chance of surviving. The term comes from the French verb *"trier"* meaning to separate, sort, shift or select.

Dominique Jean Larry was a combat surgeon who first invented the modern medical triage system during the Napoleonic Wars (1803- 1815); "treat(ed) the wounded according to the observed gravity of their injuries and the urgency for medical care, regardless of their rank or nationality"[16]. The method was relatively simple, dividing the wounded victims into three categories:

- Those who are likely to live, regardless of what care they receive.
- Those who are unlikely to live, regardless of what care they receive.
- Those for whom immediate care may make a positive difference in outcome.

Medical triage is nowadays done in cases of MCI in order to divide patients into three main categories: urgent, non-urgent and expectant (will be declared as dead later). The triage will be executed by the first arriving medical crew and should be done within a short period (often no more than just a few minutes).

2.5.1. The main triage methods

There are several models of modern triage (like the classic START algorithm) with different types of methods, concepts and technologies (to be discussed later), depending on the specific agency/country. Here are the main triage methods used today [17]:

- START (Simple Triage and Rapid Treatment):

The triage system used in most United States of America (USA) EMS organizations is the START triage method, developed in 1983 [18]. The first responder's job is to assign the casualties to one of the following four categories:

1. **Deceased**: any victim who is not breathing after airway is open will be classified as "deceased" and given a black tag. The casualty is unlikely to survive given the severity of injuries and/or level of available care.
2. **Immediate:** any heavily injured patient (respirations rate >30/minute, absent radial pulse or decreased level of consciousness) who is breathing will be classified as "immediate" and will be given a red tag. Those casualties who received red tags can be helped by quick medical intervention and transport.

3. **Delayed:** any casualty who suffers from potentially life-threatening injuries but their transport can be delayed. Those kinds of casualties can survive several hours after the incident and will be given yellow triage tag.
4. **Minor:** often called the "walking wounded", these patients have relatively minor injuries and their status is unlikely to deteriorate over days. Victims with minor injuries who can walk will receive green triage tag.

The START triage system is well- accepted worldwide and used in several EMS organizations. [19]

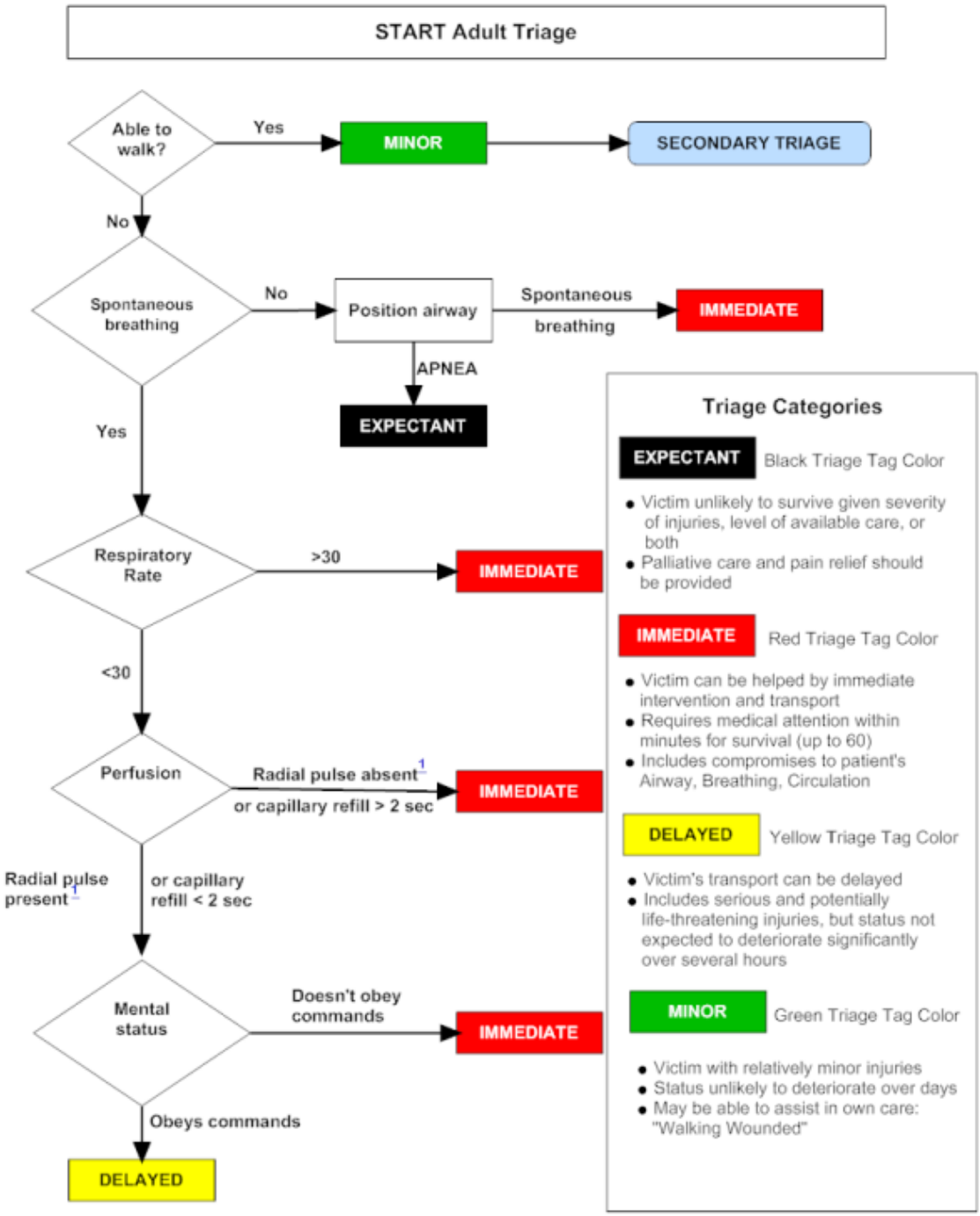


Figure 13 - *The START adult triage system* ***[19]***

- Triage Sieve and sort:

The triage system currently used by the United Kingdom (UK) is the Triage Sieve (first appeared in 1998) is a method adapted and updated from the UK military [17]. This triage method is generally accepted although its accuracy is limited. The UK system uses the same four-triage categories, the first responder will check for massive haemorrhage, if the wounded can walk presence of breathing and heart rate. The casualties eventually receive a triage colour according to their status as the following table shows:

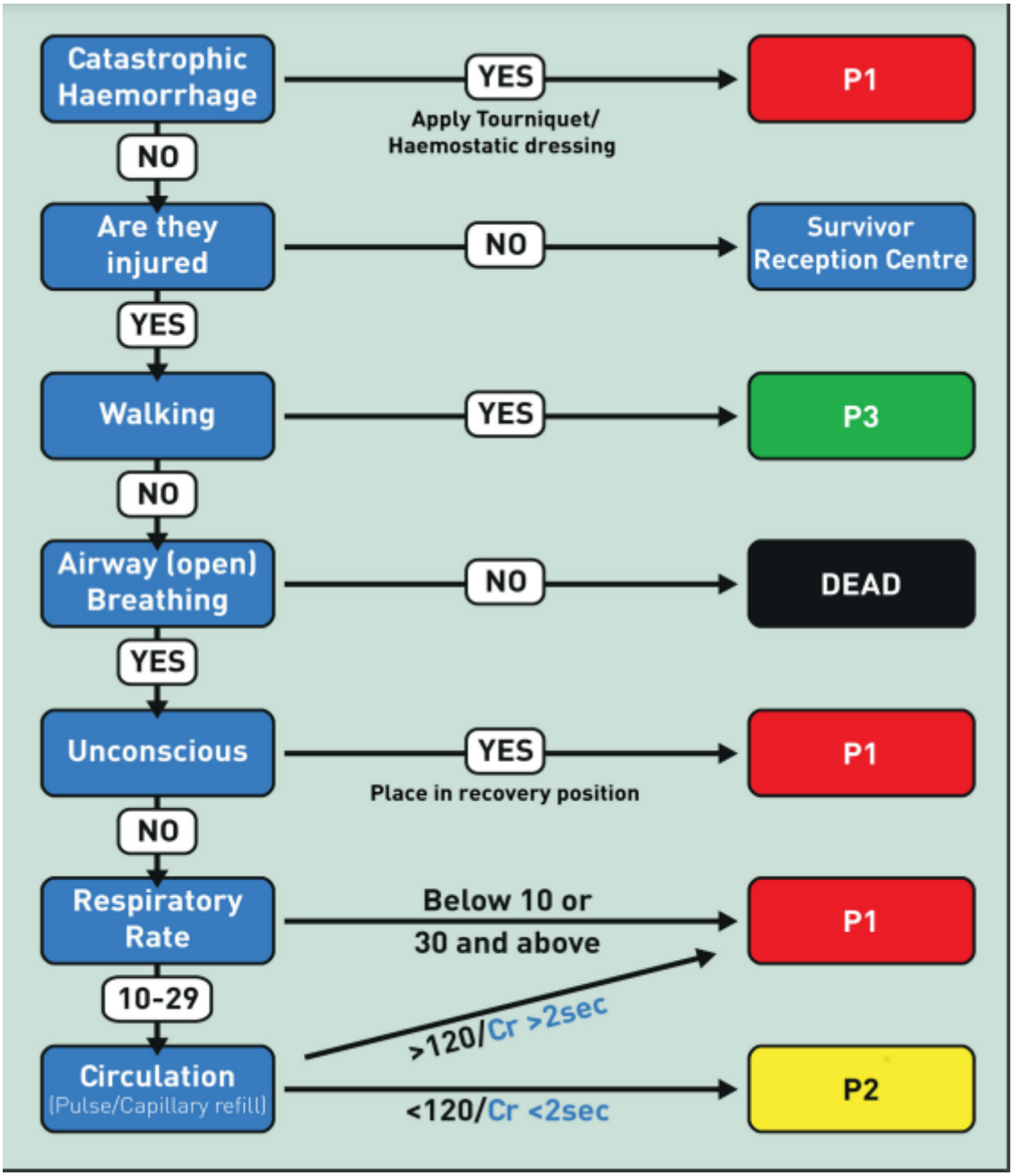


Figure 14- The Sieve and sort triage system ***[33]***

- Careflight:

The Australian model of MCI triage is perhaps the simplest method that anyone can apply [20]. If victims can walk, it can be assumed that there is no any immediate life-threating medical emergency and can be delayed/ transported in groups to hospital/staging area. Victims who do not breathe when their airway is opened are sorted deceased and the responder will move to the next patient. If the casualty requires airway manoeuvres for them to breathe or has no radial pulse, then they receive the highest priority for treatment and evacuation. The other group of injured that cannot walk but can obey command should be treated as soon as possible.

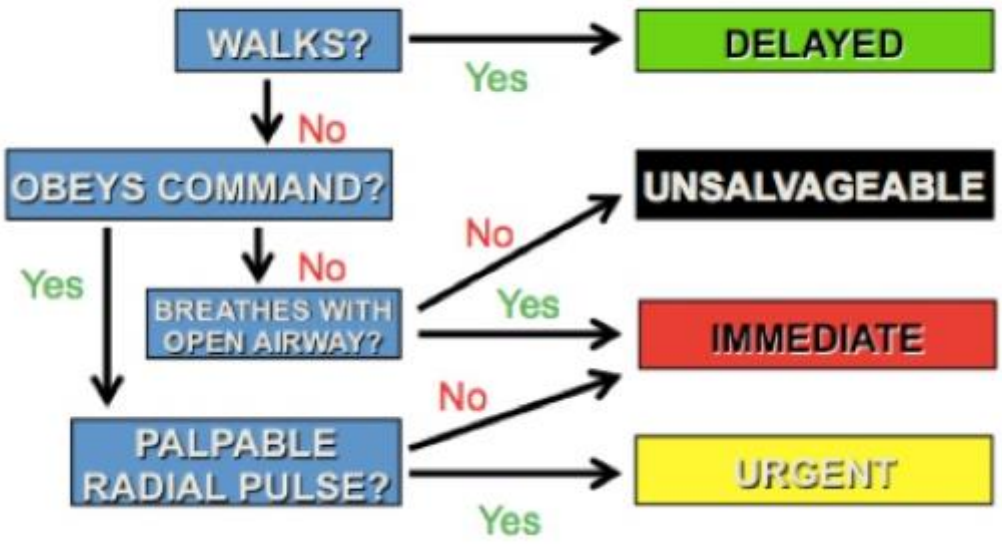


Figure 15 The Careflight triage system [34]

- SALT Mass Casualty Triage:

The SALT triage system was designed to allow agencies to easily incorporate it into their current MCI triage protocol through simple modification. Using aspects of the existing systems and based on best evidence, SALT (Sort-Assess-Lifesaving Interventions-Treatment and/or Transport) was developed as a national all-hazards mass casualty initial triage standard for all patients (e.g., adults, children, special populations). [21]

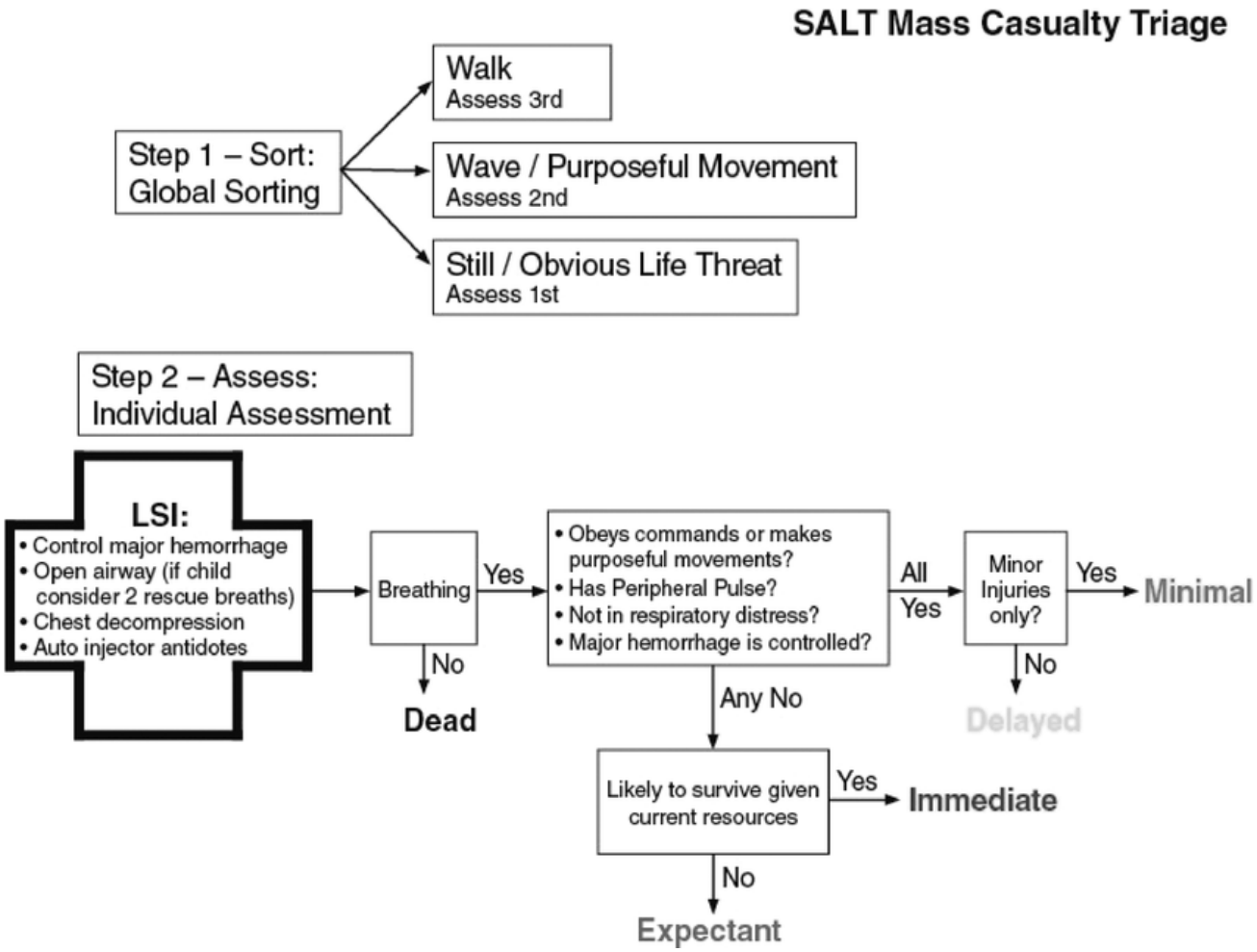


Figure 16 SALT triage system [21]

3.Technology watch

3.1. Triage supporting tools and technologies:

3.1.1. Drones

2 Unmanned Aerial Vehicles (UAV) or drones are increasingly becoming a part of the emergency response and public safety industry all around the world. With the better understanding of the advanced technologies, more and more emergency organizations started to test the abilities of drones in the field of emergency and disaster management. The first and obvious task of the drones in the world of emergency medicine is to provide life-saving equipment in a matter of minutes. This is extremely important in case of a cardiac arrest (chances of survival decreases by approximately 10% every minute when a CPR is performed without an Automatic External Defibrillator (AED)) or severe allergy (anaphylactic shock) where the drone can deliver an EpiPen.

3 With regard to MCI, drones can help identify the location of the event (although this ability is limited and must be developed further), deliver first pictures/live-streaming video from the field and even identify missing people. In 2018, the Drone Efficacy Study group carried out a study, in which they wanted to find out if a rescue team that uses drones will be more efficient than a rescue team with standard equipment. The results of the trials have shown that when a team equipped with a drone finds the victim, they do it 3.18 minutes faster than the no-drone team, in some cases those 3 minutes could be the difference between life and death [22].

Figure 17 Example of a medical UAV [35]

3.1.2. Photogrammetry

Photogrammetry is the science of measuring from images [23]. Today there are software in development that are capable of creating complete 2D/3D maps by processing images taken by a special drone. This ability can be helpful while approaching a disaster site without open routes or any access to the victims.

3.1.3. Wearable technology

The challenges and difficulties while triaging have been well-showed previously. Some technologies had been developed in order to ease the first responder's job while dealing with a busy MCI scene. The tasks are many and the resources are limited, the triaging person having to make sure the casualty is safe and has minimum vital signs, providing life-saving treatment and moving on to the next patient. Therefore, several mobile and wearable devices had been developed and tested in the last years, some of them very successfully made their way to the market and to the agencies. The most advanced technology used today in most countries in order to sort victims while triaging is the colored tags, familiar from the START triage method, although the market today offers some very advanced low and high technology devices for triaging and monitoring the patient after the first triage. Here are some examples:

- Smart glasses:

Smart glasses [24] deliver smartphone-class capabilities in a hands-free wearable device. Smart glasses can capture and provide vital information to a responder without them having to look away from the important task. Smart glasses can provide augmented reality data to the first responder.

- Ruggedized Bluetooth headset:

Hands-free accessories will enable public safety users to better conduct their mission. Bluetooth headsets are likely to be used by all MCI practitioners.

- Clothing with health monitoring sensors:

The ability to monitor vital signs can enable a first responder to make informed decisions when responding to a MCI. A vest/wearable with several sensors that provide information related to physical activity or vital signs, like respiratory rate, heart rate, blood oxygen level and more [25].

For example, the WVSM (Wireless Vital Signs Monitor) is a small device that can be worn by the patient. A unique feature of the WVSM is its multiple patient monitoring capability. Up to 20 patients can be wirelessly connected to one care provider and monitored simultaneously on one PC or mobile device. This allows for quick and easy data acquisition and aids in triage decisions during mass casualty incidents. [36]

- Smart watch:

A smart watch can include GPS, altimeter, thermometer, barometer and humidity sensors, all useful for all kind of first responders performing their mission.

- Smart triage tag and the SOGRO project:

The ability to share important information right after triaging could be lifesaving; the SOGRO project [26] suggests an appropriate solution for these situations by developing smart triage tags. Naturally, nearly every technology for emergency response purposes is measured against its benefit in the rescue efforts, in the end a good technological performance promises to save lives. Accordingly, the SOGRO system was exclusively designed as a tool for a more efficient MCI management. A special software pre-installed in a Personal Digital Assistant (PDA) could share all the important information (status of triage, gender, adult/child, and a photo of the face) with the incident commander, other responders or even hospitals. The SOGRO triage tag has three main benefits compared to simple triage tags:

a. The status of the patient is available immediately after the first contact and can be updated during the treatment (unlike the traditional triage tags);
b. Only necessary medical data are stored on the wristband (Ventilatory and pulse rates taken about a half hour ago are unnecessary for the treatment at the hospital);
c. Patients can be tracked from the scene of the MCI until arrival at the hospital – no patient gets lost.

The SOGRO Information System appears to be a logical step in the evolution of MCI management. It promises a more efficient rescue operation, particularly by reducing the time to allocate casualties to hospitals.

3.1.4. Tools currently used in MININT- Department of Fire Corps

- SO115
  - Control Centre management SW (Client-Server architecture - DB Oracle) deployed to the 100 Control Centre of the Italian Fire Corps to manage rescue activities (PSAPs level 2, teams register and tracking, incident management, etc.)
- Supreme
  - SW (WEB-based) to apply for resources from other Fire HQs in case of unavailability (both for daily and large emergencies)
- Bottone Rosso
  - SW (WEB-based) aimed at fast extracting rescue modules (teams+vehicles+tools) from the register, selecting those on duty and ready to be deployed in large emergencies at regional or National level (make us of SO115 registries)
- Sigem-Simma
  - Software for the management of hazmats, identification and simulation of Chemical, Biological, Radio-Nuclear (CBRN) incidents
- NETRAD
  - Software for the management of radioactivity network (access, maintenance and readings)
- ArcGIS
  - GIS system, both server and web-based

    - It includes the App SURVEY123 aimed at registering and managing geographical point of interest (e.g., activities, hydrants, forest fire management, fast assessing of safe conditions to operate rescue activities, as for earthquakes)
- **Global Mapper**
  - GIS SW (client-based)
- **Geovvf**
  - SW to track fire vehicles via VHF-digital
- **Geofleet**
  - SW to track fire vehicles via VHF-digital and mobile modules
- **MSA data logger**
  - SW to manage explosimeters and PIDs
- **Portale Reti Terna**
  - SW (web-based) to switch-down power lines to ensure safety of aerial forest fire fighting
- **SNIPC**
  - SW (web-based) to apply for aerial support in forest fire operations
- **CAP-ITEM**
  - SW (web-based) Interoperable Tools for Emergency Management: CAP-based interoperability system to exchange operational information with cooperating first responders Control Centres (make us of SO115 data)
- **VVF CAP-ITEM**
  - APP (Android) to collect data on the field and exchange it with other services (feed data to CAP-ITEM)
- **PEE Rifiuti**
  - SW (web-based) to draft, register and manage emergency plans for waste disposal plants
- **Prevenzione Incendi On-Line**
  - SW (web-based) to apply draft, register and manage fire safety measures applied to any building, plant or activity subject to the fire safety regulations
- **STAT-RI WEB**
  - SW (web-based) to draft and register incident reports (base for statistics)
- **Report**
  - SW (web-based) to generate statistics and reports on incidents and operational resources status
- **STAPP-RI**
  - APP to collect incident data to be fed to STAT-RI WEB
- **Portale CMR** (SAR.dipvvf.it)
  - SW to manage operational resources

3.2. The treatment

During the stage of the initial triage, the medical teams should be focusing only on sorting the patients into different statuses according to their medical status, search and treat immediate life-threatening concerns with minimum time, resources and with limited procedures. After the quick triage, the casualties are to be assembled by their categories and provided treatment by the medical

responders who arrived at the scene later. The main objective on scene is to treat the casualties as fast as possible in order to receive further care at one of the nearest hospitals (and not to try to "heal" them on scene, wasting precious time and resources). The process of triage is executed at least three times on a single patient, optionally by different caregivers, because the casualty requires instant monitoring and the patient's medical status can change during the treatment/transport.

The treatment of casualties depends on several things, but firstly it depends on the type of the injury; for example, the medical approach for a mass shooting incident is different from the medical approach for a mass fire emergency. While triaging the casualties, the main treatments focus on life-saving interventions like clearing airway manoeuvres, controlling life-threatening haemorrhage and preparing the patient for transport.

After the initial triage, the most urgent casualties have been transported to a hospital. If the casualty is less- injured or transport is not available for the urgent ones, the provider performs a secondary triage, which is much more thorough than the first one. The caregiver checks the alertness level once again, makes sure that the patient is still in consciousness, checks the upper airway and confirms that the patient is breathing efficiently, performs vital signs checks, like pulse and blood pressure, and scans the patient body in order to find bleedings/wounds not discovered before. While waiting for a transportation vehicle, the caregiver provides advanced treatment to those in need, including drugs, intubation or treating less significant bleedings/wounds.

3.2.1. Disaster Intervention Vehicle

The Disaster Intervention Vehicle (VIC) in Portugal is used in multi-victim situations. Inside, it carries various Advanced Life Support material, which allows for the setting up of an AMP.

This small field hospital is equipped with the same equipment as the Emergency and Resuscitation Medical Vehicle (VMER) and allows the treatment of 8 very serious victims simultaneously. This material is composed of defibrillator monitors, ventilators, monitors of vital parameters, infusion syringes and various drugs, among others.

In addition, the VIC is also equipped with a telecommunications cell, which makes it possible to create a communications network between the accident site, the Urgent Patient Guidance Centers (CODU) and the hospitals area.

Figure 18 Disaster Intervention Vehicle (e.g. INEM)

3.3. The transport

One of the most important stages of MCI management (in the pre-hospital phase) is the transport of casualties to hospitals and trauma centers. In many MCI protocols, a special team (often-called "the transportation group") is in charge of matching each patient (by severity of injury) with the right medical team and eventually to the right hospital. Another important duty of the transportation group is to route the transportation resources (ambulances) in order to avoid a chaotic and unmanageable MCI scene. In order to respond quickly and effectively to the multiple situations in the area of medical emergencies, the EMS in Portugal has non-medicalized and medicalized means. The first are the Ambulances, which can be Basic Life Support Ambulances (BLS) or Immediate Life Support Ambulances (SIV) and Medical Emergency Motorcycles. The medicalized means, that is, those that have a Doctor in their crew, are the Medical Emergency and Resuscitation Vehicles) and the Medical Emergency Helicopters.

First, the most urgent patients will receive emergency and resuscitation support on the field to be prepared to be evacuated with medical support during the transportation to the hospital. Other less-critical patients will be evacuated using medicalized means or non-medicalized means. Additionally, less-critical casualties are transported to hospitals later or leaving the incident scene by themselves. In less common situations, police cars, bystanders and even public transportation can transport the casualties.

One other important aspect that needs to be considered is the capacities and abilities of local hospitals and emergency departments. In Portugal, in order not to "flood" the nearest hospital, the transportation group (or the senior radio operator at the call center, like in Israel) is made by the CODU. As an example, it could be decided the destination that will benefit all patients, more specifically, a multi-trauma injured should be transported to the nearest trauma center, other casualties with minor injuries can be transported to a more distant hospital with less abilities.

3.3.1. Treatment and transportation supporting technologies and tools

There are several pieces of equipment, available in ambulances (depending on the type). As an example, ambulances have reference equipment used on immobilization and removal of trauma victims (e.g. neck brace, chair, head immobilizer, different types of stretchers, oxygen).


Neck Brace


Chair


Stretcher


Oxygen reservoir

Figure 19 Ambulance Equipment (example)

AmbuCarrier [27]:

The AmbuCarrier is a wheeled patient transport device designed to rapidly attach to a backboard or stretcher for the quick and easy transport of patients. The AmbuCarrier requires a single operator to lift and deploy for transport, can support up to 159 kg, and is adjustable in increments of 1 inch, for up to 4 inches of height adjustment. This allows the AmbuCarrier to accommodate to the preferred comfort of the operator. The AmbuCarrier can be used for the whole duration of care: from first response, to triage, and even during transport to and while on board the AmbuBus Kit.

Figure 20 The AmbuCarrier [27]

AmbuBus Kit (Bus Stretcher Conversion Kit) [28]:

The AmbuBus is an effective and efficient solution for mass evacuation and transport of special needs patients, casualties, and others who require non-ambulatory transport. Quickly and easily, retrofit buses and other vehicles of opportunity may become mass casualty transport vehicles.

Figure 21 The AmbuBus kit [28]

3.3.2. Transportation resources

The transportation resources equipment and special team with different skills are also presented since they are involved, when necessary, immobilizing and preparing the victim for transport to the hospital, and can also accompany the victims/patients to the hospital. The characteristics of the vehicles for transporting patients and their equipment in Portugal are regulated by Ordinance No. 260/2014 (amendment in 2018/ Access Ordinance 96/2018 that amends), based in European standard EN1789 (concerning medical transport vehicles and their equipment). Following the European Union recommendations, ambulances must be certified to be able to transport patients being the inspection a responsibility of the Ministry of Health. Different types of resources exist:

- Ambulance (different equipment and crew):
- Rescue Ambulance;
- Medical Emergency Ambulance;
- Immediate Life Support Ambulance;
- Emergency and Resuscitation Medical Vehicle;
- Mobile Emergency Psychological Intervention Unit;
- Emergency Medical Helicopter Service.

Rescue Ambulance:

Rescue Ambulances have the mission of ensuring the rapid displacement of a crew trained in medical emergency techniques to the place of occurrence and in the shortest possible time, in

complementarity and articulation with other pre-hospital medical emergency means as well as the eventual transport to the health unit most appropriate to the clinical condition of the victim.

The Rescue Ambulances are fixed in Medical Emergency Stations operated by civil protection agents and/or by elements of the Integrated Medical Emergency System, being manned by elements belonging to the respective entities, with specific training in pre-hospital medical emergency techniques, defined and certified by EMS (as referred, in Portugal by INEM).

Figure 22 Rescue Ambulance (e.g. firefighters)

Medical Emergency Ambulance:

The Emergency Medical Ambulances (AEM), previously known as Basic Life Support Ambulances (BLS), are part of a team of two Pre-hospital Emergency Technicians (TEPH) from EMS (INEM in Portugal).

Their mission is to quickly move a pre-hospital emergency medical team to the place of occurrence, clinical stabilization of victims of accidents or sudden illness and assisted transport to the most appropriate emergency department for their clinical condition.

The AEMs are based in EMS's own bases (INEM in Portugal) and have different equipment for evaluation, resuscitation and clinical stabilization, essential to comply with the medical decision algorithms defined by EMS and approved by the Order of Physicians.

Figure 23 Medical Emergency Ambulance

Immediate Life Support Ambulance:

The Immediate Life Support Ambulances (SIV) have the mission of guaranteeing differentiated health care, such as resuscitation manoeuvres. The crew is composed of a Nurse and a Pre-Hospital Emergency Technician (TEPH) and aims to improve the care provided in a pre-hospital environment to the population.

The Immediate Life Support Ambulances are intended to guarantee differentiated health care, namely resuscitation manoeuvres, until a team with the capacity to provide Advanced Life Support is available.

In terms of technical resources, it has the charge of a Basic Life Support Ambulance, plus a defibrillator monitor and several drugs. The IVS equipment allows the transmission of electrocardiogram and vital signs.

Emergency and Resuscitation Medical Vehicle:

The Emergency and Resuscitation Medical Vehicle (VMER) is a pre-hospital intervention vehicle intended for the rapid transport of a medical team to the place where the patient is.

Its team consists of a Doctor and a Nurse and has Advanced Life Support equipment.

The VMERs work directly under the Urgent Patient Guidance Centers (CODU) and are hospital-based.

Its main objective is pre-hospital stabilization and medical monitoring during the transport of accident victims or sudden illness in emergency situations.

Figure 24 Emergency and Resuscitation Medical Vehicle

Mobile Emergency Psychological Intervention Unit :

The Mobile Emergency Psychological Intervention Units (UMIPE), are activated by INEM's Urgent Patients Guidance Center to the place of occurrences where intervention is considered necessary, such as assistance to victims of accidents or their families and friends, support in the management of these events, namely, support at the beginning of the grieving process following unexpected and/or traumatic death, situations of imminent risk of suicide, psychiatric emergencies that imply a risk to the life of oneself or others and intervention with victims of sexual abuse/rape.

UMIPE are also integrated into EMS's (INEM in Portugal) response devices to exceptional situations, namely fires, floods, explosions, natural and human catastrophes, among others incidents.

Figure 25 Mobile Emergency Psychological Intervention Unit

3.3.3. Decision support tools

The decision support tools are identified as result of two different studies, detailed below.

I. "A translational triage research development tool: standardizing prehospital triage decision-making systems in mass casualty incidents"[29]

Reference of Triage seven standalone systems, selected by the following criteria:

- Initially, a Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)-style literature search was conducted to identify the most frequently mentioned prehospital triage systems designed for use in initially based on articles focused on prehospital, primary triage in MCIs and on a triage system itself or a comparison of a number of systems and excluded articles mentioning a triage system without any evaluation, or articles with different from the inclusion criteria MCIs [25]. The search results were limited to articles and reviews published from 2000 to 2020, written in English.
  - Inclusions criteria: Articles focused on prehospital, primary triage in MCIs and on a triage system itself or a comparison of a number of systems.
  - Exclusion criteria: Articles mentioning a triage system without any evaluation,
  - or articles with different from the inclusion criteria and All articles about pediatric triage systems.
- Group members reviewed, achieved consensus and approved the final selection of
- articles. In the final assembly of articles, abstracts were re-read and full texts studied, when needed, to determine which triage systems were mentioned.
  1. Simple Triage And Rapid Transport (START) or modified START (mSTART);
  2. Sort Assess Lifesaving Intervention Triage/Transport (SALT);
  3. Care-Flight Triage (CFT);
  4. Triage Sieve (TS);
  5. Modified Physiological Triage Tool (MPTT);
  6. Fire Department of New York modified START (FDNY-START);
  7. Amberg-Schwandorf Algorithm for Primary Triage (ASAV);

  Some triage identified systems were not considered on this list:

  - Modified Military Sieve (mMS), just mentioned once;
  - Military Sieve (MS), just mentioned once;
  - Sacco Triage Method (STM), is a mathematical model where individual vital parameters can yield different triage tiers from one event to another due to the available resources at that time;
  - Spanish Prehospital Advanced Triage Method (META), is a system where primary triage is closely integrated into a larger triage process.

In general, triage categories can be expressed as a description (Immediate; Urgent; Delayed; Expectant), Priority (1 to 4), or Colour (Red, Yellow, Green, Blue), respectively, where Immediate

category equals Priority 1 and Red. Five of the identified triage systems had four triage tiers and two had five:

- FDNY-START algorithm adds an ORANGE tier to easier identify GREEN and YELLOW casualties with the potential to medically deteriorate **Error! Reference source not found.**;
- The SALT system adds an EXPECTANT/GRAY tier. This tier consists of IMMEDIATE/RED casualties who are not likely to survive given current resources **Error! Reference source not found.**.

II. "Triage Systems in Mass Casualty Incidents and Disasters: A Review Study with A Worldwide Approach" [29].

This study is an attempt to identify available triage systems and compare the differences and similarities of the standards of these systems during emergencies and disasters through a review study. This study was conducted through a review of the triage systems used in emergencies and disasters throughout the world. Accordingly, all articles published between 1990 and 2018 in both English and Persian journals. Based on the search done in these databases, twenty different systems were identified in the primary adult triage field including START, Homebushtriage Standard, Sieve, CareFlight, STM, Military, CESIRA Protocol, MASS, Revers, CBRN Triage, Burn Triage, META Triage, Mass GatheringTriage, SwiFT Triage, MPTT, TEWS Triage, Medical Triage, SALT, mSTART and ASAV. There were two primary triage systems including Jump START and PTT for children, and also two secondary triage systems encompassing SAVE and Sort identified in this respect. ESI and CRAMS were two other cases distinguished for hospital triage systems.

"There are divergent triage systems in the world, but there is no general and universal agreement on how patients and injured people should be triaged. Accordingly, these systems may be designed based on such criteria as vital signs, patient's major problems, or the resources and facilities needed to respond to patients' needs."**Error! Reference source not found.**.

In a mass casualty incident, the factors that determine the survival rate of injured patients are diverse, but one of the key factors is the time for triage. Additionally, the main factor that determines the time of triage is the number of medical personnel. However, when relying on a small number of medical personnel, the ability to increase survivability is limited. This study "A data-driven Artificial Intelligence (AI) model for remote triage in the prehospital environment is a good example how the use AI technique may allow speedup the triage in some situations and alert the triage team of any cases to be recheck by the triage team.

The gaps identified:

- Translational triage tool for worldwide use;
- Enhancement of triage tools with AI (speed up);
- Use of AI functionalities as triage complementary tool (try to find eventual critical cases to be reevaluated by the triage team "recheck").

3.4. The challenges

Managing mass casualty incidents is challenging to any person or organisation. The ability to change mind-set, organization and medical procedures as well as decision-making processes and command structure, both from an organizational and individual perspective is essential. The variety of possible mistakes is unlimited, starting from the wrong data collection (and misunderstanding of the event right from the beginning), through communication interruption due chaotic scene, blocked access/ evacuation routes. The challenges when managing mass casualty incidents are involved were mainly related to the ability to manage uncertainty and surprising situations, using structured processes to respond. As part of the task, the Nightingale project is dedicated to point out those challenges and suggests reliable solution that can fit every country or organization.

Creating a reliable and accurate operational picture:

One of the biggest challenges in the beginning of an MCI is to identify the extent of the disaster, trying to understand what is going on in the current time and deal with uncertainty. Once the incident occurs, many civilians will call the emergency lines and will tell dispatchers about the scenario from their point of view. Naturally, there will be a significant number of misinformation and different reports so the responding organizations usually will have to wait until the first team arrive at the scene in order to create an accurate operational picture.

Triaging and monitoring the patients:

Another challenge of the MCI management is to triage and consistently monitor the casualties. First, in an MCI there are not enough resources for all casualties including staff and the situation is very unstable. In some cases, the casualties are scattered over a large area that can cause the rescue team great difficulties to locate them and rescue to a safer spot. Once a casualty has been triaged, the Emergency Medical Technician (EMT) needs to make sure that the casualty is still breathing and has a pulse while triaging other casualties which can be nearly impossible without the right tools.

Communication:

In the world of medicine, communication problems are the lead causes of medical errors [31]. There are many aspects of communication in MCI events, not just communicating with other responders, the dispatcher centre or the casualties themselves; social media, the public press and even cellular aerials fall into this category as well. Sharing information between the responders can be difficult due to field circumstances, lack of cellular signal (because severe load on the system) and even personal stress which make the whole operation more complicated.

Another aspect of communication is the benefit we attained from scrolling through social media. There are some developing SOCMINT (Social Media Intelligence) Apps on the market that can help analyse and provide huge amounts of information by specific algorithms [32]. Unfortunately, the lack of information in the internet may possibly lead to disinformation and "fake- news" so the social media networks should always be taken with limited assurance.

To balance the mismatch between plan and reality:

The ability to improvise especially during crisis is a much-needed quality that can affect the whole outcome of the event. In some cases, the protocol does not cover the right actions or is not applicable because the event developed in an unexpected way. For example, once an MCI occurs, those patients who can walk will try to assist the first responders or will try to reach the local hospital by themselves.

Conclusions

Technologies in MCI management – main challenges.

Mass Casualty Incident (MCI) management has seen in the last decade a leap forward concerning availability of technologies, used to better respond to the incident.

In an environment, chaotic by default, those tools are a benefit to better understanding the nature and the magnitude of the incident early, deploying the right resources to the right location, treating and transporting better in a more efficient manner.

At the same time, the following are still issues to be solved, in order to ensure adoption and wide use of those tools:

1. Connectivity dependency:
   Many of the tools available depend on connectivity to receive / transmit data. One of the well-known phenomena on MCI sites is collapse of the cellular system (due to overload of users on the scene, trying to contact their beloved ones). This major risk causes lack of trust among responders that the systems will actually work in real time.
   Many projects offer "ad hoc network" to be set up on site. While this could be a solution for very a large scale MCI, in an MCI with 30 victims, by the time, the network is up and running, most of the victims should be already evacuated. Having EMS personnel from the first responding ambulances set up the systems, would decrease the number of trained personnel treating patients.

2. What comes first – treating patients or using technology?
   Many of the solutions offered require trained personnel to set them up or operate them; pilots for drones, persons technically trained to set up networks, or just carrying devices that are hand-held and limit the capacity to perform treatment tasks.
   As trained EMS personnel on scene on the first minutes is limited, and severe trauma is a time dependent pathology, most EMS organizations will opt for treat first - technology later (with the exception of Fire based EMS that will count of fire fighters support for those "additional tasks"). When technology comes late, the risk is of additional confusion, as there is an important component of victims – triaged, treated and maybe transported, which are not registered in the system, thus not presented as part of the common operational picture. **This might be misleading for the incident commanders!** (In addition, will be a consideration against the adoption of the technology).
   Solution:
   To adopt autonomous technology, which is part of the equipment daily used: e.g. body cameras, network devices mounted on the ambulances, autonomous drones etc.

3. Geo-referencing:
   Real time images are one of the most valuable tools to create an "operational picture". Many tools just present the images. Without having those images geo-referenced on a map, with

a time stamp, interpretation of the image requires human effort (time consuming and prone to error) on where this image comes from. This is even more complex with drone images, as an object of interest on the screen requires understanding its location, a complex task at it requires understanding the path of the drone, its altitude and where the camera was looking at on that specific moment.
With drones an additional challenge is that a drone zooming in does not provide enough details to differentiate one street from the other, zooming out does not provide enough information on the casualties.

Solution:
All images and videos must have a geo-referencing capacity. This information should be transmitted directly to the map with time stamp.

4. Data overload and creating intelligence:
   Incident commanders and operation room's managers are bombarded with data. At this stage, "making sense" out of all the information is up to the person.
   Solution:
   The systems bringing the data to the table should come with the relevant AI technologies such as Deep Learning that allows for fast and user friendly elaboration of the data into intelligence.

5. Interoperability of data:
   MCI data needs to be shared with different actors (in different level of details), using different IT systems. Not having a single standard for that information, the data has to be accepted by different IT systems (e.g. EMS, different hospitals, and health authorities). Not having this interoperability and having a dedicated "emergency system" will end with a system that is not used daily, thus malfunctioning or not activated during an emergency.
   Solution:
   Interoperability protocol that will allow all IT system to receive the data (with the appropriate data protection protocols).

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