# Definition of functional and non-functional user requirements

## D1.8

*31.08.2022*

NIGHTINGALE

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| **Authors** | Marta Caviglia (UPO), Hamdi Lamine (UPO), George Voicescu, (UPO) | | |
| **Co-authors** | Sabina Magalini (UCSC), Stenn Lennquist (MRMID), Roberto Faccincani (ESTES), Daniele Gui (UCSC), Peter Jones (SAMU), Chaim Rafalowsky (MDA), Dimitra Dionysiou (ICCS) | | |
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## HISTORY OF CHANGES

| Version | Date | Changes |
|---|---|---|
| 0.1 | 30.05.2022 | Initial version |
| 0.2 | 23.06.2022 | First draft sent for internal revision |
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## PROJECT PARTNERS

| Logo | Partner | Short name | Country |
|---|---|---|---|
| | INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS | ICCS | Greece |
| | TOTALFORSVARETS FORSKNINGSINSTITUT | FOI | Sweden |
| | LEONARDO – SOCIETA PER AZIONI | LDO | Italy |
| | C4CONTROLS LTD* | C4C | United Kingdom |
| | INTRASOFT INTERNATIONAL SA | INTRA | Luxembourg |
| | INOV INSTITUTO DE ENGENHARIA DE SISTEMAS E COMPUTADORES, INOVACAO | INOV | Portugal |
| | EXUS SOFTWARE MONOPROSOPI ETAIRIA PERIORISMENIS EVTHINIS | EXUS | Greece |
| | UNIVERSITAT POLITECNICA DE VALENCIA | UPVLC | Spain |
| | ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS | CERTH | Greece |
| | DEVERYWARE | DW | France |
| | PARTICLE SUMMARY | PARTICLE | Portugal |
| | TREE TECHNOLOGY SA | TREE | Spain |
| | EUROPAISCHE GESENLLSCHAFT FUR TRAUMA -UND AKUTCHIRURGIE - ESTES | ESTES | Austria |
| | INTERNATIONAL MRMID ASSOSIATION | MRMID | Sweden |
| | UNIVERSITA DEGLI STUDI DEL PIEMONTE ORIENTALE AMEDEO AVOGADRO | UPO | Italy |
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| | AZIENDA SANITARIA LOCALE N 2 SAVONESE | ASL2 | Italy |
| | MAGEN DAVID ADOM IN ISRAEL | MDA | Israel |
| | CARR COMMUNICATIONS LIMITED | CCL | Ireland |
| | ASSOCIAZIONE CITTADINANZATTIVA ONLUS | CA | Italy |
| | INTERDISCIPLINARY CENTER (IDC) HERZLIYA | IDC | Israel |

*An amendment request to the GA for the substitution of C4CONTROLS LTD by ASTRIAL GmbH, as of the project start, has been submitted by the date of the Deliverable Submission.

## LIST OF ABBREVIATIONS

| Abbreviation | Definition |
|---|---|
| ACLS | Advanced Cardiovascular Life Support |
| AI | Artificial Intelligence |
| AMP | Advance Medical Post |
| App | Application |
| AR | Augmented Reality |
| BLS | Basic Life Support |
| CCPs | Casualty collecting points |
| COP | Common Operational Picture |
| DoA | Description of Action |
| ECCs | Emergency Communications Centres |
| ED | Emergency Department |
| EMS | Emergency Medical Services |
| EOCs | Emergency Operation Centres |
| EU | European Union |
| FFs | Fire Fighters |
| FRs | First Responders |
| GDPR | General Data Protection Regulation |
| GPS | Global Positioning System |
| HS | Hospital Staff |
| ICS | Incident Command System |
| ICU | Intensive Care Unit |
| IMS | Incident Management System |
| MCIs | Mass Casualty Incidents |
| NIT-MR | Novel Integrated Toolkit for Emergency Medical Response |
| OT | Operation Theatres |
| PreH | Pre Hospital |
| PSAPs | Public Safe Answering Points |
| Public G&A | Public Governance & Administration |
| RFIDs | Radio Frequency Identification |

| | |
|---|---|
| **TCCC** | Tactical Combat Casualty Care |
| **TECC** | Tactical Emergency Casualty Care |
| **TEMS** | Tactical Emergency Medical Support |
| **UAB** | User Advisory Board |
| **UAV** | Unmanned Aerial Vehicle |

# Executive Summary

The deliverable describes the methodology adopted to extract functional and non-functional requirements of the Novel Integrated Toolkit for Emergency Medical Response (NIT-MR). Specifically, it initially provides a thorough description of the context in which medical and non-medical practitioners as well as active citizens envision the use of the NIT-MR, that is the prehospital response to Mass Casualty Incidents (MCIs).

This description includes also all the potential End Users of the NIT-MR, detailing their characteristics, roles and responsibilities, tasks, and level of control (strategic, operational, and tactical) during the MCI prehospital response. A synthesis of findings is also presented to summarize all the information collected and to categorize it inside a framework that would be functional to the main objective of the NIT-MR. As explained in detail in the deliverable, this information gathering process, which sets the common ground in which the NIT-MR will be used, has exploited the expertise of the NIGHINGALE practitioners (User Partners and User Advisory Board - UAB – Members) with the overall objective of ensuring that all factors that relate to use of the systems are identified.

In a subsequent step detailed in the deliverable, Users' Needs have been identified through multiple interactive methods which prompted active users' participation, including workshops, table-top simulations, round table and dedicated discussion session, and mock-up sessions. Interactions, synergies, and idea exchanges have been elicited with technical partners to align users' need with possible technical solutions and future developments. In addition, preliminary outputs from other WP1 tasks (such as Task 1.1 "*Common Denominators and New Paradigm of Trauma Care*") have been used to provide an evidence-based and up-to-date background and to drive technical development.

As a final step, Users' Needs have been translated into an initial set of User Requirements specific for each NIT-MR component. This initial set includes a unique reference, a priority level according to the MoSCoW prioritization model, and a reference to the Use Cases described in deliverable D1.6 Scenarios and Use Cases. As the project will entail different steps of prototyping, testing, and validation through different methodologies (from laboratory to table-top, small-scale and full-scale exercises), the presented set of requirements will be iteratively reviewed, edited and refined in the different phases of the Project.

 

## TABLE OF CONTENTS



 

 

## LIST OF FIGURES



## LIST OF TABLES



 

# Introduction

The NIGHTINGALE project aims to develop, integrate, test, deploy, demonstrate, and validate a Novel Integrated Toolkit for Emergency Medical Response (NIT-MR) at the service of all first responders (FRs). This NIT-MR includes emergency medical services and non-medical civil protection agencies (fire brigades, police and search and rescue personnel, and volunteers and citizens), which ensures an upgrade to Pre-hospital life support and Triage during Mass Casualty Incidents (MCIs).

The work presented in this deliverable has been performed in the context of Task 1.5 *Definition of functional and non-functional requirements,* of Work Package (WP) 1, *Practitioners Needs & Toolkit Architecture and Design.* The main objective of this deliverable is to present the first version of user requirements for the Nightingale Toolkit components, which, along with the defined NIGHTINGALE scenarios and uses cases (Deliverable D1.6 Scenarios and Use Cases), will drive technical development, testing and validation activities of the project in work packages 2-5. The deliverable is informed by the work in the following tasks:

- **Task 1.1** *Triage Protocols, Damage Control, Prehospitalisation processes: common denominators and new paradigm for trauma care:* for considering the agreed upon methods and processes for MCI handling
- **Task 1.2** *Social, Legal and Ethical Landscape for MCIs handling and Action's Impact Assessment*: for considering relevant social, legal, and ethical aspects
- **Task 1.3** *Technology watch for EMS – Gaps and Limitations*: for considering the outputs of the performed state-of-the-art analysis
- **Task 1.4** *Overarching scenarios, definition of use cases and testing and validation activities specific planning*: for considering the toolkit components requirements in the context of specific scenarios and use cases addressed by the project.

The first version of the user requirements presented in this deliverable will be under continuous refinement throughout the project lifetime to reflect any needed adaptations as the development and testing activities proceed. The final version of the user requirements will be presented in deliverable D1.9 User functional and non-functional requirements (revisited/final), to be delivered in month 34 of the project.

The NIT-MR features several components listed in the following table. The original description of these components (component names and brief description of their functionalities) can be found in the NIGHTINGALE GA (Annex 1, DoA part B, pages 12-13); this content has been refined as a result of extensive interactions between technical and end user partners during the initial stages of the project to better reflect the envisioned functionalities and the role of each component within the NIT-MR toolkit in order to respond to the identified end user needs and capability gaps.

*Table 1. NIT-MR components*

| DoA term (Annex 1, part B, p.12-13/211) | Refined Term | Lead Beneficiary | Brief Description |
|---|---|---|---|
| Triage Device (bracelet, earplug) and Mobile App | Digital Triage Tag | ICCS | Specific type of wearable (tag) that will be used as a unique identifier for victims and will show the triage status of patient (master device). It may have also integrated Vital Signs Sensing Capabilities (see Vital Signs Wearable term) and it may be connected and/or linked with (secondary devices):<br>1. Additional Vital Signs Wearables (e.g., earplug)<br>2. Other Digital Triage Tags (family members) |
| | Triage and Vital Signs app | ICCS and UPV | The smartphone app to be used in order to:<br>1. Control the Digital Triage Tag (initialization, triage status declaration)<br>2. Enter information for victims (incl. name, surname, age, sex, location, destination, interventions/medication, etc.)<br>3. Visualize vital signs of victims (from Vital Signs Wearables) |
| | Triage wearable | ICCS | The wearable to be used (additionally to the Triage and Vital Signs app) for offering hands-free functionalities regarding:<br>1. Triage Tag initialization<br>2. Triage Status declaration |
| | Vital Signs Wearable | ICCS and UPV | Any type of wearable that will be used for vitals monitoring during MCI handling |
| UAV-based Rapid Triaging and Documentation System | UAV Rapid Triaging system | FOI | The UAV-enabled functionalities for scene assessment. The system comprises the UAV platform and the Ground control station |
| Wide area rapid thermographic scanning | Thermal scanning system | LDO | The thermographic scanning system to be deployed. The system comprises thermal/IR sensors/cameras and an application |
| Optimized transportation capabilities & Optimised Medical Resources | Resources and assets optimization service | CERTH | The algorithms to be developed to optimise use of assets, resources and transportation to hospitals (incl. proper allocation of patients) |
| SWAPP – The Citizen App connected to NG112 | SWAPP (App) | PARTICLE and INOV | The smartphone application to be used by citizens or bystanders, reporting the incident (in an updated manner) or supporting MCI tasks |

| | | | |
|---|---|---|---|
| Augmented Reality application | AR Service | ICCS and ASTRIAL | The AR/heads up display glasses that enhance FRs field of view |
| Damage Control and AI-based diagnosis and prognosis | Diagnosis and Prognosis service | TREE | The algorithms to be developed that exploit continuous monitoring of victims to output health condition and expected evolution based on treatment, health condition, etc.<br>1/ The algorithm aims to simulate an Emergency Department Environment in a flexible manner so that it may take into account the resources the end users may consider as well as patients ordered according on a triage scale. This simulator is used to train agents via Deep Reinforcement Learning models in a way that the agents learn to effectively allocate patient in the resources given, bearing in mind different aspects such as the processing time for each resource.<br>2/ These family of algorithms aim to forecast short-term behaviour of patients given the continuous monitoring of their vital signs trained on historical clinic databases by means of supervised learning |
| Multi-Information Fusion Module | Early warning and risk assessment service | CERTH and EXUS | The component providing early warning of a potential MCI and various risk notifications related to the incident scene |
| | Decision support service | CERTH | The component providing recommendations related to triaged victims, lack of resources, deterioration of incident, etc. |
| | Interoperable Data Lake | INTRA | Representation, management, storage, and interoperable access of heterogeneous data sent by the on-field components or accessed through open data sources, or legacy systems. It entails the definition of standards-based unified data model for data interoperability |
| | Data layer | UPV | The Streaming/On field real time data integration broker (Kafka based) |
| NG112 | NG-PSAP | DW | The Public Safety Answering Point (NG112) that is connected with the SWAPP App and the C3/IMS. It will enable multimedia communication between the SWAPP app and the PSAP. It will also share incidents and call information related to incidents with the C3/IMS and other NIGHTINGALE components that could need this information. |
| C3/IMS and Common | C3&IMS | ASTRIAL | The Command, Control and Coordination and Incident Management System used by the |

| | | | |
|---|---|---|---|
| Operational Picture (COP) | | | participating agencies at all levels of command |
| | C3&IMS App | ASTRIAL | The Mobile (Web based) User interface of C3&IMS |
| | C3&IMS CAD | ASTRIAL | C3&IMS Computer Aided Dispatch |
| Digitisation of Training – Scenario Builder and Execution | Scenario Builder | EXUS | It concerns the Training system that allows creation of training scenarios with allocation of incidents and actors in a chronological order |
| Situational Awareness Module | Situational Awareness Module | PARTICLE & INOV | In order to cope with a high/huge quantity of requests (typical in mass casualty events) to overcome eventual PSAP overload, a situational awareness component will be developed, capable to process multimedia data streams arriving at the PSAP (from SWAPP, PEMEA and social media streams posted to PSAP accounts) to present the overall emergency situation (e.g., heatmaps and clusters related with requests) and identify critical individual requests, using fused text and image processing, based on natural language processing and machine learning techniques and proprietary algorithms. |

A comprehensive set of clearly defined requirements is an essential prerequisite for developing the NIT-MR so that it efficiently serves the needs of its users, meets the expectations of all stakeholders, and reaches the broader objectives of the project.

Thus, we decided to apply the ongoing iterative process that actively involves intended users and technical partners in specifying such requirements, taking advantage from different methodologies including desktop and literature review, forum discussions, surveys, and workshops.

This document details the methodology applied in the ongoing user requirement elaboration process, and specifies the different steps followed.

# 1 NIT-MR Objectives

The main objective of the Nightingale project is to increase European Union (EU) resilience towards MCIs by innovating the emergency response tasks and methodologies through the integration of novel technologies. Tools and devices included in the NIT-MR will assist FRs in the different tasks performed during the response of an MCI, from the strategic, tactical, and operational point of view.

To achieve that and to be able to better focus the efforts, a list of specific objectives has been identified. It is vital to consider them when working on user requirements, as all requirements should be compared against objectives to be certain that the former always contribute to the latter.

The objectives directly related to NIT-MR are the following:

- Strategic Objectives:
    - To increase EU resilience against natural and man-made attacks by augmenting medical response capabilities in all types of disasters (multi-hazard approach)
    - To deliver a toolkit extensively validated by many emergency medical services (EMS), non-medical civil protection agencies, citizens, volunteers and technology providers in the field facilitating systematic training, standardisation and certification
    - To improve pre-hospital life support and triage, by enhancing medical operational capacities for digital identification and traceability of patients and actions, fast diagnosis and prognosis and continuous monitoring of vital signs and enablement of accurate classification, and by optimising current procedures, methods and guidelines of emergency medical and other involved actors through defining common denominators among responders, identifying gaps and challenges in medical response and materialising lessons learned on damage control and mass casualty handling from the military domain and from past events

- Technological and Scientific Objectives
    - To upgrade Triage and pre-hospital life support by developing a suite of interconnected wearable technologies, sensors and mobile applications which enhance, via Artificial Intelligence, fast diagnosis and prognosis, classification and damage control processes of emergency medical personnel, empower efficient tasking of non-medical civil protection actors and volunteers and allow digital identification, traceability and monitoring of patients and response actions during mass casualty incident handling
    - To optimise transportation and medical and civil protection resources availabilities and utilisation (e.g. personnel, vehicles, hospital beds and capacities, medical equipment, supporting equipment, etc.) by developing a set of ancillary devices and platforms, empowered by Artificial Intelligence based decision support functions, rapidly and autonomously deployed in the field which gather information, enhance awareness, facilitate the gathering of clinical information and its interpretation,

localise casualties, localise personnel and their assets, and optimise communication between teams and patients
    - To fuse all available information under an integrated framework, and develop an advanced C3 (Command, Control & Coordination) and Incident Management System for MCI (IMS), providing the Common Operating Picture to all types of response units, advancing coordination and cross-team collaboration
    - To convey the COP to the Responders, by exploiting recent advances in Augmented Reality, and developing a set of mobile Apps and that allow the FR units to better coordinate tactical and operational response

- Policy and Societal Objectives
    - To increase public safety, civil protection, and mass casualty incidents handling by greatly improving the capabilities of EU medical response and non-medical civil protection units
    - To allow cross-domain and cross-country medical and civil protection response team collaboration overcoming administrative, disciplinary and political barriers through technology and commonly agreed operational practices
    - To ensure legal, societal, ethical, security considerations and relevant impact assessments, advancing NIGHTINGALE sustainability, acceptance, credibility, and adoptability, are fully embedded by design to its implementation.
    - To engage, inclusively, all relevant emergency medical services (incl. EU and Internationally wide emergency medicine organisations) and non-medical civil protection agencies (fire brigades, police and search and rescue personnel, but also volunteers and citizens) as well as technology stakeholders in the Action maximising market penetration and exploitation of the Toolkit and the defined methods and guidelines, hence facilitating adoption by the FR community.

## 1.1 NIT-MR Stakeholders

According to the project objectives, the Nightingale key project stakeholders include the following:

- User Partners: organizations of first responders (Professional Associations, Scientific Societies, Academic Centres) that are partners in the project.
- User Advisory Board (UAB) Members: organizations that have been invited to participate in the project on voluntary basis, because of their expert knowledge of the NIGHTINGALE project topic: management of victims of MCIs and disasters.
- Technical Partners: developers and integrators that are partners in the project.

# 2 Methodology

The Nightingale work on user requirements and functional specification is based on an iterative process of data collection and analysis that aims at understanding what users and stakeholders need to better shape the end product. The chosen methodology entails 4 main steps shown in Figure 1:

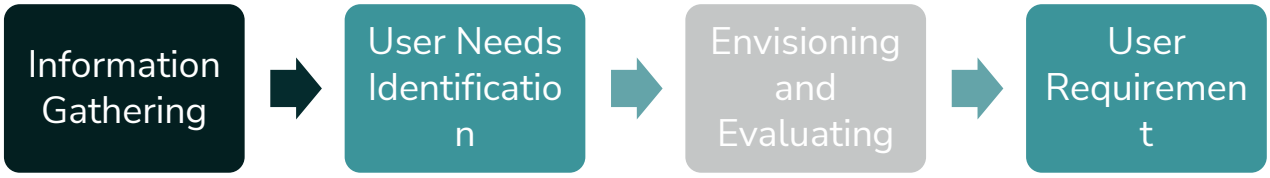


*Figure 1. Process of User Requirement Analysis. Based on: [1] User Requirements Analysis: A Review of Supporting Methods – M. Maguire, N. Bevan*

The first step of information gathering encompasses the collection and analysis of detailed information about the context of use, the intended users and their tasks, as well as the operating environment and other contextual factors that will affect the user experience. The main goals of this step are to ensure that all factors that relate to use of the systems are identified. Specifically, the **context of use analysis** describes the actual conditions and environment under which the NIT-MR will be used. The **user analysis** includes the identification of key users and stakeholders who may have an interest in the project result – the Nightingale Toolkit. We performed an analysis of the characteristics of every target user group (i.e., MCI FRs), including their level of control (operational, tactical, or strategic), their main roles, responsibilities, and task goal in relation to the system. In the **task analysis**, actions to be performed by FRs in the different steps of MCI management are described in the following categories: **a) Command, Coordination and Control activities; b) Communications; c) Triage; d) Life Support and Damage Control Interventions; e) Evacuation; f) Resource Management.**

The second step of user needs identification entailed the use of forum discussions, used for requirements elicitations and to identify issues that needed to be tackled, and user surveys. Once the initial set of needs have been identified, in the third step of envisioning and evaluating brainstorming and prototyping activities have been planned with technical partners to develop and evaluate different system designs before choosing a solution.

The final step of User requirement specification includes the documentation of the following: a) a unique reference indicating the type of requirement (functional vs non-functional); b) the requirements with an indication of their priority levels; c) reference to the related Use Cases described in the deliverable D1.6 Scenarios and Use Cases.

## 2.1 Information Gathering

Active involvement of users is essential for detailing and validating tools' requirements. To gather necessary information on intended users and their tasks, desktop research and literature review have been performed. Nightingale practitioners and User Advisory Board members, who represent key stakeholders and potential end-users of the NIT-MR, have been actively involved in the process.

### 2.1.1 Context of Use Analysis

MCIs occur as a consequence of a wide variety of events, ranging from multiple motor vehicle collisions to terrorist attacks. Sudden onset disasters, such as earthquakes and hurricanes, often result in MCIs, where the medical needs of the injured outweigh existing resources. Despite the many attempts to define such events according to the number of injured victims involved, it is commonly accepted that

> » any situation where immediately available resources are insufficient for the need of medical care to such extent that it involves a risk for life and health can be considered an MCI [2]

As such, MICs are not related to any specific number of critically ill or injured individuals, or to any specific level of resources, but to the balance between resources and need. Therefore, the threshold for activating MCI plans varies greatly between countries, according to the local context. As local response capabilities are usually overwhelmed by the abrupt and unexpected increase of the need of medical care, the medical management of MCIs cannot rely only on the routine emergency medical services (EMS) organization but should take into account the complexity that derives from a series of factors including high level of uncertainty, dynamic development of events and time-critical decision making. Unconfirmed information, lack of information and contradictory information can cause blurred pictures that make decision-making harder than in normal situations [3]. Moreover, lack of cooperation and coordination between the different forces operating in the prehospital setting (law enforcement, rescue teams, medical teams, the press, ...), logistical problems (e.g., the disruption of communication networks) and security issues, often pose an additional challenge for incident managers.

Due to the high variability of MCIs characteristics influencing the response (geographical context, location accessibility and distance from hospitals, number and spatial distribution of casualties, nature and severity of injuries, availability of rescue and medical teams, equipment...), one MCI differs from another. One of the major challenges highlighted by responders involved in past MCIs has been the need to achieve a balance between following the existing contingency plan and improvising, both individually and organizationally, as the plan either did not cover the situation at hand, or it was not applicable because the public did not behave as the plan presumed or the event developed in an unexpected direction [4,5,6]. Therefore, instead of exclusively relying on the application of standardized predetermined protocols or guidelines, responders and incident managers should rather adapt fundamental principles to each different situation [7].

Several different parameters affect the management of an MCI: type and dynamics, distance from health care facilities, time of the day and resources available. All these factors should be taken into

 

consideration during the incident management, to adapt the medical response accordingly. For instance, the geographical location of the MCI (urban vs rural setting) can influence the entire decision-making process, prompting responders to rapidly evacuate casualties to hospitals ("scoop and run" approach) or to start treating casualties on site, ensuring clinical stabilization before transportation ("stay and stabilize" or "stay and play" approach).

Given the unbalance between resources available and the need for medical care, and to optimize overall patient outcomes in such a catastrophic situation, one of the cornerstones of MCI management is the need to shift from what is best for the individual to what is best for the largest number of people. This concept implies a series of decisions, from the application of prehospital triage to discouraging heroic resuscitation efforts. As such, responders should be aware that some casualties that might have had chance to survive under normal circumstances, cannot be saved during MCIs.

#### 1.1.1.1. Different Phases of MCI management

**Immediate Response Phase**

The first minutes of the response phase are crucial to efficiently activate and organize the whole incident management system, by reporting needs and accumulating forces and commanders on scene. When an MCI is declared, emergency services and other providers should have a set of priorities that are intended to save life, relieve suffering, prevent escalation of the incident, and enable a rapid restoration of normality in the aftermath of the event.

1. Scene assessment and initial command

After the initial alert, it is the duty of first responder to make an initial assessment of the extent of the incident and report back as fast as possible. This initial assessment is the key to get the appropriate response personnel to the scene, initiate mobilization of appropriate equipment and supplies to the scene and be aware of any potential for escalation (e.g. secondary explosions, fire). To assist the first responder in the initial reporting to the EMS control centre, the "**METHANE**" mnemonic used in the UK Major Incident Medical Management and Support (MIMMS) system can be adopted [8]:

- **M** (Mass casualty incident?): confirm to the medical operation centre the occurrence of the MCI.
- **E (**Exact location): provide the exact location of the incident site, using coordinates, nearby buildings, streets, or landmarks.
- **T** (Type of incident): describe the type of occurred event (e.g., plane crash, traffic accident, building collapse…)
- **H** (Hazards present at site): identify – together with fire brigade - the onsite hazards, for example gas leak, organophosphate poisoning
- **A** (Access to site): is there a clear access to the scene?
- **N** (Numbers of casualties and specific types of injury): provide an estimated number
- **E** (Emergency services present and required): declare how many emergency vehicles BLS, ACLS, and helicopters are present and how many are needed

 

While approaching the scene to retrieve such information from forces already on site or any available bystander, the first responder must keep scene safety foremost on their minds. If present, possible and necessary, law enforcement will place an outer cordon to restrict access to the injury site, while fire brigades will guarantee safety and security during relief operations by identifying and eliminating existing hazards before permitting access to any health care staff.

2. Sectorization

After the initial assessment, the first responder should initiate the organization of the field, setting up working areas to guide all responders on scene. These areas will facilitate the creation of loops (Figure 2.), enhancing the response phase. Specifically, it is advisable to set up the following areas:

- Command and Control post, a safe and accessible spot from which all agencies and services responding (= the head of the police, emergency medical teams and fire brigades) will coordinate operations. The first responder will be located in this area until the handover to more senior personnel.
- Access and egress routes for emergency vehicles.
- Casualty collecting points (CCPs) according to the severity of injury (red, yellow, green, and black codes).

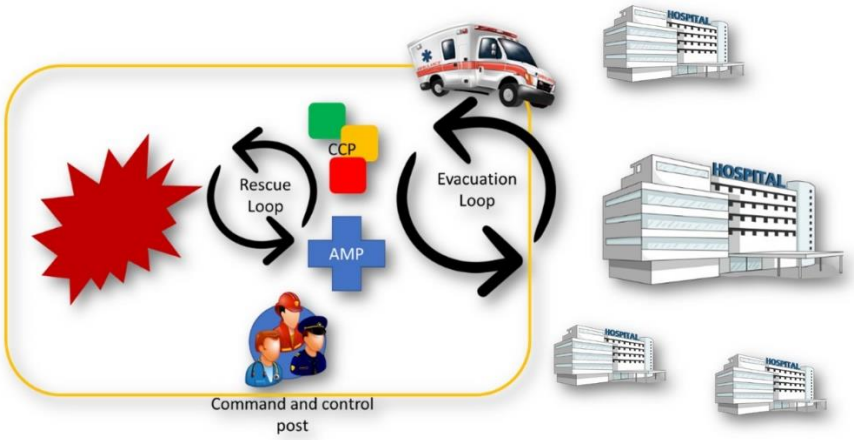


*Figure 2 MCI sectorization example*

3. Mass Casualty Triage

Mass Casualty Triage is applied to identify the most severely injured patients who require attention/immediate transport to the nearest hospital. As such, it should entail a rapid evaluation of patients' vitals and/or condition. Currently, many Mass Casualty Triage methods exist, the majority of which are relatively similar as they use a 4- or 5-category scheme that is based on basic physiological criteria or simple and rapid evaluation of major and minor injuries performed by FRs with different level of medical and/or first aid basic trainings [9]. To date, none of these triage techniques proved to be superior or more accurate. One important aspect to be stressed is that a unified Triage System should be used during a response to MCIs within and between different agencies. Regardless the algorithm chosen, a color-coded tagging method to categorize MCI casualties in the field has been almost universally adopted and incorporated into existing triage systems. To date, no technological tool is available to assist FRs in performing prehospital Mass

 

Casualty Triage, despite the fact that the use of sensors and monitoring platforms to be able to continuously monitor vital signs at home and in hospitals is a widespread practice.
Triage begins at the scene, following scene risk assessment and implementation of first responder safety and security measures. Usually, a Triage Officer is assigned. It is important to underline that Mass Casualty Triage should be considered as a dynamic process that should be performed at different stages of the emergency response. As significant life-threatening injuries can be missed during the triage performed at the first encounter with the patients, and patients who were previously stable can quickly decompensate, it is important to ensure that healthcare professionals continually monitor and reassess casualties. The thoroughness of the patient assessment should vary based on scene safety, number of patients, personnel available to participate in the triage process, and other factors. Having scalable and flexible triage protocols allows providers to properly respond to different type of MCIs. Care of the injures during initial triage procedures should entail only lifesaving procedures including:

- opening of blocked airway
- control of severe external bleeding
- management of tension pneumothorax

Further interventions should be delayed until all the injured have been identified and transported to a safer location. An important lesson learned from past events is that no matter how rapid the arrival of professional emergency responders, bystanders will always be first on the scene and are the best positioned to provide immediate care in case of bleeding emergencies. To this end, the Hartford Consensus [10] highlighted the importance of providing the public with the skills and tools needed to control hemorrhage as bystander first responders through the “Stop the Bleed” campaign, offering courses, training medical personnel to be instructors, educational material and kits to stop bleeding.

## Reorganization phase

1. Model of Command

During the response phase to MCIs, it is of paramount importance the presence of a clear leader on scene. In case of shorter MCIs, a Prehospital Command group (Incident commander from medical, fire brigade, and police) is normally established. The three figures work closely together coordinating the scene from a secure area (commonly known as Advanced Command Post). In case of protracted MCIs (>24 hours with long delays in evacuation, e.g., fires), the implementation of a standardized and functional command and control structure, commonly known as Incident Command System (ICS) [11], is advisable. The ICS is a standardized on-site management system designed to enable effective, efficient incident management, under the leadership of a unified Incident Commander. The goal of ICS is to equip responders with a scalable organizational structure capable to reduce duplication of efforts and provide a safe and efficient working environment, to ultimately be able to provide accurate information, strict accountability, and planning (figure 3).

 

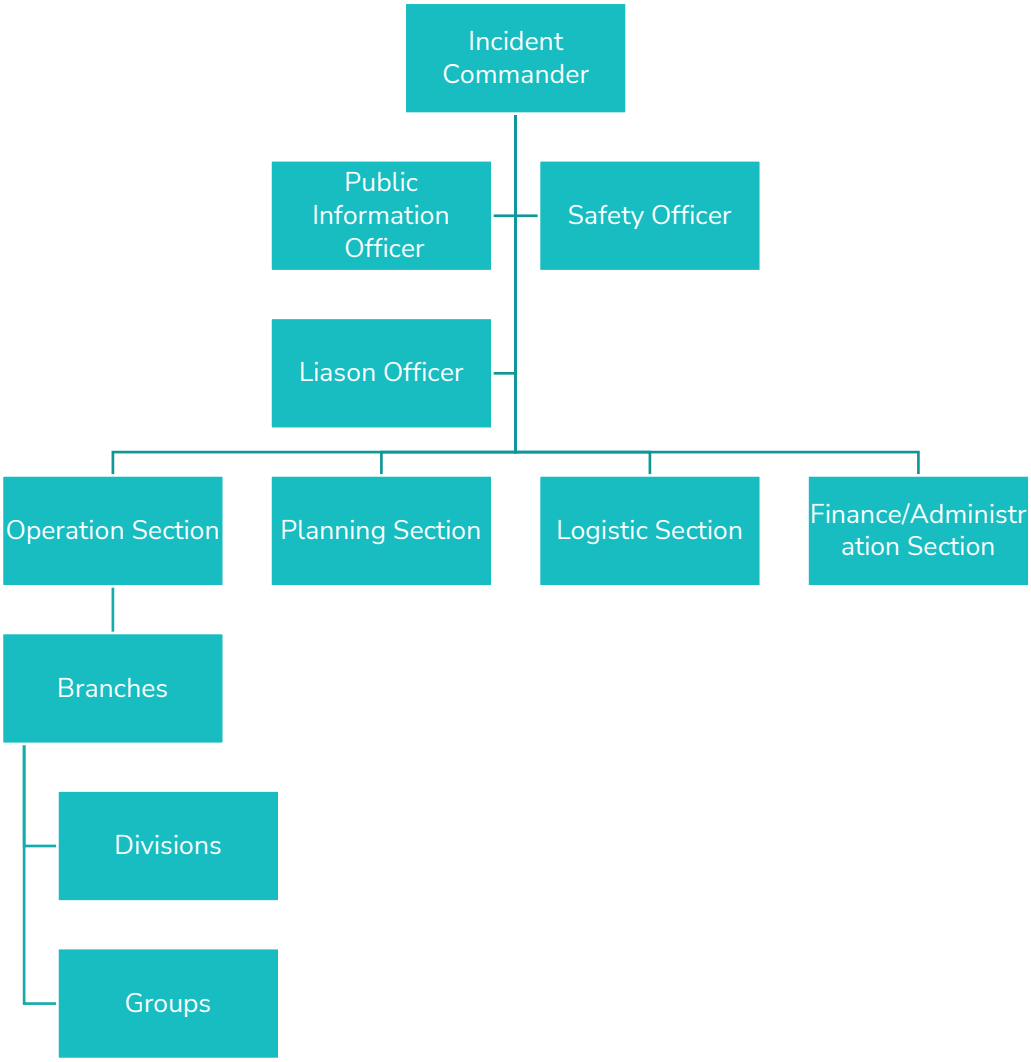


*Figure 3. Basic Incident Command System flowchart*

2. Advanced Medical Post

The establishment of an Advance Medical Post (AMP) within the chain of medical care should also be considered if deemed necessary. The AMP is basically a field treatment area that functions as an extension of a hospital emergency room, where victims are sorted, stabilized and where evacuation towards hospitals is coordinated. There should be a clearly marked entrance to which victims will be brought from the field for medical triage and a clearly marked exit through which evacuation will take place. The AMP should be located as close to the impact zone as is safely possible, and the internal space is normally subdivided into different treatment areas according to triage categories. The time of day and type of mass casualty incident, weather conditions, topography, number of severe casualties and available resources will all influence the decision regarding the setup of the AMP.

3. Treatment Principles and Evacuation

In order to establish the level of medical ambition, the Incident Commander should consider the following: a) Time required to provide the interventions; b) Healthcare provider expertise required; c) Resources required. Typically, the most efficient interventions during MCIs are those that offer

 

high benefit for minimal resource commitment, while the least efficient interventions are ones that require numerous or specialty staff, significant time, and/or a very high resource-to-benefit ratio.

As a general rule, medical treatment of casualties at the casualty collecting point should start only when enough manpower is in place. Damage control resuscitation procedures should aim at stabilizing casualties before definitive treatment is provided in health care facilities. Tourniquets, basic airway positioning and interventions, chest seals, and chest decompression are among the interventions that form the core of Tactical Combat Casualty Care (TCCC)/Tactical Emergency Casualty Care (TECC) [12].

With respect to transport, key principles are required to determine the order of evacuation: priority (triage), stabilization treatment needed before transport and patients' destination. Capacity, availability and suitability of transport has to be considered (e.g., helicopter evacuation). Failure to ensure proper evacuation structure might overburden the nearest health facilities where multiple un-triaged or minor casualties arrive using private means of transport. Urgency indicators can be used to set the priorities in evacuation (e.g., 1) Airway problems; 2) Breathing problems; 3) Hemodynamic stability problems; 4) Neurological injury; 5) Orthopedic injury 6) All the rest.)

## 2.1.2 User Analysis

The NIT-MR will be designed to assist all FRs by delivering novel, affordable, accepted, and customised medical response tools and services as part of their operational assets. As such, it should assist FRs deployed in the prehospital settings as well as emergency medical services and non-medical civil protection agencies responsible for coordination activities and managers at the hospital level. Therefore, we have identified the main NIT-MR users and divided them into specific groups in relation to type of user, role, level of control and responsibilities. This analysis was based on general knowledge and expertise in addition to the literature findings, thus, names, tasks and responsibilities may be slightly different according to the local context of a specific country.

### 2.1.2.1 Type of Users

We classified users according to their involvement into four categories:

- **Public Governance & Administration (Public G&A)**: staff responsible for political governance and administrative governance, coordinating the administration system and general workflows;
- **Medical**: professionals with health background (e.g., doctors, nurses), being responsible for medical assessment, medical management, and treatment of casualties;
- **Trained non-medical**: professional responders without medical background, specifically trained in different relevant sectors (e.g., police, fire fighters);
- **Not trained non-medical**: members of the community with no verified credentials pertaining medical/first responder trainings that might voluntarily engage in the response activity;

#### 2.1.2.2 Level of Control

We classified the level of decision-making command and control of each user into the three following categories:

- **Strategic control:** defines "what to do". High-level overview of the entire response that determines policy, overall strategy, resource deployment and the parameters within which lower levels of command and control will operate.
- **Tactical control:** defines "how to do it". It determines and directs the tactics of incident management within the strategy, parameters and with the resources defined at the strategic level.
- **Operational control:** is concerned with "doing it". Operational commanders are responsible of implementing the tactical plan. Decision-making may be characterised by an intuitive approach, based on problem-recognition from previous experience, training and exercising.

#### 2.1.2.3 Roles and Responsibilities

In this section we aim to describe the main roles and responsibilities of the NIT-MR users involved in the MCI response. The description encompasses users directly involved in the field, personnel working in emergency operation centres (EOCs) and hospital staff. According to the MRMID concept [2], that since 2009 has trained more than 7000 FRs around Europe, the EOC established at the regional level leads and coordinate the whole response to an MCI. EOCs, typically located in immediate connection to the ambulance dispatch centres, are normally in constant communication with the Prehospital Command Group on scene and the hospital command group (figure 4).

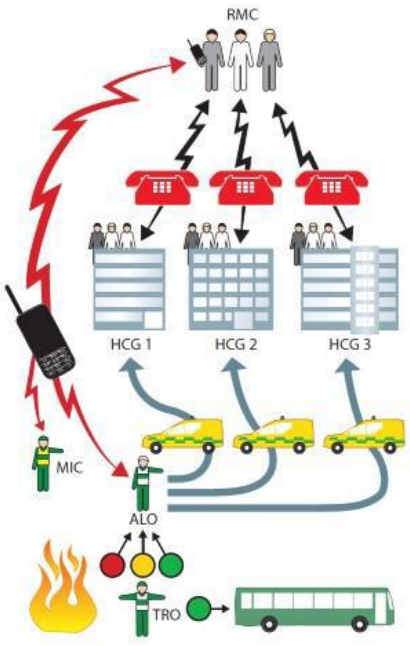


*Figure 4. Command-system according to the MRMI-concept. RMC= Regional Medical Command, HCG= Hospital Command Group, MIC=Medical Incident commander, ALO=Ambulance loading Officer, TRO= Triage Officer.*

In the following table, we present a summary of the main user roles, level of control and related responsibilities:

 

| User | Role | Level of Control | Responsibilities |
|---|---|---|---|
| Public G&A | Local/Regional/National director of health | Strategic | Responsible for the management of the situation in an overall perspective, and the governance of all stakeholders. |
| Public G&A | Local/Regional/National director of security and civil protection | Strategic | Responsible for the management of the situation in an overall perspective with a focus on security and protection of victims. |
| Public G&A | Local/Regional/National representatives of ministries involved | Strategic | Assists the decision-making process. |
| Public G&A | Director of receiving hospital | Strategic | Responsible for follow-up of the situation inside the hospital and reporting to the authorities when necessary. |
| Medical / Trained non-medical | Dispatch Centre | Tactical | The dispatch centre plays a role of coordination between the MCI management on the field and the receiving facilities, follow the situation, and it is the contact point of citizens when needed. |
| Medical / Trained non-medical | Public Safety Answering Point | Tactical | Responsible for receiving emergency calls and processing those calls according to a specific operating policy. |
| Medical / Trained non-medical | Emergency Operations Centre | Tactical | A protected site location where management decisions are made and coordinated responses to an emergency incident are orchestrated. |
| Medical / Trained non-medical | Field Incident Commander | Tactical | The individual responsible for the management of all incident operations, ensuring incident safety and setting priorities in the field. |
| Medical | Incident Commander of receiving hospital | Tactical | The individual responsible for the management of all incident operations at the hospital level, ensuring incident safety and setting priorities. |
| Medical / Trained non-medical | Incident Commander Assistant | Tactical | Assists the incident commander to help manage the workload and the management of the incident. |
| Medical / Trained non-medical | Operations section chief | Tactical | Responsible for managing all tactical operations at an incident. |

| | | | |
|---|---|---|---|
| Medical / Trained non-medical | Planning section chief | Tactical | Responsible for providing planning services for the incident. |
| Trained non-medical | Logistics Section Chief | Tactical | Ensures an adequate supply of all resources necessary for patient care activities |
| Trained non-medical | Finance/Administration Section Chief | Tactical | The Finance/Administration Section Chief is responsible for managing all financial aspects of an incident. |
| Trained non-medical | Liaison Officer | Tactical | Member of the Command Staff who is the point of contact for assisting or coordinating agencies. |
| Trained non-medical | Police Group Supervisor | Tactical | Responsible for managing all tasks related to police units. |
| Trained non-medical | Firefighters Group Supervisor | Tactical | Responsible for managing all tasks related to firefighters' units. |
| Trained non-medical | Public Information Officer | Tactical | Public information officer determines any limits on information release and supervise and assist press/media briefings. |
| Medical | Treatment Area Manager(s) | Tactical | Treatment Area Manager reports to the Incident Commander and is responsible for overseeing the treatment of patients assigned to the Treatment Area. |
| Trained non-medical | Air/Ground Ambulance Coordinator | Tactical | Each Air/Ground Ambulance Coordinator reports to the Incident Commander and manages their respective areas to maintain continuous transport services. |
| Medical / Trained non-medical | Liaison officer of receiving hospital | Tactical | Member of the hospital who is the point of contact for assisting or coordinating agencies and the contact point between the field and the hospital. |
| Medical | Operations chief of receiving hospital | Tactical | Responsible for managing all tactical operations at the hospital according to the emergency plan. |
| Medical | Triage Unit Leader | Operational | The Triage Unit Leader reports to the Incident Commander and supervises Triage Crew/Porters and the Morgue Manager. The Triage Unit Leader assumes responsibility for providing triage management and movement of patients from the Triage Area. When triage |

| | | | |
|---|---|---|---|
| | | | has been completed, the Unit Leader may be reassigned as needed. |
| Medical / Trained non-medical | Triage Units | Operational | Triage Unit(s) reports to the Triage Unit Leader. They triage patients and attach the appropriate colour to each triaged patient. |
| Medical / Trained non-medical | Morgue Manager | Operational | The Morgue Manager reports to the Triage Unit Leader and assumes responsibility for Morgue Area activities until relieved of that responsibility by the appropriate Coroner's Office. |
| Medical | Treatment Unit | Operational | Treatment Unit(s) reports to the Treatment Area Manager(s). They treat and monitor patients. |
| Trained non-medical | Transportation Units | Operational | Transport Units are in charge mainly of transporting patients to assigned receiving facility. |
| Trained non-medical | Staging Manager | Operational | Keep a record of resources present in the staging area, monitor movement of resources, and dispatch resources to appropriate locations based upon requests. |
| Trained non-medical | Firefighters | Operational | Responsible for the security of the surrounding from potential natural threats, for the extraction of victims from the affected area and for the control of the ongoing incident (fire suppression …) |
| Trained non-medical | Police | Operational | Responsible for the security of the surrounding from potential human made threats, for the security of access and exit locations and for the circulation outside and through the scene. |
| Trained non-medical | Porters | Operational | Porters report to the Triage Unit Leader. This role is established when non-ambulatory patients need to be moved from the impact area or Casualty Collection Point to the Treatment Area. |
| Not trained non-medical | Bystanders | Operational | Person immediately affected by the MCI, not injured, or minimally injured, who presents to the first response agency to assist. This person may or may not have medical or first response training, regardless, without verification of credentials is to not be expected to perform medical assessments and will be |

 

| | | | |
|---|---|---|---|
| | | | only instructed to perform basic first aid interventions or assist with non-medical tasks |
| Medical | Hospital Command Group | Tactical | Responsible for the implementation of the hospital MCI plan, including resources allocation |
| Medical | Triage staff of receiving hospital | Operational | Responsible for re-triaging received patients and dispatching them to the right location. |
| Medical | ED staff | Operational | Responsible for the clinical management of casualties at the receiving location |

*Table 2. User Analysis*

Different systems in different jurisdiction may see the allocation of responsibility differently (e.g., in most systems, the same people perform triage and provide primary life-saving treatments). It is also important to understand that during the response to an MCI, one user can play several roles. The same user can perform Triage in the initial stages of the response then act as porter or provide treatments in the treatment areas. However, we consider them to be different User Groups, as their distinctive actions will be different in every case.

### 2.1.3 Task Analysis

In this section we describe the main tasks to be performed by FRs during the prehospital response of an MCI. Based on the Users Analysis, we performed a hierarchical task analysis, focused on decomposing a high-level task in subtasks, here-after identified within the Strategic (S), Tactical (T) and Operational (O) level of control. For each task, identified by a unique ID code, we assigned a NIT-MR component that could assist FRs.

#### 2.1.3.1 Command, control, and coordination

To have a control over the MCI, commanders and coordinators needs to:

| Task ID | Task | S | T | O | NIT-MR |
|---|---|---|---|---|---|
| T1.1 | Establish position, announce location, establish communications and coordination with all responders and the Incident Command System organization needed to manage the incident. | | X | X | C3&IMS, C3&IMS App and C3&IMS CAD |
| T1.2 | Review and approve the Incident Action Plan, the Medical Plan and the Incident Action Plan for safety implications. | | X | | C3&IMS, C3&IMS App and C3&IMS CAD |
| T1.3 | Approve resource requests and use of volunteers and auxiliary personnel and information release to the media. | | | X | C3&IMS, C3&IMS App and C3&IMS CAD Resources and assets optimization service |
| T1.4 | Ensure adequate safety measures and accountability procedures are followed for both providers and victims, | X | X | X | C3&IMS, C3&IMS App and C3&IMS CAD |

| | | | | | |
|---|---|---|---|---|---|
| | after-action reports are completed, all assigned resources have checked in at the incident, each area has been established and announced, and non-disrupted, on-scene communication is maintained. | | | | |
| T1.5 | Oversee incident-related data gathering and analysis regarding incident operations and assigned resources. | X | X | X | C3&IMS, C3&IMS App and C3&IMS CAD |
| T1.6 | Collect situation information to anticipate needs of the uninjured and to develop projections and forecasts related to the incident. | | X | X | C3&IMS, C3&IMS App and C3&IMS CAD; Early warning and risk assessment service, Data Layer and Decision Support Service; |
| T1.7 | Set priorities and determine incident objectives and strategies to be followed. | X | X | | C3&IMS, C3&IMS App and C3&IMS CAD; |
| T1.8 | Identify and mitigate hazardous situations and initiate preliminary investigation of accidents within the incident area. | X | X | | C3&IMS, C3&IMS App and C3&IMS CAD; Early warning and risk assessment service |
| T1.9 | Gather and disseminate information for the Incident Action Plan. | | | X | C3&IMS, C3&IMS App and C3&IMS CAD; Interoperable Data Lake |
| T1.10 | Monitor operations within the Group, evaluate progress, make resource requests, and report as necessary to Director and verify Managers are appointed. | | | X | C3&IMS, C3&IMS App and C3&IMS CAD; |
| T1.11 | Provide to update the Incident Action Plan and track the location and status of all resources assigned to the incident. | | | X | C3&IMS, C3&IMS App and C3&IMS CAD; Resources and assets optimization service |
| T1.12 | Order demobilization as needed. | | | X | C3&IMS, C3&IMS App and C3&IMS CAD; Resources and assets optimization service |

*Table 3. Tasks – Command, control, and coordination.*

### 2.1.3.2 Communication

For communications, both internally (amongst the team members managing the incident) or externally (with other stakeholders, citizens, affected or related to the incident) users need to:

| Task ID | Task | S | T | O | NIT-MR |
|---|---|---|---|---|---|
| T2.1 | Communicate tasks, commands and information about the incident to responders. | | X | X | C3&IMS App and C3&IMS CAD; AR service |

| | | | | | |
|---|---|---|---|---|---|
| T2.2 | Request additional resources as needed. | X | X | | C3&IMS App and C3&IMS CAD; Resources and assets optimization service |
| T2.3 | Maintain current information, summaries, and/or displays on the incident. | X | X | | Decision Support service and Data Layer; C3&IMS App; AR service |
| T2.4 | Communicate resource needs | | X | X | C3&IMS App and C3&IMS CAD; Resources and assets optimization service |
| T2.5 | Send situation report and request appropriate specialty resources | | | X | C3&IMS App and C3&IMS CAD; Resources and assets optimization service |
| T2.6 | Monitor and forward media information that may be useful to incident planning. | | | X | C3&IMS |
| T2.7 | Conduct periodic media briefings and arrange for tours and other interviews or briefings that may be required. | | X | X | C3&IMS |
| T2.8 | Coordinate information and patient receiving facility destination | | X | X | C3&IMS App; Resources and assets optimization service |
| T2.9 | Determine any limits on information release | X | X | | C3&IMS |
| T2.10 | Obtain Incident Commander's approval of news releases. | | | X | C3&IMS |

*Table 4. Tasks – Communication.*

### 2.1.3.3 Triage

Beside triaging the victims and attaching colours to all injured, lots of tasks needs to be fulfilled when it comes to triage:

| Task ID | Task | S | T | O | NIT-MR |
|---|---|---|---|---|---|
| T3.1 | Determine approximate number and severity of victims. | | | X | Digital Triage Tag and Triage and Vital Signs app; Triage wearable; UAV Rapid Triaging system Thermal scanning system |
| T3.2 | Break crews up to begin triage | | X | X | - |

| | | | | | |
|---|---|---|---|---|---|
| T3.3 | Communicate accurate triage count as well as any injuries that require special resources to Triage Unit Leader. | | | X | Digital Triage Tag and Triage and Vital Signs app; Triage wearable; UAV Rapid Triaging system |
| T3.4 | Estimate extent of impact area. | | X | X | UAV Rapid Triaging system |
| T3.5 | Establish a perimeter for security and scene control, and coordinate Triage Units and Porter Units. | | | X | AR service |
| T3.6 | Maintain personnel accountability, security and control of the triage area | X | X | | - |
| T3.7 | Determine resources required. | | X | | Resources and assets optimization service |
| T3.8 | Advise Incident Command of total patient count upon completion of triage | | | X | Digital Triage Tag and Triage and Vital Signs app; Triage wearable; UAV Rapid Triaging system |
| T3.9 | Designate the Casualty Collection Point if needed | | X | X | - |
| T3.10 | Coordinate movement of patients from the triage area to the Casualty Collection Point or into the appropriate treatment area | | X | | Digital Triage Tag; C3&IMS App |
| T3.11 | Re-triage patients and relocate as necessary. | | | X | Triage tag; Triage and Vital Signs app; Vital Signs Wearable; Triage wearable; UAV Rapid Triaging system; Thermal scanning system |
| T3.12 | As necessary, call for establishment of an incident morgue area | | X | | - |
| T3.13 | Evaluate and report crew readiness for rehab or reassignment | | X | | - |
| T3.14 | Request reassignment or rehab based on personnel needs and demobilize triage unit | | X | X | - |

*Table 5. Tasks – Triage*

#### 2.1.3.4 Life Support and Damage Control Interventions

Responders and MCI managers need to continuously monitor the situation to control any possible deviation for this they need to:

| Task ID | Task | S | T | O | NIT-MR |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| T4.1 | Assess needs for additional personnel, physical and mental well-being of personnel. | X | X | | Diagnosis and Prognosis service |
| T4.2 | Provide basic treatment during triage, stopping triage only for the time needed to open the airway and control severe bleeding. | | | X | Diagnosis and Prognosis service |
| T4.3 | Ensure no patient leaves treatment area without permission, patients are appropriately treated, and that treatment area is always prepared to accept patients. | | | X | Digital Triage Tag and Triage and Vital Signs app; Triage wearable; Vital signs wearable; UAV Rapid Triaging system |
| T4.4 | Request appropriate resources needed to treat all patients. | | X | X | Resources and assets optimization service |
| T4.5 | Rotate assigned area personnel through Rehab, as needed. | | X | | - |
| T4.6 | Prioritize patients for transport. | | X | X | Digital Triage Tag and Triage, Triage Wearable; Vital Signs wearable and Vital Signs app; |
| T4.7 | Monitor crew for rehab needs | | X | | - |

*Table 6. Tasks – Life Support and Damage Control Interventions*

### 2.1.3.5 Evacuation

Evacuation is the first step in the end of the MCI management process; thus, several tasks need to be fulfilled in this important phase:

| Task ID | Task | S | T | O | NIT-MR |
|---|---|---|---|---|---|
| T5.1 | Communicate with receiving facilities | | x | | Resources and assets optimization service |
| T5.2 | Designate patient loading area(s), paths of entry and exit for all transport units and the landing zone(s) for arriving air transport units | x | x | | - |
| T5.3 | Determine total patient count and transport needs. | x | x | x | Digital Triage Tag and Triage, Vital Signs wearable, Triage Wearable and Vital Signs app; UAV Rapid Triaging system |
| T5.4 | Cooperate with Transportation Group Supervisor in maintaining transport records | | x | | C3&IMS App |

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|---|---|---|---|---|---|
| T5.5 | Coordinate the air and ground transportation of all patients | | X | | C3&IMS App |
| T5.6 | Effectively manage all transport resources within assigned area | | X | X | C3&IMS App<br>Resources and assets optimization service |
| T5.7 | Ensure patients selected for transportation are ready and loaded on the correct transport unit and that the drivers stays with the unit. | | X | X | Digital Triage Tag and Triage, Vital Signs wearable, Triage Wearable and Vital Signs app; |
| T5.8 | Ensure total patient accountability and transport record is informed | | X | X | Digital Triage Tag and Triage, Vital Signs wearable, Triage Wearable and Vital Signs app; |
| T5.9 | Establish and maintain communications with the Staging Area, the Transportation Group Supervisor and the Treatment Unit Leader | | X | X | C3&IMS App |
| T5.10 | Keep Air/Ground Ambulance Coordinator informed as directed | | | X | C3&IMS App |
| T5.11 | Maintain records of all patients departing the scene | X | X | X | C3&IMS App |
| T5.12 | Provide any needed receiving facility directions to ground transport units | | X | | C3&IMS |
| T5.13 | Transport patients to assigned receiving facility | | | X | - |
| T5.14 | When possible, notify Staging Manager of arrival at hospital and when available for service | | | X | C3&IMS |

*Table 7. Tasks – Evacuation*

### 2.1.3.6 Resource Management

Resource management is a continuous task that must be maintained throughout all the phases of MCI management, to fulfil this task responders needs to:

| Task ID | Task | S | T | O | NIT-MR |
|---|---|---|---|---|---|
| T6.1 | Track and alert when reserve levels reach minimums | | | X | Resources and assets optimization service |
| T6.2 | Analyze and prepare estimates of incident costs and cost data | X | X | | Decision support service |
| T6.3 | Plan menus, provide cooking facilities, and order, cook and serve food and manage its security and safety | | X | X | |
| T6.4 | Coordinate with the Medical Unit Staff and with Planning and Logistics Sections | | X | | C3&IMS<br>Resources and assets optimization service |
| T6.5 | Demobilize all facilities used in support of incident | | | X | C3&IMS |

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Resources and assets optimization service |
| T6.6 | Determine the best location to set up the supply post, determine the food and hydration needs of personnel assigned to the incident, determine and maintain required resource levels from the Operations Section. | | X | X | |
| T6.7 | Distribute supplies as requested to the Treatment Area(s), the Incident Action Plan and the Incident Demobilization Plan | | | X | Resources and assets optimization service |
| T6.8 | Maintain an accurate accounting of supplies distributed and still available, files on injuries and illnesses associated with the incident, all facilities used in support of incident and Incident files and data | | X | | C3&IMS<br>Resources and assets optimization service |
| T6.9 | Manage financial concerns resulting from property damage, injuries, or fatalities at the incident, monitor expenditures and track costs. | X | X | | - |
| T6.10 | Recommend cost-saving measures | X | X | | - |
| T6.11 | Request and secure additional medical supplies as necessary | | X | X | Resources and assets optimization service |
| T6.12 | Respond to requests for resource assignments | X | X | X | Resources and assets optimization service |

*Table 8. Tasks – Resource Management*

### 2.1.4 Synthesis of findings

The information gathered from the User and Task analysis has been subsequently analysed and summarized to better categorize it inside a framework that would be functional to the main objective of the NIT-MR. As a result, we report hereafter the list of main users that the Nightingale project will take into consideration for NIT-MR, their spatial localisation during the response phase of an MCI (prehospital scene, transit, command, and control centre) and the main tasks performed.

#### 2.1.4.1 NIT-MR Users

- **Emergency Medical Services (EMS) – Medical**
  According to the different EU jurisdiction, such role can be fulfilled by health care professionals with medical, nurse or paramedic background, or by ambulance service-trained volunteers. The roles undertaken in the scene are those highlighted in the ICS Operations flowchart under the medical branch (see Fig. 2).

- **Hospital staff (HS) – Medical**
  Medical staff at the receiving facility, including doctors, nurses, and crisis managers. nurse or paramedic background, or by ambulance service-trained volunteers. Their tasks encompass the clinical management of MCI casualties and appropriate re-allocation of hospital resources according to the evolving needs and status updates received from the PreH scene.

 

- **Fire Fighters (FF) – Trained non-medical**
  Within the EU different jurisdictions, FFs are in charge of scene safety-related procedures and search and rescue activities, including casualties' extractions and evacuation from the red zone. In many EU countries, the chief or foreman of the FF team plays the role of Incident Commander.

- **Police – Trained non-medical**
  Within the EU different jurisdictions, Police is usually in charge of securing the incident site, manage access and egress routes and patrolling. In some EU countries or under certain circumstances (e.g. terrorist attacks, mass shooting events…) the chief or foreman of the Police can take the role of Incident Commander.

- **Bystanders – Not-trained non-medical**
  The Nightingale project recognizes the importance of active involvement of bystanders during an MCI. This category includes people immediately affected by the MCI, not injured, or minimally injured, who presents to the first response agency to assist. These people may or may not have medical or first response training, regardless, without verification of credentials is to not be expected to perform medical assessments.

#### 2.1.4.2 NIT-MR Users spatial localization and Tasks

| User | Scene | Transit | Command & Control Centre | Possible NIT-MR to be used |
|---|---|---|---|---|
| EMS | PreH:<br>• Triage related tasks<br>• Provide advanced medical care<br>• Coordinate casualties' evacuation from scene (together with FFs and Police)<br>• Determine destination and transportation requirements for casualties<br>• Determine the approximate cause of injury<br>• Communication with EMS Dispatch Centre (initial scene assessment, resources required, evacuation procedures) | • Evacuate casualties from the scene<br>• Provide medical support during transport<br>• Communicate with EMS Dispatch Centre | EMS Dispatch Centre:<br>• Collect relevant information from the EMS on scene<br>• Management of local/regional EMS resources according to the MCI plan<br>• Coordinate evacuation of casualties from the scene according to distribution matrix<br>• Alert hospitals according to predefined hospital alert lists<br>• Guarantee continuity of care for routinary emergencies | • Digital Triage Tag<br>• Triage and Vital Signs app<br>• Triage wearable<br>• Vital signs wearable<br>• AR service<br>• UAV Rapid Triaging system<br>• Thermal scanning system<br>• Resources and assets optimization service<br>• Diagnosis and Prognosis service<br>• Decision support service<br>• C3&IMS<br>• C3&IMS App<br>• C3&IMS CAD<br>• Scenario Builder |

| | | | | |
|---|---|---|---|---|
| **FFs** | PreH:<br>• Secure and protect the incident scene (suppress fire, provide initial HAZMAT containment)<br>• Provide traffic control until police arrival<br>• Provide basic life support until EMS arrival<br>• Rescue casualties from vehicles/contaminated environment<br>• Serve as Incident Commander<br>• Perform triage<br>• Coordinate casualties' evacuation from scene (together with EMS and Police) | • Evacuate casualties from the scene<br>• Provide basic medical care during transport | FFs' communication center:<br>• Communication and coordination with Incident Commander on site<br>• Mobilization of resources as required<br>• Guarantee continuity of care for routinary emergencies | • Digital Triage Tag<br>• Triage wearable<br>• Vital signs wearable<br>• AR service<br>• UAV Rapid Triaging system<br>• Thermal scanning system<br>• Early warning and risk assessment service |
| **Police** | PreH:<br>• Secure the incident<br>• Set up scene access points<br>• Direct Traffic<br>• Safeguard personal properties<br>• Conduct investigations<br>• Serve as Incident Commander<br>• Coordinate casualties' evacuation from scene (together with FFs and EMS)<br>• Supervise scene clearance | | PSAP:<br>• Collect information from callers<br>• Dispatch of resources required (EMS, Police, FFs)<br>• Notification to relevant stakeholders (eg. Regional Coordination Centre) according to the level of MCI<br>• Monitor multiple channels (Staging, Operation, Command, Logistics)<br>• Communication and coordination with Incident Commander on Scene<br>• Guarantee continuity of care for routinary emergencies | • AR service<br>• UAV Rapid Triaging system<br>• Thermal scanning system<br>• Early warning and risk assessment service |
| **Bystanders** | PreH:<br>• Basic first aid interventions (under direct supervision from EMS/FFs) | | | • SWAPP (App) |

| | | | | |
|---|---|---|---|---|
| | • Assist with non-medical tasks | | | |
| HS | Hospital:<br>• Casualties' handover from EMS<br>• Triage and clinical management<br>• Resources allocation | | | • Resources and assets optimization service<br>• Diagnosis and Prognosis service |

*Table 9. Tasks – NIT-MR Users spatial localization and Tasks*

## 2.2 User Needs Identification

To cover the full spectrum of user needs, representatives from all key user groups (Nightingale practitioners and UAB members) have continuously been involved in the process, which also entailed a constant interaction with key representatives from technical partners.

The following methodology has been used to elicit user needs and verify requirements:

- 1st End-User Workshop to get insight and perform an in-depth analysis of the user needs for each specific task
- Table-Top Simulation to illustrate the whole chain of mass-casualty management as a base for analysis of further improvements
- Mock-Up sessions to discuss and assess prototypes elaborated by tech partners
- End-Users Round Table to finalize an initial set of requirements based on interdependent tasks (namely task 1.1 "Common denominators and new paradigm of Trauma Care")

### 2.2.1 1st End-Users Workshop

The 1st End Users Workshop was hosted by SAMU on January 17-18, 2022. Due to the unstable and possibly worsening situation related to Covid19 at the time, SAMU together with NIGHTINGALE project coordinators (ICCS), WP1 leader and User coordinator (UPO) and technical partners coordinator (ASTRIAL) decided to hold the workshop in a totally virtual modality using an online platform.

The virtual meeting included user partners, UAB members and key technical partners. During the workshop, a dedicated session to support task 1.5 "User functional and non-functional requirements" has been led by UPO. Participants to the session were asked to discuss about the different components of the NIT – MR in relation to user requirements. The participation of tech partners allowed users to get feedback about tools' program requirements, data requirements and life cycle requirements with a clear understanding of the tools' functionalities and capabilities. The main discussion points that emerged during the two-day session are presented in the Appendix.

### 2.2.2 Table-Top Simulation and NIT-MR Mock up Sessions

 

The Table-Top Simulation and NIT-MR Mock Up Sessions took place at the Karolinska University Hospital in Stockholm (Sweden) on March 21 –23, 2022, hosted by MRMID. The objectives of the event were (a) to illustrate the whole chain of mass-casualty management as a base for analysis of which parts that need to be, and can be, improved, and if so how and (b) to provide a base for discussion on how simulation techniques can be used for scientific analysis and comparative studies of different methods in mass-casualty management.

The Table-Top Simulation included user partners, UAB members and key technical partners as either active participants or guided observers. Following the simulation, a Mock Up Session has been organized and led by the Technical Manager. During the session, technical partners presented some key features of the tools included in the NIT-MR and a discussion was held to debate and assess the components, taking into consideration also the output obtained from the 1st End user Workshop (Appendix B).

### 2.2.3 End-Users Round Table

The End-User Round Table took place in Oslo (Norway) on the 24th and 25th of April 2022 and was hosted by ESTES during the European Congress of Trauma and Emergency Surgery 2022.

The objective of the End-Users Round Table was to discuss results of the translational process performed in the framework of the Task 1.1. "*Common denominators and new paradigm of trauma care*" and to support the Tasks 1.4 and 1.5 in defining scenarios, use cases and user requirements.

The 2-days meeting included User Partners, UAB members and selected technical partners. To support the definition of final User Requirement, a User Requirements Workshop has been organized and led by UPO on day 2. During the Workshop. MCIs tasks identified in the Task Analysis have been discussed amongst the end users and translated into requirements. The MoSCoW prioritization model [13] was applied to prioritize the user requirements gathered in the previous Nightingale activities. The following categories have been used to categorize requirements:

- MUST (M) - Defines a requirement that must be satisfied for the final solution to be acceptable (non-negotiable product needs that are mandatory for the team).
- SHOULD (S) - This is a high-priority requirement that should be included, if possible, within the delivery time frame. Workarounds may be available for such requirements, and they are not usually considered as time-critical or must-haves (important requirement that are not vital but add significant value).
- COULD (C) - This is a desirable or nice-to-have requirement (time and resources permitting), but the solution will still be accepted if the functionality is not included (nice to have requirements that will have a small impact if left out).
- WON'T or WOULD (W) - This represents a requirement that stakeholders want to have but have agreed will not be implemented in the current version of the system. That is, they have decided it will be postponed till the next round of developments (requirements that are not priority for this specific time frame).

 

All Requirements have been listed and prioritised by assigning categories to each (M, S, C or W), then coupled with use cases identified and described in Deliverable 1.6 “Scenarios and Use Cases”. In case multiple stakeholders expressed different opinions on what category to assign to a requirement, voting was used to reach consensus. Figure 5 present a schematic representation of the use cases described in the correspondent task:

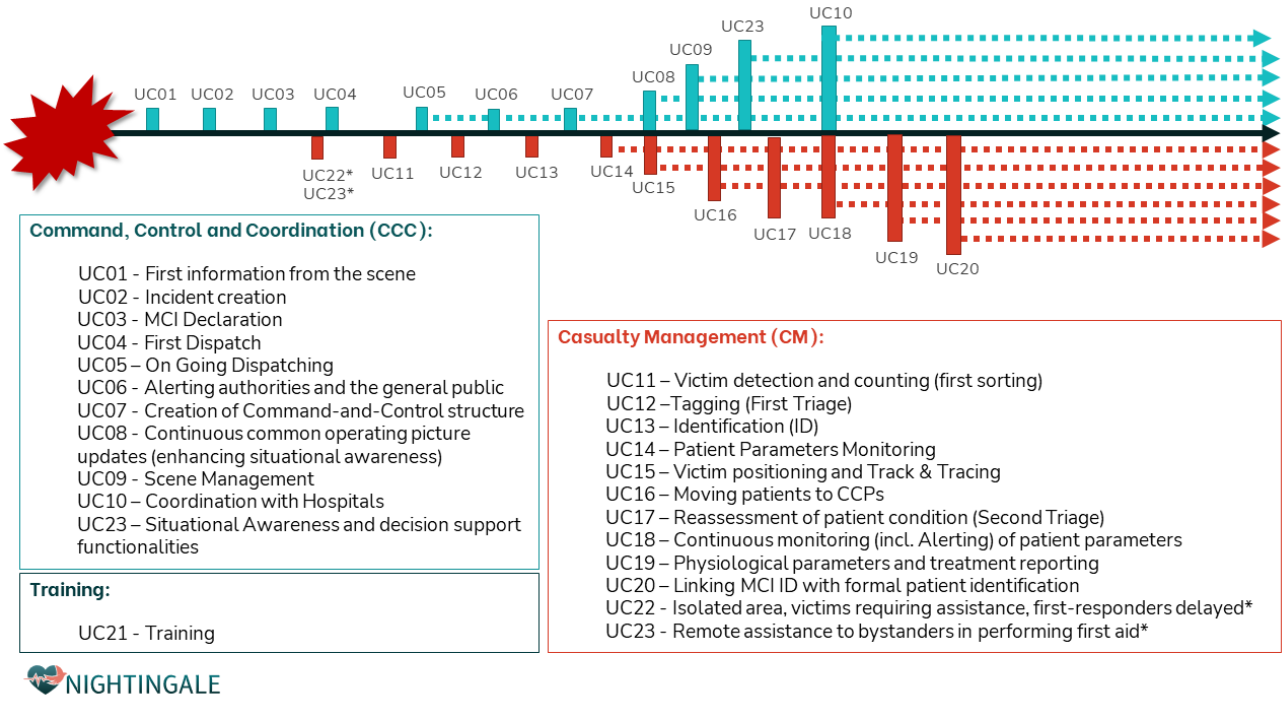


*Figure 5. Nightingale Use Cases (described in D1.6)*

Categorized requirements have been then organized in a readable format and will be reviewed throughout the project as stakeholder needs may evolve with time.

 

# 3 User Requirements Specification

These initial requirements will be validated, elaborated, and detailed in the next project phases through the involvement of users from various target user groups. User requirements have been assigned a unique progressive ID for functional requirements (FR-X) and non-functional requirements (NFR-X). For priority definition, we used the MoSCoW model. Additionally, a reference to Use Cases described in D1.6 has been added.

Initial prioritization has been done based on the NIT-MR objectives, outcome of the forum discussions between Technical and User partners and members of the UAB during 1st End User Workshop, NIT-MR Mock up Sessions, and End-User Round Table. The initial prioritization will be iteratively reviewed during later phases of the project.

Before enlisting the specific FR-X and NFR-X for each tool, general requirements that should be applicable to the NIT-MR as a whole are hereafter presented:

1. The NIT-MR should have statistical advantage over current used modalities
2. The NIT-MR should have affordable costs in terms of development, education and training (to both achieve and maintain competences), storage, deployment, and maintenance (degrade, repair, replace, renewable).
3. The NIT-MR components used in the prehospital settings should have high energy efficiency
4. The NIT-MR components should maintain high performances in different environmental settings (heat/cold, rain, smoke)
5. The NIT-MR should strive to include the most up-to-date technology

## 3.1 Triage Device (bracelet, earplug) and Mobile App

### 3.1.1 Digital Triage Tag, Triage wearable and Vital Signs Wearable

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| FR-1 | Tagging: unique ID number | M | UC11, UC12, UC13 |
| FR-2 | Tagging: colour according to TRIAGE | M | UC12 |
| FR-3 | Tacking & Tracing: geolocalization | M | UC15 |
| FR-4 | Led light integrated | M | UC11, UC15 |
| FR-5 | Continuous monitoring of respiratory rate | M | UC14, UC18 |
| FR-6 | Continuous monitoring of pulse/heart rate | M | UC14, UC18 |
| FR-7 | Continuous monitoring of blood pressure | M | UC14, UC18 |
| FR-8 | Continuous monitoring of skin temperature | S | UC14, UC18 |
| FR-9 | Continuous monitoring of heart rate variability | C | UC14, UC18 |
| FR-10 | Continuous EKG trace | C | UC14, UC18 |
| FR-11 | Alert/notification to indicate patient deterioration | M | UC18 |
| FR-12 | Data storage | M | UC12, UC13, UC14, UC15, UC17 UC18 |
| FR-13 | Possibility to link two or more wearables (e.g., mother and child) | S | UC15, UC20 |
| FR-14 | Functioning under extreme conditions (e.g., fire, storm, ...) | M | |
| NFR-1 | Different behaviour of led light according to casualty/device status (e.g., flashing light as a reminder for reassessment) | C | |
| NFR-2 | Led light visible at fully daylight and for minimum of 10 meters | S | |
| NFR-3 | First triage (sorting) tagging to be done manually on the wearable by FRs (first encounter with the casualty) | M | |
| NFR-4 | Impossibility to change colour manually on the wearable after the first encounter (e.g., not possible for casualties to change the tagging). | M | |
| NFR-5 | Possibility to attach the sensor on the forehead | S | |
| NFR-6 | Configurability according to the specificities of the MCI (location, time, ...): e.g., set off/on specific notification if required | M | |
| NFR-7 | Auto test for malfunctioning and identification of connectivity problems | M | |
| NFR-8 | Max temperature for correct performance: < 35°C | M | |
| NFR-9 | Min temperature for correct performance: > -10°C | M | |
| NFR-10 | Device environmental protection (IP37) Check table in the appendix C. | M | |

*Table 10. Requirements – Digital Triage Tag, Triage wearable and Vital Signs Wearable*

### 3.1.2 Triage and Vital Signs app

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| FR-1 | Possibility to change tagging (colour on the wearable) only thought the APP | M | UC17 |
| FR-2 | Scanning to retrieve data from bracelet | M | UC18, UC19 |

| | | | |
|---|---|---|---|
| **FR-3** | Alert for possible mistakes in performing/recording interventions (e.g., dosage of drugs) | M | UC19 |
| **FR-4** | Data storage | M | UC12, UC13, UC14, UC15, UC17 UC18 |
| **FR-5** | Possibility to take, record and transmit photos of casualties for medical purposes (e.g., injuries, )…) | M | UC19 |
| **NFR-1** | Unique ID assigned to operators that interact with the wearable | M | |
| **NFR-2** | Recording of all the interactions between the Triage App and the wearable | S | |
| **NFR-3** | Different level of access according to type of user (different FRs category) | M | |
| **NFR-4** | Possibility to record using voice to text feature | M | |
| **NFR-5** | Icons specific to all possible interventions | M | |
| **NFR-6** | ABCDE (Airway – Breathing – Circulation – Disability – Exposure) checklist | S | |
| **NFR-7** | User Friendly (hands free option) | S | |

*Table 11. Requirements – Triage and Vital Signs App*

## 3.2 UAV Rapid Triaging System

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| **FR-1** | Ability to provide clear images of an MCI scene (e.g., photography of MCI during daytime and a thermal image during night-time) | M | UC01, UC11, UC14, UC15 |
| **FR-2** | Close approximation in counting of casualties when grouped | M | UC01, UC11 |
| **FR-3** | Map victim location | M | UC01, UC11, UC15 |
| **FR-4** | Real time information transmission | M | UC01, UC11, UC14, UC15 |
| **FR-5** | Identifying the need for life saving intervention | M | UC14 |
| **FR-6** | Movement detection ability (waiving, running, …) | S | UC11, UC15 |
| **FR-7** | Detection of respiratory rate | S | UC14 |
| **FR-8** | Detection of evident external haemorrhaging | S | UC14 |
| **FR-9** | Possibility to detect deployed Triage Device (bracelet) | C | UC11, UC15 |
| **NFR-1** | Fast deployable to the scene of an MCI (transport, set up, …) | M | |
| **NFR-2** | Ability to provide first input from MCI scene within 10-15 minutes from arrival | M | |
| **NFR-3** | Long enough flying capacity (minimum 2 hours) taking into consideration possibility of landings for battery change (max 10 minutes) | M | |
| **NFR-4** | Accessible with minimum personnel (1-2 pax per drone) | S | |
| **NFR-5** | Easy to transport to the scene (e.g., little space consuming in an ambulance) | M | |
| **NFR-6** | Autopilot option | C | |
| **NFR-7** | Standalone communication (in case of communication collapse) | M | |

*Table 12. Requirements – UAV rapid triaging system*

## 3.3 Thermal scanning system

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| FR-1 | Close approximation in counting of casualties when grouped | M | UC01, UC11 |
| FR-2 | Ability to discriminate between adults and children | M | UC01, UC11 |
| FR-3 | Ability to immediately identify bones fractures (in a time frame from 0 to 30 min max from the fracture) | S | UC14, UC17, UC18 |
| FR-4 | Possibility to detect "core" body temperature | M | |
| FR-5 | Data storage | S | |
| NFR-1 | Possibility to have portable (mobile) and fix scanners | M | |
| NFR-2 | Battery enabled (if no power available) >= 4hrs | M | |
| NFR-3 | Resilient to extreme conditions (waterproof, dustproof) | M | |
| NFR-4 | Ability to adjust to external temperature when scanning | M | |
| NFR-5 | Connected to Triage Device | S | |

*Table 13. Requirements – Thermal Scanning System*

*Brief Synthesis of the Ongoing discussion on Thermal Scanning and End User Requirements for this tool/tools*

The concept of the utility of thermographic scanning in MCI has been extensively discussed among User Partners and UAB members, as it is foreseen in task 2.3 Development and Prototyping of Rapid and Wide Area Triage Services in the air and on the ground. It has been identified that the measurement of body temperature has a vital importance in triage in specific situations: it makes possible to do triage in hypothermic patients more efficiently, identifying those being in the risk zone for poikilothermy (below 28°C), which should have high priority [2]. Note that it is a misconception that hypothermia (body temperature below 35°C) only occurs in cold environment. Severely injured patients lying flat on the ground can become hypothermic in temperatures far above zero centigrade, that occurs in all parts of the world. In a bleeding patient in circulatory shock, low body temperature is one of the most dangerous threats and can rapidly lead to irreversible shock. To detect low body temperature and keep the patient warm can be of the outmost importance. When we refer to hypothermia we are talking about the "core" body temperature, i.e., the temperature inside the body that can be measured in the mouth or in the ear, or in the anus, not on the naked skin. On the naked skin the temperature is always lower than inside the body and the difference between core and skin temperature is variable in dependence of external temperature, wind, moisture, sun, or shade, etc. Moreover, in case of shock where the measure should be more valuable from the medical point of view, the body reaction is to deviate the blood from the skin to the internal organ (vasoconstriction) so that the temperature on the surface declines. Since the thermal camera can measure only skin temperature, it's not so useful for this purpose. Moreover, when engineers speak about "corrections" to calculate the internal temperature from that of the skin (or from the canthus of the eye), it's doubtful that this is reliable considering the great variability of conditions in the MCIs. The possibility of reliably measuring the core body temperature is under investigation by the lead beneficiary of the thermographic scanning component of NIGHTINGALE (LDO).

Another possibility proposed by the technical partners was the identification of limb fractures. Nevertheless, diagnosis of limb fractures is not perceived as a major issue on the scene of an MCI by

 

end-users. The limb fractures of importance for the triage are (a) the open fractures and (b) the dislocated, and those any responder can see. Suspected non-dislocated closed fractures should be transported stabilized, but not with high priority. Diagnosis of fractures from thermal scanning is a promising alternative to conventional radiography in constrained resource settings, however the method has not been at the moment validated. Validation of the method would require extensive clinical trials (to train the AI), which are outside the scope of the NIGHTINGALE project. Nonetheless, LDO is considering whether it might be possible to initiate a parallel clinical trial with external funding that could envision active participation of User Partners, the results of which might be informative for the NIGHTINGALE project.

In addition, based on the interactions and analysis performed up to now, it is currently unclear if and how wide area rapid thermographic scanning could be incorporated effectively in NIGHTINGALE use cases. Given these considerations the thermographic scanning component of NIT-MR will be subject to further investigation, and updated information will be provided in subsequent deliverables and in the context of the project periodic reports. The NIGHTINGALE User Partners and UAB members will support this process; in the meantime, they have discussed and listed several FRs and NFRs hereafter reported and connected to the NIT-MR Use Cases described in D1.6, so as to respond to the NIGHTINGALE GA stipulations, with the awareness that such requirements might experience extensive revisions in the upcoming months of the Project.

## 3.4 AR service

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| FR-1 | Compass and direction of FRs inside and MCI scenario | M | UC08, UC15 |
| FR-2 | Receive hazard warnings | M | UC08 |
| FR-3 | Data storage (scene footage) | S | UC08 |
| NFR-1 | Possibility to visualize distance markers (e.g., distance of casualties from FRs) | C | |
| NFR-2 | Possibility to manually lock some patient data for continuous monitoring | S | |
| NFR-3 | Possibility to receive inputs from Triage Devices | S | |
| NFR-4 | Possibility to receive remote instruction/suggestions/indications in case of help (e.g., illustration guidelines and voice support) | C | |
| NFR-5 | Comfortable to wear | M | |
| NFR-6 | Reusable (sterilizable) | M | |
| NFR-7 | Resilient to extreme conditions (waterproof, dustproof) | M | |
| NFR-8 | Portable recharging base | S | |
| NFR-9 | Removable battery | S | |
| NFR-10 | Long enough battery life (min 4-5 hours) | M | |

*Table 14. Requirements – AR service*

## 3.5 SWAPP (App)

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **FR-1** | Perform emergency calls to PSAP, supporting traditional (audio) and multimedia (video, audio and/or chat) forms. | M | UC01, UC02, UC03 |
| **FR-2** | Support sharing footage to PSAP (max pre-recoding time 5 hours) | M | UC01, UC02, UC03 |
| **FR-3** | Support reverse 112 communication (e.g., messages/notification issued by the PSAP) | M | UC22, UC23 |
| **FR-4** | Provide a template for information reporting/recording (e.g., METHANE) | S | UC01, UC02, UC03 |
| **FR-5** | First aid educational material available online and offline | S | UC23 |
| **FR-6** | Ability to receive public alert through official channels of communication (e.g., Civil Protection, …) | M | |
| **FR-7** | Ability to receive information messages issued by public authorities (e.g., location of shelters, medical posts, …) | M | |
| **NFR-1** | Optional pre-registration | M | |
| **NFR-2** | Allow citizens to submit their competences upon registration (CPR courses, first aid, …) | M | |
| **NFR-3** | Validation of registered citizen by SWAPP administrators | M | |
| **NFR-4** | Allow citizen to submit their personal data | M | |
| **NFR-5** | Possibility to share user location to the PSAP (subject to user consent) during an MCI | M | |
| **NFR-6** | Possibility to share personal information (including medical data) to the PSAP (subject to user consent) during and MCI | C | |
| **NFR-7** | Possibility to express willingness to donate blood and to be directed to the nearest hospital during and MCI | S | |
| **NFR-8** | Possibility to filter the footage received at the PSAP level | S | |
| **NFR-9** | Group creation for information sharing (family groups, friends' groups) | S | |
| **NFR-10** | Pan-European support (via PEMEA protocol) | M | |
| **NFR-11** | Support offline mode: peer-to-peer citizen-to-citizen communication | M | |
| **NFR-12** | Support community building and citizen-based specialized support in offline mode (refers to the ability to search and discover citizen with certified capabilities, like CPR, first aid, …) | M | |

*Table 15. Requirements – SWAPP (App)*

## 3.6 Diagnosis and Prognosis service

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| **FR-1** | AI to consider patients' vital trends | M | UC14, UC17, UC19 |
| **FR-2** | AI to consider patient changes in triage status | M | UC14, UC17, UC19 |
| **FR-3** | Alert in case of patient deterioration | M | UC14, UC17, UC19 |
| **FR-4** | Support decision-making process on treatment (prehospital damage control and lifesaving interventions) | M | UC14, UC17, UC19 |
| **FR-5** | Support decision-making on patient distribution matrix (priority transportation) | M | UC16 |

| | | | |
|---|---|---|---|
| NFR-1 | Connected to Triage Device | M | |
| NFR-2 | Include patient medical history in the algorithm | W | |
| NFR-3 | Connected to the Resource and assets optimization service | C | |
| NFR-4 | Possibility to switch from automatic to manual mode | C | |

*Table 16. Requirements – Diagnosis and Prognosis service*

## 3.7 Resources and assets optimization service

At present, the resource and assets optimization service envisioned by CERTH features 3 different modules, including respectively MCI triage and patient allocation to different hospitals, ED bed allocations and task allocation to patients. As the latter will revolve around in-hospital management of MCI casualties, Users and UAB members decided to concentrate their effort in extracting requirements related to MCI triage and patient allocation to different hospital, in line with the NIT-MR context of use and overall objective. Nonetheless, the expansion of the resource and assets optimizations inside the Emergency Department will be examined in the future by the consortium.

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| FR-1 | Possibility to store and map available preH resources in a predefined area (Ambulances, helicopter, tents…) | M | UC04, UC10 |
| FR-2 | Possibility to store and map available infrastructures (Roads, railways, shelters…) | M | UC04, UC10 |
| FR-3 | Possibility to store and map available hospital resources (Beds, staff, materials…) | M | UC04, UC10 |
| FR-4 | Possibility to manually update preH resources in a predefined area (Ambulances, helicopter, tents…) | M | UC05, UC10 |
| FR-5 | Possibility to manually update infrastructures (Roads, railways, shelters…) | M | UC05, UC10 |
| FR-6 | Possibility to manually update hospital resources (Beds, staff, materials…) | M | UC05, UC10 |
| FR-7 | Optimization of the casualty distribution matrix existing in the hospital network of each jurisdiction | S | UC10 |
| FR-8 | Direct interaction with the Emergency Department (ED) | M | UC04 |
| FR-9 | Data storage (for post-incident analysis) | C | |
| NFR-1 | All hospitals should be coordinated with the rest components of the system | M | |
| NFR-2 | Possibility to customize and limit accessibility to the system by different users | S | |

*Table 17. Requirements – Resource and Assets optimization service*

## 3.8 C3&IMS, C3&IMS App and C3&IMS CAD

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| FR-1 | Record/Store data and operators | M | UC08 |
| FR-2 | Estimate the number of users in a designated area | S | UC08 |
| NFR-1 | Smart engine/AI to be able to aggregate and analyse information from different platforms | M | |

| | | | |
|---|---|---|---|
| **NFR-2** | Access permits to different layers | M | |
| **NFR-3** | Graphic information | M | |
| **NFR-4** | Cybersecurity | M | |
| **NFR-5** | Back-up system | M | |
| **NFR-6** | Analyse and provide inputs/outputs from and to social media | C | UC06 |
| **NFR-7** | Easily expandable to non-traditional users (e.g., outside the normal referral system) | M | |
| **NFR-8** | Integration with other system in place | M | UC06 |

*Table 18. Requirements – C3&IMS, C3&IMS App and C3&IMS CAD.*

## 3.9 Scenario Builder

| Req ID | Description | Priority | Ref. to Use Cases |
|---|---|---|---|
| **FR-1** | Multiple incident type design | M | UC21 |
| **FR-2** | Include press communication feature | S | UC21 |
| **FR-3** | Include strategic, tactical, operational levels | M | UC21 |
| **FR-4** | Real time supervision from instructors | M | UC21 |
| **FR-5** | Timeline representation | M | UC21 |
| **FR-6** | Include a variety of MCI triage systems | M | UC21 |
| **FR-7** | Evaluation of trainees' performance | M | UC21 |
| **NFR-1** | Multiple language function | S | |
| **NFR-2** | Automatically connects to/scrape incident event data from publicly available database to inform the scenario | C | |
| **NFR-3** | Manual adjustment of scenario by users | M | |
| **NFR-4** | Includes all/gaming technology to allow multiple scenario output based on injects | W | |
| **NFR-5** | Usable by multiple agencies | M | |
| **NFR-6** | Simple and user friendly | M | |
| **NFR-7** | Possibility to manually change the resources/setting according to the scenario progressing | S | |
| **NFR-8** | Include mapping | M | |
| **NFR-9** | Possibility to include meteorological factors | S | |
| **NFR-10** | Scenario to be exported in a file | M | |
| **NFR-11** | Compatible with different operating systems (Apple and Microsoft) | M | |
| **NFR-12** | Record treatment interventions and triage tagging | S | |

*Table 18. Requirements – Scenario Builder*

# Conclusions

The deliverable presented the methodology adopted to exploit the expertise of NIGHTINGALE Practitioners and extract functional and non-functional requirements of the NIT-MR. The four steps of information gathering (including context of use, users, and task analysis), users' needs identification, envisioning and user requirements specification have been presented. The initial set of requirements will guide the technical development of the different component of the NIT-MR, while the list of requirements will be iteratively updated in the different phase of prototyping, testing and validation of the Toolkit.

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# Appendices

### Appendix A

Main discussion points that emerged during the 1st End-User Workshop

| NIT-MR Component (Terms used in DoA) | Discussion Points |
|---|---|
| Triage Device (bracelet, earplug, and Mobile App) | • Integration of GPS and tracking features<br>• Importance of a unique patient number to allow patient traceability<br>• Possibility to integrate Airtags and RFIDs<br>• Possibility to integrate a "voice-to-text" feature<br>• Importance to allow FRs to work "hands free"<br>• Importance of testing the tool in selected Emergency Departments (logistic and framework of action to be provided by User Partners) to understand the reliability in assessing vitals in patient with hemodynamic shock<br>• Importance of embracing the different needs of different FRs, including non-medical<br>• Prioritisation of biometrics to be gathered by the tool<br>• Possibility of assessing mental status of patients using the tool |
| UAV based Rapid Triaging, and Documentation System | • Possibility of using UAV to transport equipment<br>• Possibility of having different customized UAV with different functions<br>• Importance of patient location within the scene<br>• Legal considerations related to the use of drones in each European jurisdiction<br>• Possibility of using UAV to convey commands, announcements, and instructions for the injured people around an incident scene |
| Wide area rapid thermographic scanning | • Possibility to identify casualties under rubbles<br>• Possibility to integrate thermal cameras on smartphones vs installing fixed cameras on scene<br>• Importance of assessing pelvis fractures while triaging patients in the scene |
| Augmented Reality | • Remote assistance upon request from ICs, especially in remote settings<br>• Possibility to visualize patients' vitals<br>• Possibility of using AR for training purposes<br>• Discussion on type of users that could benefit from the tool (ICs vs all FRs) |
| SWAPP APP | • Possibility of adding a checklist that can be filled by citizens on scene to provide information to the Command Centre before the arrival of EMS |

| | |
|---|---|
| | • Importance to filter important messages among the overload of data received by Public Safe Answering Points (PSAPs) though the APP<br>• Legal consideration related to the action of bystanders during the response of an MCI |
| Damage Control and AI-based diagnosis and prognosis | • Importance of early detection of deterioration of vitals |
| Resource and assets optimization | • Data access and data exchange between different agencies (major challenge)<br>• Dedicated personnel will be needed to guarantee efficiency of the system<br>• Importance of having "real time" data<br>• Type of data needed: available rooms in the Emergency Department (ED), ED staff, Intensive Care Unit (ICU) and ventilators availability, Operation Theatres (OT) availability, expertise of the receiving hospital |

## Appendix B

Main discussion points that emerged during the Mock-up session:

| NIT-MR Component (Terms used in DoA) | Discussion Points |
|---|---|
| Triage Device (bracelet, earplug, and Mobile App) | • Importance of obtaining real time monitoring of patient vitals<br>• Possibility to change the triage colour code applied<br>• Possibility to obtain warning signals when patient's vitals are deteriorating<br>• Reinforcement of the importance of having a unique identification/patient number to allow for patient traceability<br>• Casualties' interaction with the tool: patient should not be able to exchange the Device nor to change the triage colour code applied by the FRs<br>• Emphasis on the importance of obtaining position of patient at any given time (Map visualization)<br>• Ruggedization vs non reusable Triage Device<br>• Importance of having a wearable Device to be applied either on upper or lower extremities |
| UAV based Rapid Triaging, and Documentation System | • Situation awareness: discussion on the level of accuracy required in counting casualties and determine the exact position<br>• Integration of thermal cameras<br>• Possibility to integrate an AI feature to Triage (e.g., counting of breaths)<br>• Importance of extending the UAV time of flying (currently 20 minutes) |

| | |
|---|---|
| | • Definition of Users that will be flying the drones (Police forces according to specific flying regulations) |
| Wide area rapid thermographic scanning | • Importance of taking into consideration external environmental temperature/condition<br>• Possibility to detect hypothermic patients with 1 degree sensitivity<br>• Possibility to test the device in hospital settings<br>• Possibility to detect active bleedings in the abdominal cavity |
| Augmented Reality | • Importance of integrating a checklist (assets to be sent to the scene)<br>• Identification of primary actors: Incident Commanders |
| SWAPP APP | • Online and Offline mode<br>• Possibility of educational material to be provided by the APP<br>• Possibility to have a registration/certification feature for volunteers<br>• Importance of sharing sensitive information within a legal and GDPR framework<br>• Sinergy with other NIT-MR devices |
| Damage Control and AI-based diagnosis and prognosis | • Possibility to integrate existing database (Trauma Registry?)<br>• Importance of input in the system information on pre-existing patients' conditions and treatment performed |
| Resource and assets optimization | • Need to integrate details on treatment task duration details, incoming patient time details and specific resources/assets that can be defined by users<br>• Importance of having dynamic updates in the system<br>• Importance of integrate examples of early warning, risks, and alerts |
| Scenario Builder | • Possibility to integrate a feature for patient deterioration<br>• Possibility to integrate messages from social media and TV announcement |

## Appendix C

Index of Protection rating chart.

| Level | Solids | Liquids |
|---|---|---|
| 1 | Protected against solid objects over 50mm (example: hands). | Protected against vertically falling drops of water. |
| 2 | Protected against solid objects over 12mm (example: fingers). | Protected against direct sprays of water up to 15 degrees from the vertical. |
| 3 | Protected against solid objects over 2.5mm (example: tools and wires). | Protected against direct sprays of water up to 60 degrees from the vertical. |

| | | |
|---|---|---|
| 4 | Protected against solid objects over 1mm (example: small wires). | Protected against water sprayed from all directions. |
| 5 | Dust protected — limited ingress of dust permitted. | Protected against jets of water from all directions. |
| 6 | Dust-tight — no ingress of dust permitted. | Protected against powerful jets of water from all directions. |
| 7 | / | Protected against the effects of immersion in water — between 15 cm (5.9 inches) and 1 meter (3.3 feet) for up to 30 minutes. |
| 8 | / | Protected against the effects of long periods of immersion in water under pressure. Usually 1.5 meters (4.9 feet) of immersion for up to 30 minutes. |