Scenario and Use Cases

D1.6

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NIGHTINGALE

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HISTORY OF CHANGES

Version	Date	Changes
0.1	20.03.2022	Table of Contents
0.2	23.05.2022	Initial version
0.3	26.05.2022	Internal review during technical meeting In Novara, Italy
0.4	21.06.2022	Revised Draft
0.5	28.06.2022	2nd Internal Review Completed
1.0	31.08.2022	Consolidation and final draft

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1		INSTITUTE OF COMMUNICATION AND COMPUTER SYSTEMS	ICCS	Greece
2		TOTALFORSVARETS FORSKNINGSINSTITUT	FOI	Sweden
3		LEONARDO – SOCIETA PER AZIONI	LDO	Italy
4		C4CONTROLS LTD *[TERMINATED]*	C4C *[TERMINATED]*	UK *[TERMINATED]*
5		NETCOMPANY-INTRASOFT	INTRA	Luxembourg
6		INOV INSTITUTO DE ENGENHARIA DE SISTEMAS E COMPUTADORES, INOVACAO	INOV	Portugal
7		EXUS SOFTWARE MONOPROSOPI ETAIRIA PERIORISMENIS EVTHINIS	EXUS	Greece
8		UNIVERSITAT POLITECNICA DE VALENCIA	UPV	Spain
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10		DEVERYWARE	DW	France
11		PARTICLE SUMMARY	PARTICLE	Portugal
12		TREE TECHNOLOGY SA	TREE	Spain
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LIST OF ABBREVIATIONS

Abbreviation	Definition
AI	Artificial Intelligence
ALS	Advanced Life Support
AMP	Advance Medical Post
App	Application
AR	Augmented Reality
BLS	Basic Life Support
C3	Command, Control and Coordination
CBRN	Chemical, biological, radiological and nuclear
CCPs	Casualty collecting points
COP	Common Operational Picture
DoA	Description of Action
ECCs	Emergency Communications Centres
ED	Emergency Department
EMDM	European Master in Disaster Medicine
EMS	Emergency Medical Services/System
EMS-MOC	Emergency Medical Service - Metropolitan Operative Center
EOCs	Emergency Operation Centres
EU	European Union
FRs	First Responders
GA	Grant Agreement
GDPR	General Data Protection Regulation
GPS	Global Positioning System
ICS	Incident Command System
ICU	Intensive Care Unit
IMS	Incident Management System
KPI	Key Performance Indicator
MCIs	Mass Casualty Incidents
METHANE	Major Incident Declared, Exact location, Type of incident, Hazards, Access, Number and type of casualties, Emergency services present and required
Mx	Month x of the project

NIT-MR	Novel Integrated Toolkit for Emergency Medical Response
OT	Operation Theatres
PPK	Post Processing Kinematic
PSAPs	Public Safe Answering Points
Public G&A	Public Governance & Administration
RFIDs	Radio Frequency Identification
RTK	Real Time Kinematic
TCCC	Tactical Combat Casualty Care
TECC	Tactical Emergency Casualty Care
TEMS	Tactical Emergency Medical Support
UAB	User Advisory Board
UAV	Unmanned Aerial Vehicle
WP	Work package

Executive Summary

The NIGHTINGALE project aims to develop, integrate, test, deploy, demonstrate, and validate a Novel Integrated Toolkit for Emergency Medical Response (NIT-MR) comprising a multitude of tools and applications at the service of all first responders (FRs), emergency medical services and non-medical civil protection agencies, which will ensure an upgrade to Pre-hospital life support and Triage during Mass Casualty Incidents (MCIs).

The present deliverable has been prepared in the context Task 1.4 *Overarching scenarios, definition of use cases and testing and validation activities specific planning*, of NIGHTINGALE Work Package (WP) 1*, Practitioners Needs & Toolkit Architecture and Design*. The main objective of the deliverable is to present the first version of the scenarios and use cases in NIGHTINGALE, which, along with corresponding user requirements in deliverable D1.8 *User functional and non-functional requirements*, will drive the development, testing, and validation activities of the project. The deliverable is informed also by other activities in WP1, such as the definition of common denominators for triage protocols, damage control and prehospitalization processes, the consideration of the social, legal, and ethical landscape for MCI handling, the state-of-the-art analysis of technologies used in MCIs, and the design and architecture of the NIT-MR toolkit.

Within this document we describe the range and extent of MCIs and their potential effect on the human body. We analyse several scenarios from real life MCIs in order to be used as frameworks to illustrate possible applications of the NIT-MR technologies through the construction of relevant use cases. The Nightingale Toolkit will be developed, iteratively tested, and validated according to the defined scenarios and use cases. This methodology is part of our objective to test and validate the toolkit in progressively more realistic settings, along the pathway from laboratory testing and tabletop exercises to small scale exercises and finally two full scale exercises; the first planned to take place in Savona in Northern Italy and the second in or near to Paris in France, towards the end of the project. The definition of scenarios and use cases constitutes a work of dynamic nature, which will be continuously updated and refined throughout the project lifetime, as the development, testing and validation work proceeds.

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1 Introduction

Mass Casualty Incidents (MCIs) are increasing in frequency and are by their nature unpredictable and diverse. The definition of an MCI event varies; nevertheless, common ground can be found on the principle that the number of casualties out-strips the available resources. Some MCI will put severe pressure on resources and the Emergency Medical Services (EMS) may be overwhelmed.

Two general types of MCI occur; those related to extreme weather events (e.g., storms, flooding, droughts) or seismic hazards (volcanos and earthquakes), and those that are induced by the human [1]. Human activity can equally have an influence on the severity of the former, for example deforestation and soil subsidence during heavy rains.

Preparation for MCIs is complex and requires a multidisciplinary approach with a high level of preparedness and training. Preparedness requires both the out-of-hospital and in-hospital planning and integration of both the EMS and the Hospital Services. Robust triage systems and communication networks are required so that the treatment and evacuation of casualties can be done efficiently and effectively [2]. EMS capacity must be expandable, and a plan is needed for surge capacity which will ensure greater provision for casualties. Paediatric casualties have a particular place in the provision of specialist services as paediatric casualties have particular needs.

Effective communication is an integral part of an MCI response [2]. All the actors need to be able to work together and within each EMS communication is vital to best organise scarce resources. From triage to the distribution of casualties in the operating theatres or hospital beds, decisions need to be relayed with the minimum of difficulty and the maximum of accuracy. Uncoordinated actions or erroneous communications can turn what would otherwise have been an effective MCI response into a failure [2]. MCIs generate extreme stress of existing communication networks; for example, mobile phone coverage was lost after the 2017 Manchester Arena Bombing [3], and during the 2013 Boston Marathon Bombing the police decided to shut down the mobile phone networks [4].

Emergency Service Responders are also potentially the target of malevolent attacks that seek to confuse and dissimulate their efforts [5]. This can either be by creating false alerts of by direct attacks on the EMS themselves during their responses. The safety and security of EMS responders is not only important itself but ensures an effective response.

Training is an integral part of any MCI response. Although the frequency of MCIs is increasing the young age of many personnel means that many members of EMS teams will not participate in an MCI in a calendar year. Tabletop exercises (TTX) and small- or full-scale exercises (SSX, FSX) are often used to ensure a maximum level of preparedness [6]. Finally, audit and research are a common feature of MCIs reflections and is an integral part of the preparation for a future generation of MCIs.

It is the interaction of several components that defines a successful, or unsuccessful, MCI response. The failure of any one component in the MCI response can be critical for the rest but more importantly the failure of integration of the components as a whole can have a severely detrimental effect.

The NIGHTINGALE project seeks to create a paradigm for interventions of the EMS in MCIs. The NIGHTINGALE project will 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 EMS 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 NIT-MR will comprise a multitude of tools and applications. Each component of the project technology is interlinked but many components will be able to function autonomously as well. The scope of the technology means that the search and rescue capabilities, triage, transport and hospital access for casualties will be modernised and enhanced by new technologies which are able to go beyond any existing tools currently available. Whilst the emphasis of the Nightingale project is primarily out-of-hospital, Nightingale technologies will interdigitate with the hospital environment.

Above and beyond each individual technology Nightingale offers an integrated approach whereby the technologies will communicate, where necessary and where possible, with each other. The sum of the parts shall be greater than the whole.

1.1 Relation with NIGHTINGALE GA requirements and other tasks of the project

The work presented in this deliverable has been performed in the context of Task 1.4 Overarching scenarios, definition of use cases and testing and validation activities specific planning, of Work Package (WP) 1, Practitioners Needs & Toolkit Architecture and Design. The main objective of this deliverable is to present the first version of scenarios and use cases of the Nightingale Toolkit, which, along with corresponding user requirements (Deliverable D1.8 User functional and non-functional requirements, M10, Task 1.5 Definition of functional and non-functional user requirements), will drive technical development, testing, and validation activities of the project in work packages 2-5. The deliverable takes also as an input the work performed 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 1.6** *Technical Requirements, Specifications and Toolkit Architecture*: for developing use cases in line with the design and architecture of the NIT-MR toolkit.

Error! Reference source not found. presents the relation of the contents of this deliverable with NIGHTINGALE Grant Agreement (GA) requirements within the Task 1.4.

Table 1. Relation of the contents of the deliverable with NIGHTINGALE GA requirements

Task 1.4 in NIGHTINGALE GA	Section(s) of D1.6
"…the NIGHTINGALE practitioners will define overarching multi-hazard mass casualty scenarios…"	Section 3
"…coupling them with emergency medical response tool's usability and operational framework developed"	Section 3
"The scenarios will be further elaborated with use cases where NIGHTINGALE Toolkit supports operations"	Section 4
"…this task includes the realisation of the 1st Workshop and the 1st TTX"…." The former is meant to bring together practitioners for progressing on work of T1.4 and T1.5, whilst the latter shall allow users and technical partners to train over a TTX that will include mock-up versions (presentations or available tools with limited functionalities) of the entirety of NIGHTINGALE NIT-MR over a realistic MCI scenario so that needs and gaps are identified and the added value of the novel tools of the project are thoroughly comprehended."	Sections 5 and 6
"… this task will deliver TTXs, LITs, SSXs and FSXs' specific planning (following the integration, testing and validation plan and timeline) sketching field set-up, deployment of teams and utilisation of tools and services of the NIGHTINGALE toolkit in realistic conditions."	Section 7

The rest of the document is organised as follows:

Section 2 starts with an overview of the approach that has been followed in order to develop the NIGHTINGALE scenarios and use cases, in tight connection with the work performed for the definition of user requirements. The section continues with the presentation of MCI-relevant terminology and the classification of MCIs according to the type of an event. An overview of the anticipated types of injuries in an MCI is also presented.

Section 3 deals with the MCI scenarios of NIGHTINGALE. The approach that has been adopted involves the study and analysis of real past MCI events, as well as a FSX conducted in the context of the European Master in Disaster Medicine (EMDM), to analyse capability gaps and link the NIGHTINGALE technologies with candidate areas for improvement. The selected MCIs can serve as frameworks to illustrate the application of the NIGHTINGALE technologies, through the construction of relevant use cases. The use cases that have been defined up to this stage of the project are presented in **Section 4**, clustered into two main categories: 1) Command, Control and Coordination use cases and 2) Casualties Management use cases. The template that has been used for each use case includes the title of the use case, the event that triggers the use case, involved actors and actions performed by them, the components of the NIT-MR that are involved in the use case, their relevant functionalities and generated outputs, as well as connected NIT_MR components and any identified technical constraints. The link to related end user requirements is also provided.

Sections 5 and 6 constitute reports from the NIGHTINGALE 1st end user workshop and 1st Tabletop Exercise, respectively. These two events have been important opportunities to advance the work presented in this deliverable.

The deliverable also includes information about the activities performed up to now for the planning of the two NIGHTINGALE full-scale exercises (FSX) (**section 7**).

Finally, the **Conclusions** section briefly summarizes the main outcomes of the performed work with an emphasis on its dynamic nature and the intention to consider the present deliverable as a living document which will be updated and refined throughout the project lifetime as the development, testing and validation work continues. The final version of scenarios and use cases will be presented in deliverable D1.7 *Final Scenarios and Use Cases & Exercise planning* (M34).

2 Setting the scene – Methodology, MCI-related terminology

2.1 Brief overview of the adopted approach

As detailed in the subsequent sections, the overall approach that has been adopted to develop the NIGHTINGALE scenarios and use cases can be characterised by the following main principles:

- Development of scenarios and use cases in tight connection with the work performed for the definition of user requirements

- Definition of scenarios that are at the same time as representative as possible of different types of MCIs and relevant to the foreseen functionalities of the NIT-MR components

- Consideration of lessons learnt from real-life past MCIs to link the NIT-MR components functionalities with identified capability gaps and areas of potential improvement.

2.2 What is a Mass Casualty Incident?

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 [7]. As such, MCIs are It 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 [7]. Clearly the disposition of existing resources is highly variable according to the country and the location within that country. Resources are usually highly concentrated in urban areas and more sparsely is rural areas.

2.3 Classification of MCIs according to Type of Event

MCIs can result from two major types of events, extreme weather/seismic events, or human-induced hazards [1]. Whilst there is a difference in the way they are generated there are many similarities is the kinds of physical injury that they generate and the response of the EMS. Each type can have different forms thus needs different strategies of management (Figure 1). The following paragraphs provide definitions and more details for the various types of events.

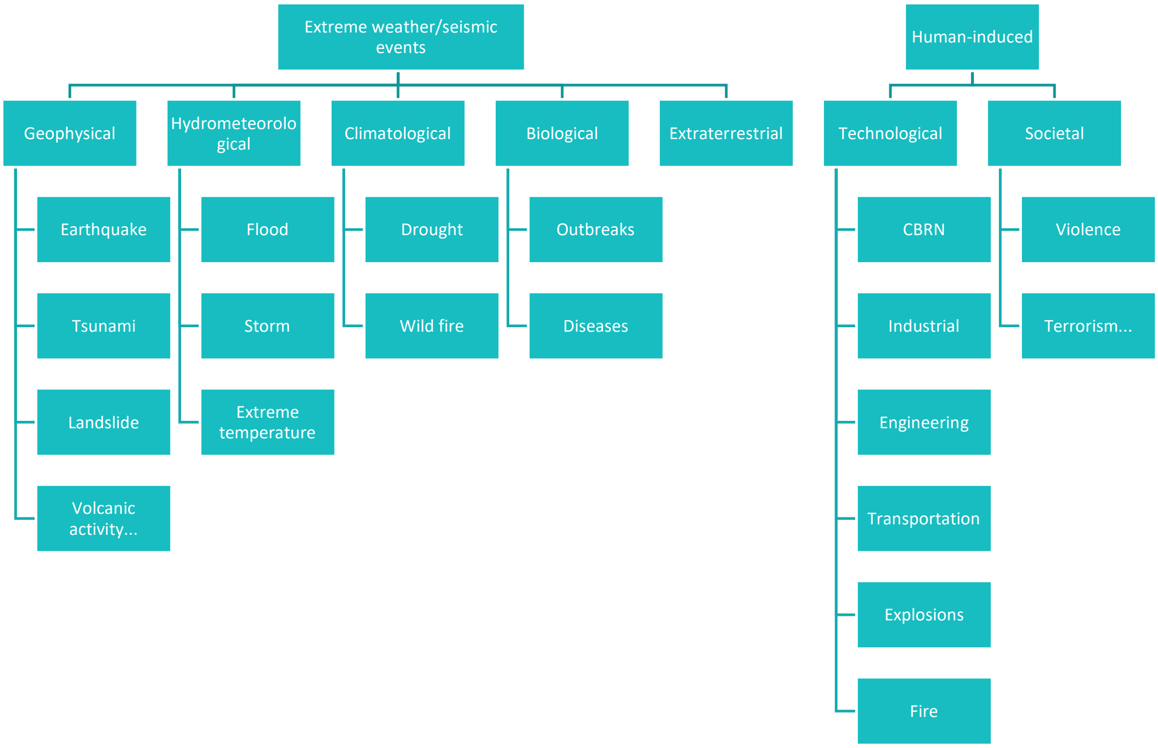

Figure 1. Types of hazards generating an MCI.

2.3.1 Extreme weather/seismic events

Geophysical hazards

These hazards originate from processes that are out of direct control of humans. Examples are earthquakes, volcanic activity and emissions, and related geophysical processes such as mass movements, landslides, rockslides, collapse of soil and rock surfaces and debris or mud slides.

Earthquakes*:* a sudden and rapid shaking of the ground caused by the shifting of rocks beneath the earth's surface, or by volcanic or magmatic activity in the earth. Earthquakes strike without warning and can occur at any time. They can lead to death, injuries, property damage, loss of shelter and livelihoods and disruption of critical infrastructure. Most deaths are due to buildings collapsing or to secondary hazards, such as fires, tsunamis, flooding, landslides and release of chemicals or toxic materials.

Tsunami: a sea wave triggered by a large-scale displacement of the sea floor. They are most commonly caused by earthquakes but can also be caused by major underwater (or 'submarine') landslides or volcanic eruptions. They can strike any coast at any time. Tsunamis can move quickly across the open ocean and can hit land with waves higher than 20 metres. Water can wash inland for several kilometres in flat lying areas and move up streams and rivers, destroying everything in its path. Waves may continue to strike the shoreline for many hours and dangerous currents can continue for several days.

***Landslides**:* mass movement of rock, debris, earth, or mud down a slope. Landslides are caused by gravity and are usually precipitated by rainfall, earthquakes, volcanic eruptions, groundwater pressure, erosion, destabilization of slopes as a result of deforestation, cultivation and construction, and snow or glacial melt or a combination of these factors. Debris flows, or mudflows, are fast-moving landslides that are especially dangerous due to their speed and volume.

***Volcanic activity**:* A volcano is an opening or rupture in the earth's surface that allows magma (hot liquid and semi-liquid rock), volcanic ash and gases to escape. They are generally found where tectonic plates come together or separate, but they can also occur in the middle of plates due to volcanic hotspots. A volcanic eruption is when lava and gas are released from a volcano—sometimes explosively. The most dangerous type of eruption is called a 'glowing avalanche' which is when freshly erupted magma flows down the sides of a volcano. They can travel quickly and reach temperatures of up to 1,200 degrees Fahrenheit. Other hazards include falling ash, and lahars (mud or debris flows).

Hydrometeorological hazards

These hazards are of atmospheric, hydrological, or oceanographic origin. Examples are tropical cyclones (also known as typhoons and hurricanes); floods, including flash floods; heatwaves and cold spells; and coastal storm surges. Hydrometeorological conditions may also be a factor in other hazards such as landslides, wildland fires, epidemics and in the transport and dispersal of toxic substances and material from volcanic eruptions.

***Floods**:* are when water overflows from the normal boundaries of a stream, river or other body of water or accumulates in an area. There are two main types of floods: inundation floods are slow, developing over hours or days, while flash floods occur suddenly, often without warning, usually due to heavy rain. Though annual flooding is a natural phenomenon in many parts of the world, human habitation and land-use practices have led to an increase in frequency and magnitude of floods. Floods are also predicted to become even more frequent and severe in future due to climate change. Flooding can be dangerous and cause massive human, environmental and material damage to communities.

***Hailstorms**:* Hail is a type of solid rain made up of balls or lumps of ice. Storms that produce hail which reaches the ground are known as hailstorms. They typically last for no more than 15 minutes but can cause injuries to people and damage buildings, vehicles and crops. When hail builds up it can cause a loss of power lines, bring down trees and cause flash floods and mudslides in steep areas. Hailstorms can sometimes be accompanied by other severe weather events, such as cyclones and tornadoes. On rare occasions, massive hailstones have been known to cause concussion and even fatal head injuries.

***Cyclones**:* Tropical cyclones are rapidly rotating storm systems that rotate (counter clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere) around a low-pressure centre. They are generally slow moving but severe, with winds of between 120-320 kilometres an hour. Most cyclone-related deaths are from flooding, but also from electrocution, collapsed structures and blowing debris.

Climatological hazards

Climatological hazards are caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability. These hazards can be subdivided:

Drought and over-heating*:* a long-lasting period of low precipitation (rainfall, snowfall, or snowmelt) resulting in a shortage of water. When communities don't have enough water for drinking, sanitation, and agriculture it can lead to food insecurity, the spread of disease, malnutrition and starvation, migration, and economic losses. Drought can also have a negative impact on power generation, transportation and commercial or industrial needs in a country.

Whilst draught may not necessarily be associated with an MCI there is no doubt that it can have a very major indirect impact on the mechanisms that lead both to an increase in MCI frequency, for instance the struggle for resources and geological tension, and a reduction in resilience, for example subsidence in mountainous areas due to a reduction in soil strength.

Similarly heat waves over an extended period of unusually high temperatures and often high humidity. They are expected to become more frequent and more severe in future due to climate change. People affected by heat waves can suffer from shock, become dehydrated and develop serious heat illnesses. Heat waves can also worsen chronic cardiovascular and respiratory diseases.

Cold waves*:* sometimes known as a cold snap or deep freeze, is a weather event involving a cooling of the air, or the invasion of very cold air, over a large area. It is marked by a drop of average temperature well below the average n. Cold waves can have negative impacts on people, crops, properties and services. They can be preceded or accompanied by significant winter weather events, such as blizzards or ice storms. And they can feel even colder during periods of high winds.

Biological hazards

Hazards of organic origin or conveyed by biological vectors, including pathogenic microorganisms, toxins, and bioactive substances. Examples are bacteria, viruses, or parasites, as well as venomous wildlife and insects, poisonous plants and mosquitoes carrying disease-causing agents. Many arise from new pathogens transmitted from animals to humans. An obvious example is the current Covid-19 pandemic [8]. Biological hazards can cause epidemics or pandemics.

Epidemics are an increase of a specific illness within a community or region. Pandemics are when an epidemic occurs worldwide, crossing international borders and affecting a large number of people. Several communicable diseases can be significant health threats at the local, regional, and global level and lead to epidemics or pandemics. Epidemics and pandemics can be prevented and/or mitigated through a range of household and community measures, such as good hygiene, social distancing, vaccination, and the provision of medical care.

2.3.2 Human-induced hazards

Technological hazards

Technological hazards are those that originate from technological or industrial conditions, infrastructure failures or specific human activities. Examples include industrial pollution, nuclear radiation, toxic wastes, dam failures, transport accidents, factory explosions, fires, and chemical spills. Technological hazards also may arise as a result of the impacts of a natural hazard event.

***CBRN** (Chemical, biological, radiological, and nuclear) hazards:* they are commonly grouped together because they share lots of similarities, and many of the preparedness and response measures are the same or very similar.

- Chemical hazards are the unexpected release of a substance that is potentially harmful to humans, animals, or the environment.
- Biological hazards are biological substances that threaten the health of humans and other living beings. They include infectious disease outbreaks, epidemics, animal plagues and infestations. Contamination can occur through natural exposure to the agent, accidental release of microorganisms, for example from a research facility, or by deliberate acts.
- Nuclear hazards are hazards involving the accidental or intentional release of potentially harmful radioactive materials, for instance from nuclear power plants, research reactors or nuclear weapons.
- Radiological hazards are hazards involving all other sources of radiation—for instance, radiography machines, radioactive material used in industry and lost or stolen radioactive sources.

***Industrial**:* accidents result in releases of hazardous materials usually occur in a commercial context, such as mining accidents. They often have an environmental impact, but also can be hazardous for people living in close proximity.

***Engineering**:* Engineering hazards occur when structures used by people fail or the materials used in their construction prove to be hazardous.

***Transportation**:* this could be an aviation, rail, road or even a space incident / accident, all of which can result in loss of life.

***Explosion**:* a violent shattering or blowing a part of something.

***Wildfires**:* also known as bushfires in non-urban areas, brush fires or forest fires, are large, uncontrolled, and potentially destructive fires that can affect both rural and urban areas. They can spread quickly, change direction and even ‘jump’ across large distances when embers and sparks are carried by the wind. They are caused by a range of natural causes (such as lightning) or by human carelessness (such as a discarded cigarette). The spread of a wildfire depends on the arrangement of land, available fuel (vegetation or dead wood) and weather conditions (wind and heat). Their nature can be spread rapidly over a large area in an uncontrolled manner.

Societal hazards

Certain societal hazards can arise as a result of failure to detect a danger, or wilful intent by human inactivity or neglect. Although not everything is within the scope of human control, there are anti-social behaviours and crimes committed by individuals or groups that can be prevented by reasonable apprehension of injury or death.

Violence: behaviour that puts others at risk of injury or death on a large scale

Terrorism: is the use or threatened use of violence for the purpose of creating fear to achieve a political, religious, or ideological goal. Targets of terrorist acts can include private citizens, government officials, military personnel, law enforcement officers, firefighters, or people serving the interests of governments.

Human Stampede: *related to crowd surge during mass gathering events. It is normally related to different type of hazard including d*angerous behaviour (such as climbing on or destroying structures and equipment), overcapacity, bad crowd control, narrow spaces or physical barriers, fire hazards. The impulsive mass movement of the crown often results in injuries, lack of oxygen and death.

2.4 Anticipated types of injuries in an MCI

Blunt Trauma

Blunt trauma, also known as non-penetrating trauma or blunt force trauma, refers to injury of the body by forceful impact, falls, or physical attack with a non-penetrating object. Blunt trauma can be caused by a combination of forces, including acceleration and deceleration (the increase and decrease in speed of a moving object), shearing (the slipping and stretching of organs and tissue in relation to each other), and/or crushing pressure.

Blunt trauma can generally be classified into four categories: contusion, abrasion, laceration, and fracture. Contusion—more commonly known as a bruise—is a region of skin where small veins and capillaries have ruptured. Abrasions occur when layers of the skin have been scraped away by a rough surface. Laceration refers to the tearing of the skin that causes an irregular or jagged-appearing wound. Lastly, fractures are complete or partial breaks in bone. Such injuries can often occur in motor vehicle crashes, physical assaults, and falls.

Penetrating Trauma

Penetrating trauma is an injury caused by a foreign object piercing the skin, which damages the underlying tissues and results in an open wound. The most common causes of such trauma are gunshots, explosive devices, and stab wounds. The penetrating object may remain in the tissues, come back out the way it entered, or pass through the tissues and exit from another area. An injury in which an object enters the body or a structure and passes all the way through is called a perforating injury, while penetrating trauma implies that the object does not pass through.

Burns

Burns are tissue damage that results from heat, overexposure to the sun or other radiation, or chemical or electrical contact. Burns can be minor medical problems or life-threatening emergencies. Depending on how deep the skin is damaged burns can be classified into one of three categories.

- 1st-degree burn: This minor burn affects only the outer layer of the skin (epidermis). It may cause redness and pain. After the healing process there is generally no scarring. Skin grafting may be necessary.

- 2nd-degree burn: This type of burn affects both the epidermis and the second layer of skin (dermis). It may cause swelling and red, white, or splotchy skin. Blisters develop, and pain can be severe. Deep second-degree burns can cause scarring.

- 3rd-degree burn: This burn reaches to the fat layer beneath the skin. Burned areas may be black, brown, or white. The skin may look leathery. Third-degree burns can destroy nerves, causing numbness. Healing is complex and may result in scars. Skin grafting may be necessary.

Crush Injuries

Crush injury is the result of physical trauma from prolonged compression of the torso, limb(s), or other parts of the body. This type of injury most often happens when part of the body is squeezed between two heavy objects. The resultant injury to the soft tissues, muscles, and nerves can be due to the primary direct effect of the trauma or ischemia related to reduction in blood flow.

Exacerbation of Chronic Disease

In medicine, exacerbation may refer to an increase in the severity of a disease or its signs and symptoms. For example, an exacerbation of asthma might occur as a serious effect of inhalation of noxious chemical released from a fire at a chemical plant, leading to shortness of breath.

Gastrointestinal Illness

Illness caused by a variety of different disease-causing microbes or/or chemical agents that can be acquired by consuming contaminated food or beverages, contact with contaminated recreational water, infected animals or their environments. Gastrointestinal diseases affect the gastrointestinal (GI) tract from the mouth to the anus.

Respiratory Impact

The respiratory tract is the portal of entry of air pollutants. Pollutants can be released from chemical fires and/or industrial accidents and have a direct effect on either the upper or lower airways or both. Substances can have direct effects on the epithelium or secondarily through the ingestion and transfer of chemical substances to other parts of the body via the circulation. Because of the very fine epithelium and very large surface area the adsorption and redistribution can be very rapid.

Primary effects on gaseous exchange in the lung may quickly result in a deficit in oxygen transfer and a state of hypo-oxygenation which may be lethal. Inhaled dust may also affect the reactivity of bronchial tissue. The range of respiratory diseases that can be caused by air pollution exposure is large. Studies on the health impacts of air pollution differentiate between acute and chronic effects. The acute effects of pollution may be apparent within hours or days of exposure, but other health effects of air pollution result from long-term exposure, leading to chronic disease. Some pollutants may lead to cancer at a late date.

Submersion Injury

Submersion injury occurs when a person is submerged in any liquid. After initial breath holding, the individual attempts to breathe and thus either aspirates water (wet drowning) or has laryngospasm without aspiration (dry drowning)

Infected Wounds

Infected wounds are a localized defect or excavation of the skin or underlying soft tissue in which pathogenic organisms have invaded into viable tissue surrounding the wound. Infection of the wound triggers the body's immune response, causing inflammation and tissue damage, as well as slowing the healing process.

Table 2 provides an overview of the anticipated types of injuries per MCI type.

Table 2: Anticipated injuries in an MCI by type of hazard

MCI category		Blunt Trauma	Penetrating Trauma	Burns	Crush	Exacerbation of Chronic Disease	Gastro-intestinal Illness	Respiratory Impact	Submersion Injury	Infected Wounds	Contaminated Wounds
Geophysical	Earthquake	X	X	X	X	X	X	X		X	
	Tsunami	X	X		X			X	X	X	X
	Landslide	X	X		X			X		X	X
	Volcanic activity			X		X		X			
Hydrometeorological	Flood	X	X					X	X	X	X
	Storm					X	X	X			
	Extreme temperatures			X		X	X	X			
Climatological	Drought					X	X	X			
	Wildfire			X				X			
Technological	CBRN	X	X	X	X	X	X	X		X	X
	Industrial	X		X	X	X	X	X			
	Engineering	X	X	X	X						
	Transportation	X	X	X	X			X			
	Explosion	X	X	X	X			X		X	X
	Fire			X				X			
Societal		X	X	X	X			X			

3 MCI scenarios

The following paragraphs present the MCI events that have been selected to be used as a basis for NIGHTINGALE scenarios and use cases. The consortium has adopted the approach of studying real MCI events to analyse capability gaps and define areas for improvement where the incorporation of NIGHTINGALE tools can be expected to make a difference. In addition, an MCI scenario developed in the context of the full exercises of the European Master in Disaster Medicine (EMDM), and provided by partner UPO, has been also used. Although the chosen MCI events are not representative of the entire scope of possible MCIs, they can efficiently serve as frameworks to illustrate the application of the NIGHTINGALE technologies, through the construction of use cases that follow the expected timeline of the handling of an MCI.

The chosen events involve the following types of incidents:

- Train derailment accident
- Terrorist attack (bombings, gun shooting)
- Multiple vehicles' collision and tank explosion

The analyses presented below include basic information about each event, qualitative and quantitative indicators whenever available, and important lessons learnt. For identified shortcomings, relevant NIGHTINGALE technologies are indicated.

3.1 Train Derailment in Milano

3.1.1 Description

On January 25, 2018, at around 07h00, a five-car train containing 300 passengers derailed in Pioltello, a town in the eastern suburbs of Milan in Lombardy region [9]. The incident was first reported to Emergency Medical Services (EMS) by a passenger of the derailed train by mobile phone at 06h59. At 07h07 the same morning the Emergency Medical Service - Metropolitan Operative Center (EMS-MOC) in Milan declared an MCI. As part of the MCI the nearest and most appropriate hospitals were informed and asked to prepare for an influx of casualties.

At the time, there were 12 hospitals involved in the management of the casualties. All were located within a 20-kilometre radius of the scene of the accident. According to the reported times of the alert, the EMS alerted the more important hospitals nearest to the scene first, then the smallest closest hospitals and finally the more distant hospitals.

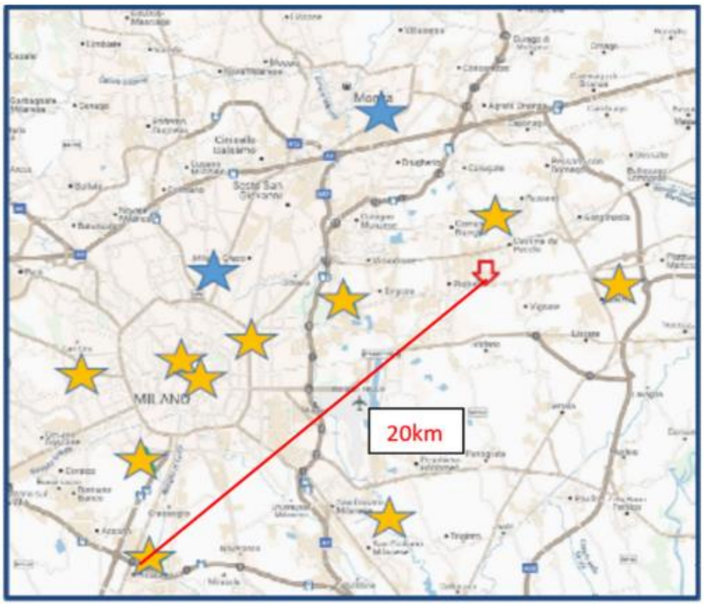

Figure 2. Map of the location of health facilities near the site of the crash[1].

The initial capacity for severely injured patients (red code) was high, with available Operating Rooms and Intensive Care Unit (ICU) beds increased. Capacity increased over time, due to the cancellation of elective activities and discharging of patients from ICU beds.

Within approximately 45 minutes (range: 25 to 75 minutes), the Hospital Command Group (HCG) was established in all the hospitals. In most cases the HCG included representatives from the Medical Service Direction, the Head of the Critical Clinical Departments, and the Nurse Coordinators. Other members of the HCG included Heads of non-clinical services, such as maintenance and communication.

The first ambulance (BLS Basic Life Support) arrived at the scene at 07h21. At the same time, the fast car arrived at the scene with the advanced team (ALS Advanced Life Support) that started scene management including sectorisation, triage and the establishment of an Advanced Command Post (ACP) with representatives of the other emergency agencies on ground (fire fighters and police). The first severely injured patient (red code) was evacuated from scene at 08:31 am, 70 minutes after the arrival of the first ambulance.

A total of 133 patients have been managed by the EMS. According to START triage (the triage routinely used by EMS in Lombardy in case of MCI), 3 patients (2.25%) were dead at the time of access to scene by medics (black code), five (3.75%) were red (highest priority to evacuation), 9 (6.76%) were yellow (intermediate priority) and 116 (87.24%) were green (low priority). Out of the total 133 patients 78 (58.64%) were hospitalized. From the data made available by the Railway Lombardy Company, the number of passengers was approximately 300; it is supposed that some 170 (56.6%) passengers did not pass through the evaluation of the EMS.

[1] The red arrow represents the site of the crash. The blue stars represent trauma centres and the yellow stars are non-trauma centre hospitals [9].

All the five red code patients went to the operating rooms and four of them needed ICU after surgery. Of the nine yellow code patients, at least six were admitted to ward; none needed the operating rooms or ICU. Some of the green code patients needed to be admitted, but the majority was sent home the same day. At 10h22, the scene was cleared of all casualties and hospital deactivation started.

3.1.2 Quantitative indicators

Hereafter we present a series of quantitative indicators depicting the main tasks performed by FRs during the described MCI and related prehospital times.

Table 3. Quantitative indicators extracted from the after-action report (9 hospitals included in the analysis)[9].

Indicator	Value (elapsed time from first report by passenger)
Declaration of MCI by EMS-MOC	8 minutes
Arrival of first ambulance (BLS -Basic Life Support)	22 minutes
Arrival of fast car at the scene (ALS – Advanced Life Support)	22 minutes
Activation of MCI plans by hospitals	0-60 minutes
Time for capacity reports (6 hospitals)	3 hospitals: within 15 minutes 3 hospitals: up to 1 hour
Time for Hospital Command Group establishment	25-75 minutes
1st severely injured patient (red code) evacuated from scene	70 minutes after arrival of first ambulance (=92 minutes)
1st severely injured patient reaches the closest appropriate hospital (or "admission of the 1st severely patient to the hospital"?)	Around 2 hours (111 minutes)
Scene cleared of all casualties. Deactivation started.	3 hours and 23 minutes

3.1.3 Lessons learnt

The post-hoc analysis showed that there was an over-activation of hospital resources by EMS with respect to the real demand, as well as an over-response by the hospital network because of the activation of their internal MCI plan. The real figures of injured people came late due to the problem of accessibility to the train due to the rough terrain, and in particular accessibility to the most damaged cars. In the context of a metropolitan area, with several hospitals available, it may be correct to alert more resources at an early stage and then to downgrade later on, to avoid underestimating the required response. It is also true that this over-response by hospitals could be avoided with a step-by-step activation of the MCI plan, dependent on the actual arrival of victims, instead of an all-or-none, perhaps implementing to a standby phase in anticipation of patient arrival before mobilizing all available resources and freezing all ordinary activities.

The management of the incident by EMS was effective in terms of distribution of the patients; none of the hospitals exceeded their capacity. The timely released capacity during the incident was greater than the one previously declared by hospitals to the Health Authorities in case of activation of the

MCI plan. This can be explained by the time and day of incident, that took place early morning in a working day, when the medical personnel on duty is double, because of the changing between the night and the morning shifts and operating rooms and staff are already present inside the hospital, preparing for the daily ordinary surgical interventions to start. This is an important point in that the number of staff available was double due to the changing shift.

The inordinate flow of telephone calls reaching EMS from hospitals overwhelmed the telephone operators and detracting time and resources from their main tasks. Back-up systems such as VHF radios and information carriers should always be available, and heads of communication and maintenance departments, responsible in part for the MCI response planning and implementation, should be included as members of the HCG.

The hospital departments in charge of communication and maintenance should be involved in the preparation of the MCI plan and represented in the HCG during an emergency, but it seems from the reports that only a few hospitals included them

Communication between the EMS-MOC and the Emergency Departments was perceived as effective while communication between the EMS and HCGs was perceived as ineffective. Communication between the HCGs and the Emergency Departments is described as very effective. In all nine hospitals, the preferred way of communication between HCG and EDs is the internal telephone landline, while in five cases, the use of personal or institutional mobile phones is proposed.

3.1.4 Potential improvements with the use of the NIT-MR technologies

In line with the lessons learnt and the gaps highlighted from the after-action reports of the MCI, a list of tasks that could have benefit from the use of the NIT-MR technologies (in connection with related use-cases presented in section 4 of this document) is hereafter presented.

Table 4. Potential improvements with the use of NIT-MR technologies in the train derailment scenario

Task	Discussion	NIT-MR potential support
Scene Assessment	While MCI declaration and subsequent implementation of MCI plan was extremely rapid, alerted hospitals reported an over-activation compared to the real need. Even though this is common in MCIs (and preferable to an under-activation), MCI plans activation demands the cancellation of elective diagnostic and therapeutic procedures, as well as elective surgery and ambulatory activities, thus impacting the provision of basic health services for the population. As such, the future of MCI response should focus on a more thorough and systematic initial assessment of the MCI scene, including real figures of involved casualties.	**SWAPP (App)**: first information from the scene and following updates including footage from scene area **UAV rapid triaging system & thermal scanning system**: support in victim counting, especially when accessibility pose challenges to FRs **Digital Triage Tag**: tracking and tracing of casualties in the scenario **C3&IMS App & Resources and assets optimization service**: support

		in hospital activation according to the real needs from the field
Communication & Coordination	Communication between the EMS-MOC and HCGs was perceived as ineffective. Preferred way of communication where either telephone landline, personal or institutional mobile phones, resulting in an inordinate flow of telephone calls reaching EMS-MOC from hospitals, overwhelming the telephone operators and detracting time and resources from their main tasks.	**C3&IMS App:** support exchange of information and providing a Common Operational Picture to all levels involved in the response (operational, tactical and strategic)
Hospital MCI plan activation	The often-blurred scenario that characterize MCIs impacts the decision-making process of FRs, who are often exposed to unconfirmed or contradictory information, constant stress, and time-pressure. In this context, simulation and training activities are extremely important to expose FRs to challenging scenarios.	**Scenario Builder:** provide a training platform

3.2 Paris attacks of 13 November 2015

3.2.1 Description

The November 2015 Paris attacks [10], often known as the 'Bataclan Attacks' were coordinated attacks by Islamic Terrorists that took place on the 13 November 2015 in Paris, France and at the Stade de France, North of Paris.

Starting at 21h15 the first explosion near the stadium occurred about 20 minutes after the start of an international football game. Three minutes after the first bombing, the second bomber blew himself up outside another security gate Twenty-three minutes after that, the third bomber's explosive device detonated near the stadium. Over fifty people were injured, seven seriously.

The first shootings occurred around 21h25 in the 10th arrondissement in Paris. The attackers got down from a car killed the driver of a car in front of them, and then shot at people outside Le Carillon restaurant. They then shot people inside the restaurant Le Petit Cambodge. Thirteen people were killed and ten others were critically injured. Doctors and nurses from the nearby Hôpital Saint-Louis were in Le Carillon when the attacks happened and treated many of the wounded.

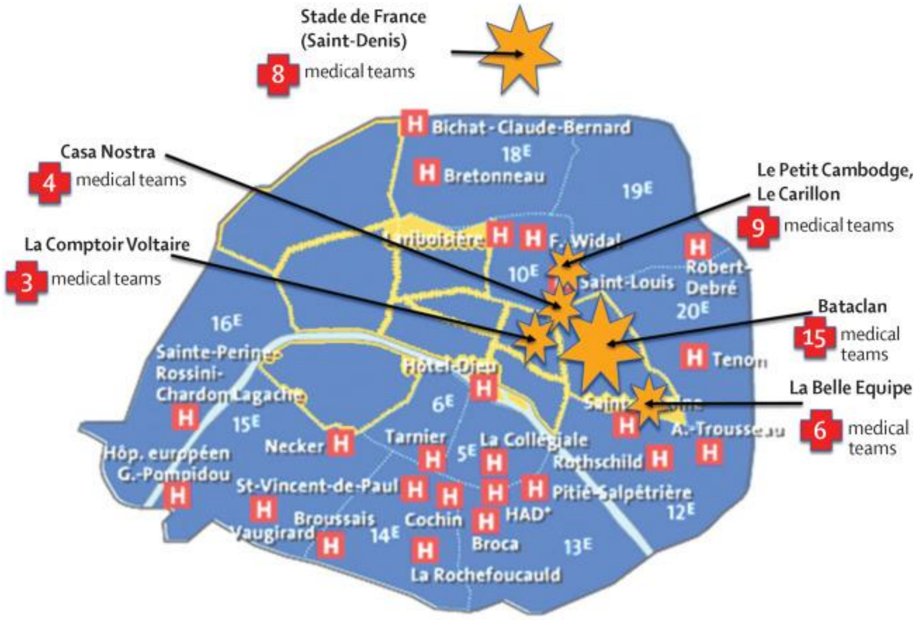

Figure 3. Map depicting the locations of the attacks of the 13 November 2015.

At 21h32, the attackers arrived at the Café Bonne Bière, located close to the terrace of the Italian restaurant La Casa Nostra. There, they fired on people who were drinking. Five people were killed and eight others were injured. At 21h36, the assailants arrived at the restaurant La Belle Équipe on the rue de Charonne in the 11th arrondissement. There, they fired for several minutes at the outdoor terrace. Twenty-one people were killed, and seven others were seriously hurt. At 21h40, one of the attackers was dropped off at the boulevard Voltaire in the 11th arrondissement and entered a restaurant. The attacker detonated his explosive vest, killing himself and injuring fifteen people, one of them seriously.

Beginning at around 21h50, a mass shooting and hostage-taking happened at the Bataclan theatre on the boulevard Voltaire in the 11th arrondissement. An American rock band was playing to an audience of approximately 1,500 people. Three men got out of a car and opened fire on people outside the Bataclan, killing three. Then, they entered the Bataclan and opened fire. Rows of people were killed or dropped to the ground to avoid being shot. The gunmen also fired into the balconies, and dead people fell down below.

People tried to escape as the terrorists were reloading their weapons. Those who reached the exits were shot by a third gunman. Two terrorists went upstairs to the balconies, while another stayed downstairs and fired at people who tried to escape. The Brigade of Research and Intervention (BRI) arrived on the scene at 22:15 followed by the elite tactical unit. At 22h15, the first two police entered the building and was shot whilst detonating his explosive vest.

The remaining two terrorists took about twenty hostages into a room at the end of the building. From this point the terrorists fired on police and first responders arriving at the scene, none of these was injured. At 23h30, an elite police squad entered the building. The police assault began at 00h20 and lasted three minutes.

At the Bataclan, ninety people were killed, and hundreds of others were wounded. Almost all of those who died were killed within the first twenty minutes of the attack. During long periods of shooting, the streets surrounding the attacks remained difficult and dangerous for emergency intervention teams. Seriously injured hostages in the hands of terrorists or obstructed by fire could not be evacuated.

In total, three hundred and thirty-seven casualties were admitted to hospital. Of these two hundred and eight six (85%) were from gunshot wounds and 51 (15%) people were injured in the explosions. Gunshot casualties had more severe injuries. Emergency surgery was performed for 181 (54%) casualties and was inevitably used more for gunshot wounds than for those injured in the explosions.

The emergency medical services (Service d'Aide Médicale d'Urgence, SAMU) in Paris is a pre-hospital Emergency Service that has thirteen ambulances equipped with a specialist emergency physician, anaesthetic nurse and ambulance driver including advanced intensive care equipment. With units from just outside Paris and the Fire Brigade medial units, a total 45 medical pre-hospital teams were mobilised although 15 were kept in reserve. The SAMU is part of the APHP (Assistance Publique Hopitaux de Paris) hospital group that compromises of 40 hospitals, the biggest hospital group in Europe with over 100 000 health professionals, a capacity of 22 000 beds, and 200 operating rooms.

In total, 256 wounded people were transported by the pre-hospital EMS, the other 'walking wounded' self-presented to Emergency Departments. Seventy-six casualties were categorised at RED or YELLOW and were transported by the pre-hospital services. Thirty-five surgical teams operated during the night. There were four deaths (1%) among the 302 injured patients, including two deaths on arrival at hospital.

Three people were treated for heart attacks during the time of the attacks that were not related to the attacks themselves. A total of 35 psychiatrists and psychiatric nurses were also mobilised.

3.2.2 Quantitative indicators

Hereafter we present a series of quantitative indicators depicting the main tasks performed by FRs during the described MCI and related prehospital times, calculated according to [11].

Table 5. Quantitative indicators for the Paris attacks on 13th November 2015 [11].

Indicator	Value (elapsed time from the event)
First report by witness on the first scene (Stadium)	08 minutes
Activation of the "Red plan Alpha" for the first event	24 minutes
Arrival of fire brigade and SAMU on the first scene	10 minutes
Severely injured patient (red code) evacuated from first scene	53 minutes
First scene cleared of all casualties. Deactivation started.	4 hours and 41 minutes
First report by witness on second scene (Comptoir voltaire)	03 minutes

Activation of the plan "Nombreuses Victimes"(many victims)	07 minutes
Crisis cell at the SAMU	11 minutes
Activation of the "Red plan Alpha" for the second event	10 minutes
Arrival of fire brigade on the second scene	14 minutes
Severely injured patient (red code) evacuated from second scene	1 hour and 01 minute
Second scene cleared of all casualties. Deactivation started.	3 hours and 22 minutes
First report by witness on the third scene (Bataclan)	03 minutes
Arrival of fire brigade on the third scene	10 minutes
Severely injured patient (red code) evacuated from third scene	46 minutes
Third scene cleared of all casualties. Deactivation started.	6 hours and 41 minutes

3.2.3 Lessons learnt

When the attacks were first reported it was clear that there was a potential for them to progress dangerously. These facts led to a first decision: the activation of the "White Plan" (by the APHP Director General) occurred at 22h34. This plan mobilised all hospitals and recalled staff whilst releasing beds to cope with an influx of wounded. Because of the activation of this plan, at no time during the emergency response was there a shortage of personnel. The capacity of the hospital group matched the demand. At one major hospital (La Pitié Salpetrière) close to the Bataclan, ten operating theatres were opened to treat injured patients (mostly with penetrating trauma), absolute emergencies (mostly admitted in the shock trauma unit).

When it was felt that it might be necessary to deal with an influx of severely injured people, two further "reservoir" capacities were prepared: other hospitals in the area were put on alert. Other hospitals just outside Paris mobilised ten helicopters to organise the transport of the wounded if necessary; although these reservoirs were not, in fact, necessary.

Several factors may have contributed to these favourable outcomes. First, the injured patients arrived very quickly (in small groups of four or five) because we had worked for several months with the medical service of the French elite tactical unit or Recherche, Assistance, Intervention and Dissuasion (RAID), pre-hospital emergency teams, and in-hospital trauma teams to be able to provide a fast-track service for penetrating trauma, particularly during a terrorist attack.

A key element was the excellent cooperation of all caregivers under the supervision of two trauma leaders in the shock trauma unit and an operating room allocation leader, who were not directly involved in the care of the patients and who continuously communicated between each other and regularly collated information concerning the entire cohort of injured patients.

Another key element was related to the dramatic characteristic of the event; only nine hours after the event, it was possible to reduce the number of operating rooms to six and send home some of the more exhausted staff. Within 24 h, all emergency surgeries (absolute and relative emergencies) had been done and no victims were still in the emergency department or the shock trauma unit. Another attack was anticipated with the following days and hospitals and pre-hospitals services were prepared for a new influx of wounded.

The sterile supply chain was augmented to allow a fluid workflow, and administrative staff supported the medical work, finding logistic solutions when necessary; for example, patient registration, finding free beds.

Timing might also have played a part in the success of the response. This disaster occurred at the beginning of a weekend and during the night. Some of the aspects might have been more difficult if it had happened during a working day, when the sterile stock is partly unavailable and when doctors and staff are already busy. The control of the terrain and evacuation routes was difficult because of the multiple sites and threats around, thus the protection of medical teams in the field was a problem.

The main identified areas for possible improvement are the following [11]:

- Absence of regulation was noted specifically when it comes to evacuations of victims from the different scenes to local hospitals.
- The evacuation process and the extraction of many victims in the exclusion zone started while the Police security interventions were being held which was a problem on the scene.
- Scepticism was noted about when to trigger the muti-site plan and until when to keep it.
- Many false alarms where overloading the call centres and their management was a burden.
- Telecommunication systems and backup network where lacking.

3.2.4 Potential improvements with the use of the NIT-MR technologies

In line with the lessons learnt and the gaps highlighted from the after-action reports of this MCI, a list of tasks that could have benefit from the use of the NIT-MR technologies (in connection with related use-cases presented in section 4 of this document) is hereafter presented.

Table 6. Potential improvements with the use of NIT-MR technologies in the terrorist attack scenario

Task	Discussion	NIT-MR potential support
Scene Assessment	The multiple scenes that were reported simultaneously was a problem, challenging to follow, to understand the pattern, and to confirm.	**SWAPP (App)**: first information from the scene and following updates including footage from scene areas with exact location and timeframe **UAV rapid triaging system & thermal scanning system**: support in victim counting, especially when accessibility pose challenges to FRs, but also in scenes location, and continuous threat detection **Digital Triage Tag**: tracking and tracing of casualties in the scenes **C3&IMS App & Resources and assets optimization service**: support in hospital activation according to the real needs from the fields **AR service:** support the detection of threats and understanding the location specificities.
Communication & Coordination	Communication posed a problem to manage the situation; there were no backup for telecommunication systems and coordination were lacking between FRs, Police, Hospitals.	**C3&IMS App:** support exchange of information and providing a Common Operational Picture to all level involved in the response (operational, tactical, and strategic)
Hospital MCI plan activation	The often-blurred scenario and complex that characterize a multi-site MCI impacts the decision-making process of FRs, who are often exposed to unconfirmed or contradictory information, constant stress, and time-pressure. In this context, simulation and training activities in multi-site scenarios are extremely important to expose FRs to challenging scenarios.	**Scenario Builder:** provide a training platform

3.3 After-Action Report of the Full-Scale Exercise in Novara, May 25, 2022

3.3.1 Description

The following scenario is derived from a report of a full-scale exercise (FSX) organized by UPO and performed in Novara on the 25 May 2022, during the 22nd edition of the European Master of Disaster Medicine (EMDM) The objective of the FSX was to provide a formative assessment of the competences gained by the EMDM students in 3 different areas: 1) Command, Control and Coordination; 2) Prehospital Management; 3) In-hospital Management. Eighteen EMDM students have been provided a scenario background, then divided into 3 teams and asked to manage an MCI scenario with all the resources available in the area (Table 7).

Table 7. Main characteristics of the MCI scenario performed during the EMDM FSX

<table>
<tr><td>Background</td><td>The fictitious country of Riceland went through years of economic and social crisis. Healthcare facilities suffered cutbacks to their services. Recently, a conflict spread through the country, forcing people to leave their homes. The Army was asked to provide a role in health organisation. A field hospital and ambulances, with the aid of logisticians, were supplied by the army. Local Non-Governmental Organisations were involved already with health care and were asked to provide ambulances, logisticians, and health care workers.</td></tr>
<tr><td>Scenario(s)</td><td>On Wednesday 25 May 2022, at 19:30, in a rural area a truck runs off road and hits a convoy of refugees and some vehicles. It has been later discovered that the truck driver suffered from a heart attack. On the same day, at 20:50 in a nearby improvised refugee camp set up in the woods, a gas tanks explodes.

</td></tr>
<tr><td>Roles</td><td><u>Prehospital Team:</u> 9 EMDM students including the Incident Commander on Scene. Resources available to the team:
❖ 8 ALS ambulances
❖ 5 BLS ambulances
❖ 1 mobile light tower
❖ 2 mini vans
❖ 8 nurses (1 on each ALS ambulance)
❖ 26 volunteers (2 per each ambulance)</td></tr>
</table>

	❖ 5 radios for internal communication at the scene ❖ 2 cell phones to communicate to Emergency operation Center (EOC): 1 phone to the First Responder on Scene, 1 phone to the Incident Commander on scene. Hospital Team: 7 EMDM students including the Hospital Manager. Resources available to the team: ❖ 5 hospital nurses ❖ equipment of the field hospital including: 1 OR, lab, XRAY, portable CT scan, US, 8 hospital bed. Emergency Operation Centre (EOC): 3 EMDM students. Resources available to the team: ❖ 3 radio operators ❖ direct liaison with EMS dispatch centre ❖ Cell phone to communicate with the FR and IC on scene ❖ phone landline to communicate with the Hospital Manager ❖ Maps of the area ❖ Whiteboard "Smart" victims: 116 medical students with make-up and evolving parameters according to the storyboard. Evolution of casualties depended on time and treatment performed by the EMDM players. Colour code distribution at time zero (according to START Triage): 63 GREEN; 33 YELLOW; 14 RED; 6 BLACK.

3.3.2 Quantitative indicators

Hereafter we present a series of quantitative indicators depicting the main tasks performed by FRs during the described MCI and related prehospital times, calculated from the beginning of the FSX. Data collection and data analysis has been performed by UPO thought the Disaster Simulation Suite (DSS) **Error! Reference source not found.**, a multi-dimensional tool, for planning, implementation and evaluating a drill, performing multi-user real time data collection, and showing the results in real time.

Table 8. Quantitative indicators extracted from the EMDM data analysis and debriefing session

Indicator	**Value (elapsed time from beginning of the FSX)**	
	Scenario 1 (start 19:30)	**Scenario 2 (start 20:50)**
Declaration of MCI by EOC	9 minutes	

Decision on resources to be dispatched to the scene	12 minutes	
Decision on which hospital should receive patients from the scene	12 minutes	
Activation of Field Hospital MCI plan	17 minutes	
Arrival of first ambulance (First Responder on Scene)	19 minutes	
First official report (METHANE[2]) from the scene	25 minutes (6 from the arrival of First Responder on scene)	29 minutes
Arrival of Fire Fighters on scene	31 minutes	1 minutes
Verbal Triage for Green Patients	33 minutes	
Scene Declared Safe	40 minutes	
START triage and evacuation to CCPs	41 minutes	21 minutes
Decision on guidelines for referring patients to hospitals	55 minutes	
Incident Commander on scene	58 minutes	
1st severely injured patient (red code) evacuated from scene	60 minutes	
Notification of patient distribution matrix to hospitals	65 minutes	
Evacuation of green patients from the scene with a minibus	83 minutes	

3.3.3 Lessons learnt

At the prehospital level, FRs had to face a complicated and chaotic scenario featuring a narrow road in the woods, accessible only from one site (Figure 4). First assessment of the situation and subsequent alert of the EOC was only possible after the scene had been declared safe by the firefighters; due to the impossibility to access the scene during the first minutes, FRs decided to perform verbal triage and initial sorting by asking to GREEN casualties (i.e., “all those who can walk” according to the START algorithm).

[2] METHANE: Major Incident Declared; Exact location; Type of incident; Hazards; Access; Number and type of casualties; Emergency services present and required

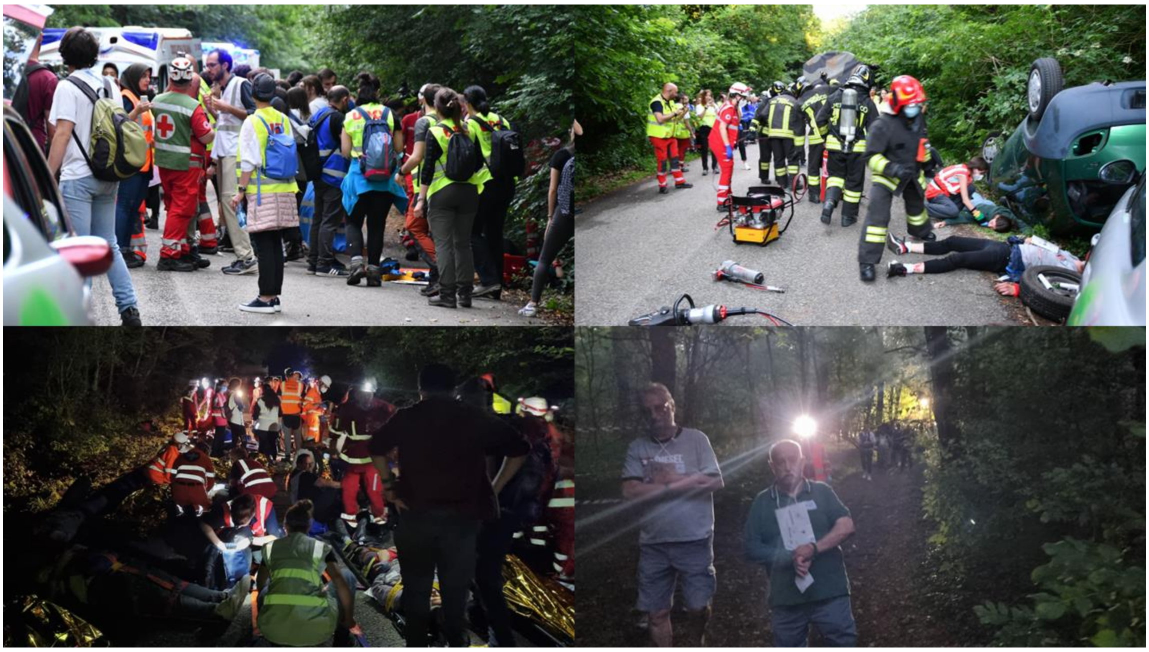

Figure 4. Footage from the Novara FSX

Communication between the Prehospital Scene and the EOC was conducted via cellular phone, while the FRs team had at their disposal radio for internal communication; despite this, radio communication was reduced to minimum, preferring face-to-face communication between FRs on scene, including inter-agency communication. There was good cooperation between the FR and the incident commander, with a clear separation of roles. There was also good cooperation between the healthcare providers and the firefighters' team. On the contrary, the principal remark was related to communication issues between the Prehospital Scene and the EOC, the latter struggling to have a clear picture of the situation.

Triage and evacuation procedure started when scene was declared safe. Casualties were scattered along the road and inside the woods. Visibility also posed a challenge to FRs, as the scene became dark after 21:00 CEST. FRs correctly applied the START triage, with low percentage of over and under triage (Figure 5).

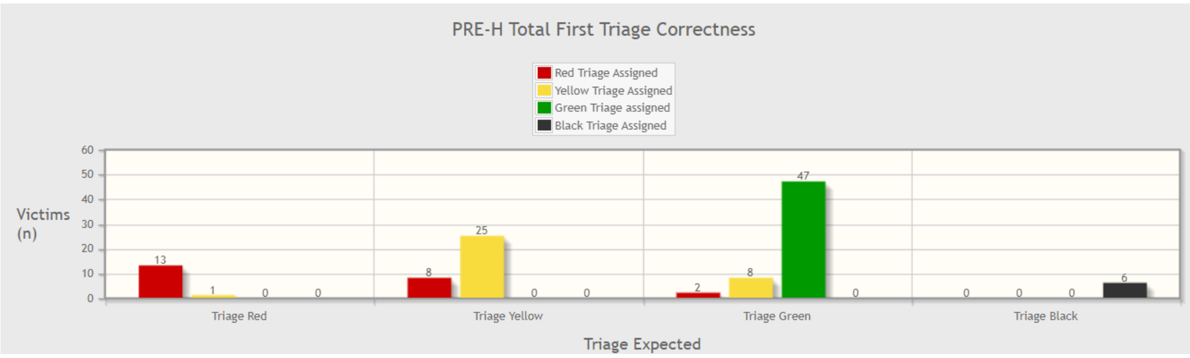

Figure 5. Prehospital first triage correctness

Regarding resource allocation, the EOC focused primarily on the needs of the hospital, thus affecting the pre-hospital response. At the beginning of the exercise, the EOC was under the impression that the hospital could not receive more than four patients: ambulances were ready to leave the scene with patients on board but were prevented from doing so. Later, the hospital requested referrals to make room for new casualties, and many ambulances were assigned to the task, leaving no more ambulances for taking new casualties from the scene. The hospital never gave the “maximum of four patients” signal, nor did the exercise control. That meant that the hospital was never actually over-stretched by the incident.

3.3.4 Potential improvements with the use of the NIT-MR technologies

In line with the lessons learnt and the gaps highlighted above, a list of tasks that could have benefit from the use of the NIT-MR (in connection with related use-cases presented in section 4 of this document) is presented in the following table.

Table 9. Potential improvements with the use of NIT-MR technologies in the multiple vehicles’ collision and tank explosion scenario

Task	Discussion	NIT-MR potential support
Scene Assessment	In many MCI scenarios, accessibility poses a challenge as EMS personnel should only enter after safety has been assessed and granted by fire fighters. As such, first communication to PSAPs/EOC and first sorting of patients are sometimes delayed, and so is the activation of the whole rescue chain.	**SWAPP (App)**: first information from the scene and following updates including footage from scene area **UAV rapid triaging system & thermal scanning system**: support in victim counting, especially when accessibility and visibility pose challenges to FRs **Digital Triage Tag**: tracking and tracing of casualties in the scenario, applied by Fire fighters
Communication & Coordination	It is common for the PSAPs/EOCs to struggle having a clear picture of all the needs of the prehospital scene. As such, the whole MCI response can be affected.	**C3&IMS App and component of the Multi-Information Fusion Module (DoA term):** support exchange of information and providing a Common Operational Picture to all level involved in the response (operational, tactical and strategic) **AR service:** providing a continuous common operating picture update (enhancing situational awareness)
Hospital MCI plan activation and casualty distribution	In the described MCI scenarios, the EOC decision to safeguard the hospital was made based on the misconception of the available hospital resources and its surge capacity.	**Resources and assets optimization service:** enhance coordination with hospitals providing a clear picture of updated hospital availability data

4 Definition of MCI Use Cases

Having studied and analysed in the previous section of the deliverable the selected exemplary MCI scenarios, this section considers them as frameworks to define the first version of NIGHTINGALE Use Cases. After a brief reminder on the NIT-MR terminology, including also updates and refinements compared to the original GA definitions, the NIGHTINGALE Use Cases are defined using a specific structure, and considering their clustering into two major categories: 1) Command, Control and Coordination Use Cases, and 2) Casualties Management Use cases. For the definition of use cases the detailed descriptions of NIT-MR users, their roles, level of control, tasks and responsibilities in the context of an MCI, presented in deliverable D1.8 *User functional and non-functional requirements,* have been considered.

4.1 Use Cases Notation

The NIT-MR toolkit comprises a multitude of components. 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 10 depicts the outcome of these interactions: refined component terms/names and descriptions.

Table 10. Terms and brief description of the components of NIT-MR toolkit

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): 1. Additional Vital Signs Wearables (e.g., earplug) 2. Other Digital Triage Tags (family members)
	Triage and Vital Signs app	ICCS and UPV	The smartphone app to be used in order to: 1. Control the Digital Triage Tag (initialization, triage status declaration) 2. Enter information for victims (incl. name, surname, age, sex, location, destination, interventions/medication, etc.) 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: 1. Triage Tag initialization 1. 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. 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. 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 Operational Picture (COP)	C3&IMS	ASTRIAL	The Command, Control and Coordination and Incident Management System used by the 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.

Table 11 presents the Use Case structure that has been adopted for presenting the various NIGHTINGALE Use Cases. The subsequent tables provide the definition of the various Use Cases, clustered into two main categories: 1) Command, Control and Coordination Use Cases, and 2) Casualties management Use cases.

Table 11. The adopted Use Case structure

Title	Use Case ID – Use Case Title
Trigger	The Event triggering the Use Case
Actors	The involved Actors
Actions	The Actions performed by the Actors in the Use Cases
Preconditions	What Preconditions need to be met for the Use Case to occur.
Components / Functions	The list of NIT-MR Components involved in the Use Case and their functions relevant to the Use Case. (Actors are indicated by listing them in between round brackets) [Functions are reported in between square brackets].
Outputs	The Outputs produced by the Components involved in this Use Case.
Connected Components	The List of "end-point" Components, receiving the Outputs produced by the Components involved in the Use Case.
Technical constraints	The Technical constraints that need to be met for the Use Case to be performed correctly. If not met, some indications about the possible alternatives.

Related User Requirements	The list of User Requirements described in D1.8 User Functional and Non-Functional Requirements related with the Use Case, in the form “NIT-MR Component”: [Requirements List]

4.2 Command Control and Coordination

UC01 - First information from the scene

Title	UC01 - First information from the scene
Trigger	Incident
Actors	1. Bystanders 2. First responders first arriving at the scene (all types of agencies depending on the incident) 3. Victims/Casualties
Actions	1. Whatever you get from a bystander (low level info or a METHANE Report[3]) 2. METHANE report creation from FRs 3. Identification of area of incident 4. Identification of person count
Preconditions	1. Bystanders have installed the “SWAPP (App)” 2. UAV drone needs to reach the scene manually or automatically 3. FRs are equipped with ““C3&IMS App””
Components / Functions	1. “SWAPP (App)”: (Bystanders), [F2: Incident Reporting] 2. “NG-PSAP” -> “C3&IMS” 3. “NG-PSAP” -> “Situational Awareness Module” 4. “C3&IMS App”: (First Responders), [NF1: METHANE Report Creation] 5. “UAV Rapid Triaging system”: (First Responders), [F1: exploration of the affected area, F1: injured people/victims’ localizing and counting] 6. “Thermal scanning system”: [F1: injured people/victims’ counting from fixed video/IR camera installed in specific locations of a town/city]
Outputs	1. “SWAPP (App)”: First Incident description (Location, Images, Videos, Type of incident– Time of incident - can be as extensive as needed via a form) 2. “C3&IMS App”: METHANE Report 3. “UAV Rapid Triaging system”: injured people/victims’ localization and count and row output (images and videos) 4. “Thermal scanning system”: injured people/victims’ count and row output (images and videso)
Connected Components	1. “SWAPP (App)” → “NG-PSAP” 2. “UAV Rapid Triaging system” → “Data Layer” → “C3&IMS” “UAV Rapid Triaging system” → “Interoperable Data Lake” → “C3&IMS

[3] METHANE mnemonic used in the UK Major Incident Medical Management and Support (MIMMS) system (http://mimms.org.au/)

	3. “Thermal scanning system” → “Data Layer” → “C3&IMS” “Thermal scanning system” → “Interoperable Data Lake” → “C3&IMS
Technical constraints	a. In case of non-standard connectivity b. “SWAPP (App)” information cannot be used c. “C3&IMS App” information cannot be used d. “Thermal scanning system”: information cannot be used e. It is expected that FRs can still use their own satellite comms
Related User Requirements	“UAV Rapid Triaging system”: [FR-1, FR-2, FR-3, FR-4] “Thermal scanning system”: [FR-1, FR-2] “SWAPP (App)”: [FR-1, FR–2, FR-4]

UC02 - Incident creation

Title	UC02 – Incident creation
Trigger	Arrival of the first information from the scene via: 1. Telephone or “SWAPP (App)” from Bystanders 2. “C3&IMS App” METHANE Report from First Responders 3. Automatic, via “Early warning and risk assessment service”, getting data from the “Data Layer” and/or the “Interoperable Data Lake”)
Actors	1. PSAP Operators (via “NG-PSAP” or Telephone) 2. Agency Specific Operators (via “C3&IMS”, also Mobile)
Actions	1. The Operator assesses the received call (or automatically generated alert) 2. If assessment confirms the received information, the incident is created.
Preconditions	1. Operators need to be active and operative.
Components / Functions	1. “NG-PSAP”: (Operators), [F7: Response function – Acknowledge Incident] 2. “C3&IMS”: (Operators), [NF2: Response function – Acknowledge Incident]
Outputs	1. Incident created
Connected Components	1. “NG-PSAP” → “Data Layer” → “C3&IMS” “NG-PSAP” → “Interoperable Data Lake” → “C3&IMS”
Technical constraints	N/A
Related User Requirements	“SWAPP (App)”: [FR-1, FR-2, FR-4]

MCI Declaration

Title	UC03 – MCI Declaration
Trigger	Incident created and data assessed
Actors	1. Senior First Responder first arrived on the scene (Incident Commander?)

	2. PSAP / Agency Specific Senior Officer (Strategic)
Actions	1. If received data about the incident requires it, 2. declare MCI
Preconditions	1. Data on the incident is already available. 2. Some of the arrived data is reliable (arrives from First Responder or “SWAPP (App)”) and the arrived parameters and values, e.g., number and severity of casualties, define the incident as MCI.
Components / Functions	1. “C3&IMS” (Senior Officers), [NF3: Assessment of the incident data to verify it is an MCI]
Outputs	1. MCI declared
Connected Components	1. “C3&IMS” → “Data Layer” “C3&IMS” → “Interoperable Data Lake”
Technical constraints	N/A
Related User Requirements	“SWAPP (App)”: [FR-1, FR-2, FR-4]

Dispatching and alerting of involved agencies

First Dispatch

Title	UC04 - First Dispatch
Trigger	Incident created
Actors	1. Agency Specific Operators (Tactical)
Actions	1. Incident Data is assessed; based on: a. the incident type and hazards, b. estimated number of victims c. First Responders availability d. First Responders proximity to the incident area 2. The proper First Responders are selected based on their capabilities (e.g., confined space rescue teams, chemicals disposal teams, etc...) 3. First Responders are dispatched on the scene based on the available incident data.
Preconditions	1. This first dispatch for the given incident has not been performed.
Components / Functions	1. “Resources and assets optimization service”: (Automatic), [NF1: Availability and capacity real-time status] 2. “C3&IMS CAD” - Computer Aided Dispatch (Operators) [NF4: Send dispatch orders]
Outputs	1. Dispatch orders to Agencies
Connected Components	1. “Resources and assets optimization service” → “Data Layer” “Resources and assets optimization service” → “Interoperable Data Lake” 2. “Data Layer” → “C3&IMS CAD” → “Data Layer” “Data Layer” → “C3&IMS CAD” → “Interoperable Data Lake”
Technical constraints	Data Exchange among Agencies should follow standard like the EXDL-HAVE, EXDL-RM, etc...

Related User Requirements	“Resources and assets optimisation service”: [FR-1, FR-2, FR-3, FR-8]

On Going Dispatching

Title	UC05 – On Going Dispatching
Trigger	1. New/Updated Needs from the Incident Area 2. New/Updated Resources Availability Data
Actors	1. Agency Specific Operators (Tactical)
Actions	1. New/Updated Incident and Resources Data are assessed; based on: a. Counts of Victims still on the scene b. Actual Victims Conditions c. Hospitalization Needs d. Resource Availability (Hospitals / Transportations, etc…) 2. First Responders are re-dispatched on the scene as needed and possible.
Preconditions	2. Data from the Incident Area and Available Resources are continuously updated
Components / Functions	1. “Resources and assets optimization service”: (Automatic), [NF1: Availability and capacity real-time status] 2. “C3&IMS CAD” - Computer Aided Dispatch (Operators) [NF4: Send dispatch orders])
Outputs	2. Dispatch orders to Agencies
Connected Components	1. “Resources and assets optimization service” → “Data Layer” “Resources and assets optimization service” → “Interoperable Data Lake” 2. “Data Layer” → “C3&IMS CAD” → “Data Layer” “Data Layer” → “C3&IMS CAD” → “Interoperable Data Lake”
Technical constraints	Data Exchange among Agencies should follow standard like the EXDL-HAVE, EXDL-RM, etc.
Related User Requirements	“Resources and assets optimisation service”: [FR-4, FR-5, FR-6]

Alerting authorities and the general public

Title	UC06 – Alerting Authorities and General Public
Trigger	1. MCI Declared
Actors	1. Agency Specific Operators (Tactical)
Actions	1. Alert Authorities (via “C3&IMS”, dedicated channels?) 2. If MCI is of type and severity allowing for that, alert also the General Public (via the News? via Public G/A Authorities)?
Preconditions	1. The alert to the General Public is not going to generate chaos, nor to make the MCI worse.
Components / Functions	1. “C3&IMS” (Operators), [NF5: Alert Authorities and General Public]
Outputs	1. Agencies are and General Public are alerted

Connected Components	1. "C3&IMS" → "Data Layer" "C3&IMS" → "Interoperable Data Lake"
Technical constraints	N/A
Related User Requirements	"C3&IMS": [NFR-6, NFR-8]

Creation of the command-and-control structure (including comms)

Title	UC07 – Creation of Command-and-Control Structure
Trigger	1. Incident created and data (METHANE) assessed or 2. MCI Declared
Actors	1. Senior First Responders first arrived on the scene (Incident Commander?) 2. Agency Specific Senior Officer (Strategic)
Actions	1. The Senior officer creates the command-and-control structure, including: a. Agencies C3 relationships and chain of commands b. Emergency medical services are organized as needed c. Fire and rescue services are organized as needed d. Public safety services (Police) are organized as needed e. Specialized teams (e.g., for nuclear or chemical hazards) are organized as needed Etc.
Preconditions	1. Proper data about the incident (MCI Declaration?) is available?
Components / Functions	1. "C3&IMS": (Agency Specific Senior Officer/Incident Commander), [NF7: Create C3 Structure]
Outputs	1. Command and control structure Created
Connected Components	1. "C3&IMS" → "Data Layer" "C3&IMS" → "Interoperable Data Lake"
Technical constraints	(At least Satellite) Communications on the scene and between the scene at the Agencies coordination centres must be in place and working
Related User Requirements	

Continuous common operating picture updates (enhancing situational awareness)

Title	UC08 – Continuous common operating picture updates (enhancing situational awareness)
Trigger	1. New/Updated Data from the Incident Area
Actors	1. Automatic / Manual (FRs, Operators)
Actions	1. All integrated data from the scene is analysed 2. Synthetic data is presented back to the FRs

	3. Decision support system helps tactical officers at the agencies centres and on the scene 4. Decisions are proposed automatically but actually taken by people
Preconditions	1. Updated data on the incident is available on the "Data Layer" and or "Interoperable Data Lake"
Components / Functions	1. "Expert Reasoning service": (Automatic), [F5: Analyze data from the scene and send common picture and actions to be done to First Responders]. 2. "Data Layer" and or "Interoperable Data Lake" 3. "C3&IMS App": (First Responders), [F1: show COP information to First Responders] 4. "Augmented Reality Service" (First Responders) [F5: show COP info to FRs]
Outputs	1. Information about the scene is passed to all officers. 2. Decisions to be taken,
Connected Components	1. "Decision support service" → "Data Layer", "Interoperable Data Lake" → "C3&IMS App" 2. "Decision support service" → "Data Layer", "Interoperable Data Lake" → "Augmented Reality Service"
Technical constraints	(At least Satellite) Communications on the scene and between the scene at the Agencies coordination centres must be in place and working
Related User Requirements	"Augmented Reality Service": [FR-1, FR-2, FR-3] "C3&IMS":[FR-1, FR-2]

Scene Management

Title	UC09 – Scene Management
Trigger	1. Incident created and data (METHANE) assessed
Actors	3. Senior FRs first arrived on the scene (Incident Commander?)
Actions	2. The Senior FR creates the Scene Management Structure, including: a. (at least) the Incident Commander b. If needed the sectorization in areas (with area commander) c. If needed the identifications of functions and posts with their related commander d. Access/Escape roots e. Casualty Collection Points
Preconditions	2. Proper data about the incident is available?
Components / Tools / Applications	3. "C3&IMS": (Incident Commander), [NF6: Create Scene Management Structure]
Outputs	2. Scene Management Structure Created
Connected Components	2. "C3&IMS" → "Data Layer" "C3&IMS" → "Interoperable Data Lake"
Technical constraints	(At least Satellite) Communications on the scene and between the scene at the Agencies coordination centres must be in place and working

Related User Requirements	

Coordination with the hospitals

Title	UC10 – Coordination with the Hospitals
Trigger	1. New/Updated Hospital Needs from the Incident Area 2. New/Updated Hospitals Availability Data
Actors	1. EMS FRs send new/updated data about hospitalization needs 2. Agency Specific Operators (Tactical)
Actions	1. New/Updated Incident and Resources Data are assessed; based on: a. Counts of Victims still on the scene b. Actual Victims Conditions c. Hospitalization Needs d. Resource Availability (Hospitals) 2. Hospitals Resources are (re)-allocated as needed and possible.
Preconditions	1. Data from the Incident Area and Available Resources are continuously updated
Components / Functions	1. “C3&IMS App” (First Responders) [NF7: Needs from the field] 2. “Resources and assets optimization service”: (Operators at the Hospitals), [F1: Optimal utilization help operators in resource planning]
Outputs	1. Optimized Hospital Allocation
Connected Components	1. “C3&IMS App” → “Data Layer” → “Resources and assets optimization service” “C3&IMS App” → “Interoperable Data Lake” → “Resources and assets optimization service” 2. “Resources and assets optimization service” → “Data Layer” “Resources and assets optimization service” → “Interoperable Data Lake”
Technical constraints	Data Exchange with/among the hospitals should follow the EXDL-HAVE standard.
Related User Requirements	“Resources and assets optimisation service”: [FR-1 - FR-7]

4.3 Casualties Management

Victim detection and counting (first sorting)

Title	UC11 – Victim detection and counting (first sorting)
Trigger	First dispatch occurred
Actors	1. First responders arriving at the scene (all types of agencies depending on the incident) 2. Victims/Casualties
Actions	1. Identification of areas of incident and person count

	2. First assessment of casualties' severities in the various areas
Preconditions	1. UAV drone needs to reach the scene manually or automatically, 2. FRs are equipped with ""C3&IMS App""
Components / Functions	1. "C3&IMS App": (First Responders), [NF1: METHANE Report Creation] 2. "UAV Rapid Triaging system": (First Responders), [F1: exploration of the affected area, NF1: injured people/victims' localizing and counting] 3. "Thermal scanning system": [NF1: injured people/victims' counting from fixed video/IR camera installed in specific locations of a town/city]
Outputs	1. "C3&IMS App": METHANE Report 2. "UAV Rapid Triaging system": injured people/victims' localization and count 3. "Thermal scanning system": injured people/victims' count
Connected Components	1. "UAV Rapid Triaging system" → "Data Layer" → "C3&IMS" "UAV Rapid Triaging system" → "Interoperable Data Lake" → "C3&IMS 2. "Thermal scanning system" → "Data Layer" → "C3&IMS" "Thermal scanning system" → "Interoperable Data Lake" → "C3&IMS
Technical constraints	1. In case of non-standard connectivity a. It is expected that FRs can still use their own satellite comms
Related User Requirements	"UAV Rapid Triaging system": [FR-1, FR-2, FR-3, FR-4, FR-6,] "Thermal scanning system": [FR-1, FR-2]

First triage

Tagging

Title	UC12 – Tagging
Trigger	First dispatch occurred
Actors	1. EMS First Responders 2. Victims/Casualties
Actions	1. First Responders examine the victims and tag them. 2. FR categorises the victim using buttons on the Triage Wearable (preferable) or using the Triage and Vital signs app
Preconditions	1. First Responders should have enough Digital Triage Tags 2. FR wears the Triage Wearable and checks that it is operational 3. FR places the Digital Triage Tag onto the victim's wrist and couples the two devices (a special LED code indicates that the Digital Triage Tag is operational)
Components / Functions	1. "Digital Triage Tag", "Triage Wearable", "Triage and Vital Signs app": (EMS First Responders), [F6: Classification of patients/victims to triage categories (green, orange, red, black)]
Outputs	1. Patient/Victim tagged with unique ID (format under discussion) 2. The Digital Triage Tag displays the triage categorisation colour

	3. C3&IMS receives update: additional victim
Connected Components	1. Digital Triage Tag <-> Triage Wearable<-> Triage and Vital Signs app 2. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS"
Technical constraints	1. In case of non-standard connectivity a. It is expected that FRs can still use their own telecommunication equipment b. The Digital Triage Tag will be able to store data for some short time period (to be specified in later stages) 2.
Related User Requirements	"Digital Triage Tag": [FR-1, FR-2, FR-4,FR-12]

Patient parameters monitoring (can be physiological or anatomical)

Title	UC14 - Patient parameters monitoring (can be physiological or anatomical)
Trigger	The victim has already been triaged and is either red or yellow
Actors	1. First responders reading the victims' vitals (either the first time or afterwards 2. Victims/Casualties
Actions	1. Vitals are monitored: a. By the Vital Signs Wearable b. Manually/Automatic by UAV c. Automatically (by a Video/IR camera on a standoff in the field hospital or via a Video/IR Camera on mobile phone) 2. First Responders read the Vital Signs Wearable data on the "Triage and Vital Signs app" 3. FRs read the Vital Signs Wearable data on the AR Display
Preconditions	1. FR is in Bluetooth range with the victim Vital Signs Wearable(s) 2. FRs are equipped with "Triage and Vital Signs app" and the Triage wearable 3. Patients/Victims are equipped with ""Vital Signs Wearable"The Triage wearable and the Vital Signs Wearable are coupled. 4. UAV drone needs to reach the scene manually or automatically, 5. "Thermal scanning system" needs to be installed at Casualty Collection Points, Fields Hospitals (or on the mobiles of FRs)
Components / Functions	1. "Vital Signs Wearable", "Triage and Vital Signs app": (First Responders), [F3: Fast diagnosis & prognosis over AI-based algorithms (requiring manual confirmation), F4: Continuous monitoring of vital signs, F5: Alerting on abnormal vitals] 2. "UAV Rapid Triaging system" (Automatic), [F2: AI-based Detection of injured persons based on body position, movement, sound data, temperature, image based extracted features such as blood or bones;] 3. "Thermal scanning system" (Automatic), [F2: Delineation of body parts (torso, arms, legs, head) depicting thermal screening F3.

	Identification of fractures (limbs, such as buckle, green stick, ulna, wrists) with thermography]
Outputs	1. Patient Vitals displayed on the Triage and Vital Signs app 2. Patient vitals are sent to C3&IMS
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → C3&IMS "Triage and Vital Signs app" → "Information Data Lake" → C3&IMS 2. "UAV Rapid Triaging system" → "Data Layer" (How about the patient ID?) "UAV Rapid Triaging system" → "Information Data Lake" (How about the patient ID?) 3. "Thermal scanning system" → "Data Layer" (How about the patient ID?) "Thermal scanning system" → "Information Data Lake" (How about the patient ID?)
Technical constraints	1. In case of non-standard connectivity a. It is expected that FRs can still use their own satellite comms b. Victims' vitals stored in the Digital Triage Tag for a short period of time are sent to the smartphone when the FR is in Bluetooth range and the two devices are NFC paired. The data are sent to C3&IMS when internet connectivity is restored. c.
Related User Requirements	"Vital Signs Wearable": [FR-4, FR-5, FR-6, FR-7, FR-8, FR-9, FR-1, FR-12] "UAV Rapid Triaging system": [FR-1, FR-3, FR-4, FR-6]

Victim positioning and tracking and tracing (x,y)

Title	UC15 - Victim positioning and tracking and tracing (x,y)
Trigger	Victims on the scene
Actors	1. First Responders on the scene 2. Victims/Casualties
Actions	1. The "Triage and Vital Signs app" associates the "Digital Triage Tag" ID with the Location obtained by the Mobile Phone GPS or 2. The UAV drone locates the victim and: a. Get the ID from the "Digital Triage Tag" If feasible, IDs are associated to locations
Preconditions	1. FRs are equipped with "Triage and Vital Signs app" 2. Patients / Victims have been digitally tagged. 3. UAV needs to reach the scene manually or automatically
Components / Functions	1. "Digital Triage Tag", "Triage and Vital Signs app" (First Responders), [F1. Unique digital identification of patients/victims, NF1: getting GPS position] 2. "UAV Rapid Triaging system": (First Responders), [F3: Position determination F4: Autonomous navigation around possible injured

	people, NF1: injured people/victims' localizing and counting, NF2: Getting ID from "Digital Triage Tag"]
Outputs	1. "Triage and Vital Signs app": Set of (ID, Location) Couples 2. "UAV Rapid Triaging system": a. Set of Spots, where victims have been identified b. if possible, Set of (ID, Location) Couples
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS" 2. "UAV Rapid Triaging system" → "Data Layer" "UAV Rapid Triaging system" → "Interoperable Data Lake"
Technical constraints	1. The UAV may require RTK or PPK for better positioning 2. It is expected that FRs can still use their own satellite comms
User Related Requirements	"Digital Triage Tag": [FR-3, FR-4, FR-12, FR-13] "Triage and Vital Signs app": [FR-12] "UAV Rapid Triaging system": [FR-1, FR-2, FR-3, FR-5, FR-8]

Moving patients to the collection point

Title	UC16 - Moving patients to the collection point
Trigger	Victims on the scene required to be moved (either Red or Yellow)
Actors	1. First Responders on the scene 2. Victims/Casualties
Actions	1. EMS First Responders move Victims and transport them to the Collection Point 2. At the Collection Point the Victim status and Location get updated
Preconditions	1. EMS First Responders are equipped with "Triage and Vital Signs app" 2. Victims are wearing "Digital Triage Tag" and "Vital Signs Wearable" 3. First Responders are equipped with "C3&IMS App"
Components / Functions	1. "Digital Triage Tag", "Vital Signs Wearable", "Triage and Vital Signs app": (First Responders), [F1. Unique digital identification of patients/victims, NF1: getting GPS position, F3: Fast diagnosis & prognosis over AI-based algorithms (requiring manual confirmation), F4: Continuous monitoring of vital signs, F5: Alerting on abnormal vitals] 2. "C3&IMS App", "C3&IMS": [NF8: update patient status and location]
Outputs	1. "Triage and Vital Signs app": Victims status and location get updated 2. "C3&IMS": Victims status and location get updated
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS" 2. "C3&IMS App" → "Data Layer" → "C3&IMS" "C3&IMS App" → "Interoperable Data Lake" → "C3&IMS"

Technical constraints	1. In case of non-standard connectivity a. It is expected that FRs can still use their own satellite comms
User Related Requirements	"Diagnosis and Prognosis service": [FR-5]

Second triage

Reassessment of patient condition

Title	UC17 - Reassessment of patient condition
Trigger	Victims/patients have arrived at collection points / fields hospitals
Actors	1. EMS First Responders 2. Victims/Casualties
Actions	1. Victims are sorted upon arrival at collection points / fields hospital 2. Victims get (iterative process): a. Re-assessed / Re-sorted b. Treated if Needed / Possible 2. Yellow patients are monitored (iterative process): c. via the wearable device d. via the video/IR camera checking them 3. In case of wrong values, alerts get generated
Preconditions	1. EMS First Responders are equipped with "Triage and Vital Signs app" 2. Victims are wearing "Digital Triage Tag" and "Vital Signs Wearable" 3. First Responders are equipped with "C3&IMS App" 4. Video/IR Cameras installed in collection points / field hospitals or available in the EMS First Responders Mobile
Components / Functions	1. "Digital Triage Tag", "Vital Signs Wearable", "Triage and Vital Signs app": (First Responders), [F1. Unique digital identification of patients/victims, NF1: getting GPS position, F3: Fast diagnosis & prognosis over AI-based algorithms (requiring manual confirmation), F4: Continuous monitoring of vital signs, F5: Alerting on abnormal vitals] 2. "Thermal scanning system" (First Responders with Mobile / Automatic), [F2. Delineation of body parts (torso, arms, legs, head) depicting thermal screening; F3. Identification of fractures (limbs, such as buckle, green stick, ulna, wrists) with thermography] 3. "C3&IMS App", "C3&IMS": [NF8: update patient status and location]
Outputs	1. "Triage and Vital Signs app": Victims status and location get updated 2. "Thermal scanning system": Victims status get updated 3. "C3&IMS": Victims status and location get updated
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS" 2. ""Thermal scanning system" → "Data Layer" → "C3&IMS" ""Thermal scanning system" → "Interoperable Data Lake" → "C3&IMS"
Technical constraints	1. In case of non-standard connectivity

	a. It is expected that FRs can still use their own satellite comms
User Related Requirements	"Diagnosis and Prognosis service": [FR-1, FR-2, FR-3, FR-4] "Vital Signs Wearable": [FR-12] "Triage and Vital Signs app": [FR-1, FR-4]

Continuous monitoring (incl. alerting) of patient parameters (physiological)

Title	UC18 - Continuous monitoring (incl. alerting) of patient parameters (physiological)
Trigger	Victims/patients have arrived at collection points / fields hospitals
Actors	1. EMS First Responders 2. Victims/Casualties
Actions	1. Victims get (iterative process): a. Re-assessed / Re-sorted b. Treated if Needed / Possible 2. Yellow patients are monitored (iterative process): a. via the wearable device b. via the video/IR camera checking them 3. In case of wrong values, alerts get generated
Preconditions	1. EMS First Responders are equipped with "Triage and Vital Signs app" 2. Victims are wearing "Digital Triage Tag" and "Vital Signs Wearable" 3. First Responders are equipped with "C3&IMS App" 4. Video/IR Cameras installed in collection points / field hospitals or available in the EMS First Responders Mobile
Components / Functions	1. "Digital Triage Tag", "Vital Signs Wearable", "Triage and Vital Signs app": (First Responders), [F1. Unique digital identification of patients/victims, NF1: getting GPS position, F3: Fast diagnosis & prognosis over AI-based algorithms (requiring manual confirmation), F4: Continuous monitoring of vital signs, F5: Alerting on abnormal vitals] 2. "Thermal scanning system" (First Responders with Mobile / Automatic), [F2. Delineation of body parts (torso, arms, legs, head) depicting thermal screening; F3. Identification of fractures (limbs, such as buckle, green stick, ulna, wrists) with thermography] 3. "C3&IMS App", "C3&IMS": [NF8: update patient status and location]
Outputs	1. "Triage and Vital Signs app": Victims status get updated 2. "Thermal scanning system": Victims status get updated 3. "C3&IMS": Victims status get updated
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS" 2. "Thermal scanning system": → "Data Layer" → "C3&IMS"

	"Thermal scanning system": → "Interoperable Data Lake" → "C3&IMS"
Technical constraints	1. In case of non-standard connectivity a. It is expected that FRs can still use their own satellite comms
User Related Requirements	"Diagnosis and Prognosis service": [FR-1, FR-2, FR-3, FR-4] "Vital Signs Wearable": [FR-5, FR-6, FR-7, FR-8, FR-9, FR-10, FR-11, FR-12] "Triage and Vital Signs app": [FR-2, FR-4]

Physiological parameters and treatment reporting

Title	UC19 - Physiological parameters and treatment reporting
Trigger	Patients are transferred to the hospitals (pre-hospitalizations)
Actors	1. EMS First Responders either at the Collection Points or Transports 2. Victims/Casualties
Actions	1. Information about the patient (ID, status and treatment) is sent to the receiving hospital
Preconditions	1. EMS First Responders are equipped with "Triage and Vital Signs app" 2. Victims are wearing "Digital Triage Tag" and "Vital Signs Wearable" 3. EMS First Responders are equipped with "C3&IMS App"
Components / Tools / Applications	1. "Digital Triage Tag", "Vital Signs Wearable", "Triage and Vital Signs app": (First Responders), [F1. Unique digital identification of patients/victims, NF1: getting GPS position, F3: Fast diagnosis & prognosis over AI-based algorithms (requiring manual confirmation), F4: Continuous monitoring of vital signs, F5: Alerting on abnormal vitals] 2. "C3&IMS App", "C3&IMS": [NF8: update patient status and location]
Outputs	1. Data about the patient (ID, status and treatment) are sent to the receiving hospital (it is expected the hospital is part of the C3&IMS collaboration network)
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS"
Technical constraints	1. In case of non-standard connectivity a. It is expected that FRs can still use their own satellite comms
User Related Requirements	"Diagnosis and Prognosis service": [FR-1, FR-2, FR-3, FR-4] "Triage and Vital Signs app": [FR-2, FR-3, FR-5]

Linking MCI ID with formal patient identification (e.g., social number)

Title	UC20 - Linking MCI ID with formal patient identification (e.g. social number)
Trigger	The patient has arrived at the hospital and any urgently needed treatment is finished
Actors	1. EMS personnel at the receiving hospital 2. Victims/Casualties
Actions	1. The EMS personnel look for personal identification by: a. Asking the patient if possible b. Looking for ID documents if available 2. If personal identification is found, the personal is associated to the MCI ID (is the "MCI ID" = "Digital Triage Tag ID"?) 3. If no personal identification is found, a picture of the patient is taken and passed to the office responsible for identifying missing people
Preconditions	1. Patients/Victims have an MCI ID
Components / Functions	1. "Digital Triage Tag", "Vital Signs Wearable", "Triage and Vital Signs app": (First Responders), [F1. Unique digital identification of patients/victims,] 2. "C3&IMS App", "C3&IMS": [NF9: Associate MCI ID with Personal ID]
Outputs	1. Personal ID / MCI ID Association
Connected Components	1. "Triage and Vital Signs app" → "Data Layer" → "C3&IMS" 2. "Triage and Vital Signs app" → "Interoperable Data Lake" → "C3&IMS"
Technical constraints	N/A
	Digital Triage Tag": [FR-13]

Training

Title	UC21 - Training
Trigger	FRs need training
Actors	1. First responders (all types of agencies depending on the incident)
Actions	1. First Responders use the "Scenario Builder" component to get training on their task
Preconditions	1. First Responders have access to the "Scenario Builder" 2. Dedicated Training Sessions are available
Components / Tools / Applications	1. "Scenario Builder": (Trainers, First Responders), [F1: Intuitive scenario building capability, F2: Seamless scenario execution capability, F3: Capability to edit, modify, add scenario building parameters in real-training-time; F4: Access rights; F5: Save, store, modify, evaluate scenario functions; F6: Encapsulation of current training and simulation systems]
Outputs	1. First Responders get trained
Connected Components	N/A

Technical constraints	N/A
Related User Requirements	"Scenario Builder": [FR-1, FR-2, FR-3, FR-4, FR-5, FR-6]

Isolated area, victims requiring assistance, FRs delayed

Title	UC22 - Isolated area, victims requiring assistance, FRs delayed
Trigger	Victims requiring assistance First responders delayed
Actors	1. Bystanders (Active Citizen) 2. Victims/Casualties
Actions	1. Victim asks for help - "SWAPP (App)" 2. Bystander (Active Citizen) with proper training is directed to the Victim
Preconditions	1. Bystanders are equipped with "SWAPP (App)" 2. Victims are equipped with "SWAPP (App)" 3. Bystanders have received proper training and have been certified.
Components / Tools / Applications	1. "SWAPP (App)": (Victims, Bystanders), [NF1: Victim asks for help, NF2: Direct certified Bystander to Victim]
Outputs	1. Bystanders (Active Citizens with certified training) get directed to Victims in need.
Connected Components	1. "SWAPP (App)" ← → "NG-PSAP"
Technical constraints	1. In case of non-standard connectivity a. "SWAPP (App)" information cannot be used
Related User Requirements	SWAPP (App): [FR-3]

Remote assistance to bystanders performing first aid activities

Title	UC23 - Remote assistance to bystanders in performing first aid
Trigger	Bystander requires assistance in performing first aid activity
Actors	1. Bystanders (Active Citizen) 2. Victims/Casualties 3. "NG-PSAP" Operator
Actions	1. Bystander ask for assistance in performing first aid activity 2. "NG-PSAP" Operator, with certified medical training, provides assistance.
Preconditions	1. Bystanders are equipped with "SWAPP (App)" 2. "NG-PSAP" Operators have received certified medica training
Components / Tools / Applications	1. "SWAPP (App)": (Victims, Bystanders), [NF3: Bystander asks for assistance] 2. "NG-PSAP": (Operators), [NF1: Provide Assistance (possibly using audio/video)
Outputs	1. Assistance is provided to the Bystander by the "NG-PSAP" Operator

Connected Components	1. "SWAPP (App)" ←→ "NG-PSAP"
Technical constraints	1. In case of non-standard connectivity a. "SWAPP (App)" information cannot be used
Related User Requirements	SWAPP (App): [FR-3, FR-5]

Situational awareness and decision support functionalities

Title	UC24 – Situational awareness and decision support functionalities
Trigger	1. First Triage has been performed
Actors	1. Tactical and Strategic officers
Actions	1. All integrated data from the scene is analyzed 2. The Early Warning and Risk Assessment, and the Decision Support service help tactical and strategic officers at the agencies centres with higher level interpretation results 3. Early warnings, Risks and Decisions are proposed that can help the officers in their decisions
Preconditions	1. Updated data on the incident is available on the "Data Layer" and "Interoperable Data Lake"
Components / Functions	1. The Early Warning and Risk Assessment, and the Decision Support Service send early warnings, risks, and decisions to the tactical and strategical medical and non-medical personnel 2. "Data Layer" and "Interoperable Data Lake" 3. "C3&IMS App"
Outputs	1. Early warnings, risks and decisions, regarding the casualty deterioration, early detection of unusual events, how to handle many victims collectively, and any other sophisticated information arising from heterogeneous sources etc, are passed to all officers
Connected Components	1. "Early Warning and Risk Assessment" and "Decision Support service" → "Data Layer" , "Interoperable Data Lake" → "C3&IMS App"
Technical constraints	N/A
Related User Requirements	C3&IMS: [NFR1] C3&IMS App: [NFR1] C3&IMS CAD: [NFR1]

5 Report from the NIGHTINGALE 1st End User Workshop

Event: 1st NIGHTINGALE End User Workshop

Date: 17-18 January 2022

Venue: Online[4]

Organiser: APHP-SAMU

Participants: The Workshop was end-user driven, with participation of all NIGHTINGALE end user partners, and User Advisory Board (UAB) members on a voluntary basis. Technical partners ICCS, ASTRIAL and INTRA participated to contribute mainly in terms of functionalities of the tools and their role in the NIT-MR toolkit.

Objectives

The main objectives of the 1st NIGHTINGALE End User Workshop were to support the work in the context of the following WP1 tasks:

- Task 1.4 *Overarching scenarios, Definition of use cases and testing and validation activities specific planning*
- Task 1.5 *Definition of functional and non-functional user requirements*
- Task 1.2 *Social, Legal and Ethical Landscape for MCIs handling and Action's Impact Assessment*
- Task 1.7 *User and Technical Validation Protocol, KPIs and Plan*

The program of the Workshop included a brief recap of the NIT-MR technical components by ASTRIAL, a presentation of current technologies used in MCIs delivered by MDA, three discussion forums and a legal, ethical and social aspects session, as described below.

1st Discussion Forum: MCIs scenarios and use cases related to the NIT – MR components

This session included a presentation of different types of MCIs, both man-made and natural. A particular incident, the 'Paris Bataclan Attacks' was used as a detailed example of a MCI. This presentation has set the scene for a discussion about the methodology to be followed for defining

[4] Due to the heath situation regarding the Covid epidemic and the new Omicron variant the Paris NIGHTINGALE End User Workshop of 18/19 January 2022 was held solely using an on-line platform.

the NIGHTINGALE Scenarios and Use Cases, and the coupling of the Scenarios with the different components of the NIT-MR.

2nd Discussion Forum: MCIs user requirements related to the NIT – MR components

This session included a thorough interaction between end user and technical partners on the NIT-MR components functionalities. The purpose of this interaction was to better familiarise the end users with the various tools and to enable a clear understanding of the tools' capabilities for enhancing MCI handling, so us to facilitate subsequent interactions for the definition of user requirements. For more details on this topic see Deliverable D1.8 *User functional and non-functional requirements*, M9.

3rd Discussion Forum: Key Performance Indicators (KPIs)

In this discussion forum technical and end user partners interacted on the definition of both technical and operational KPIs. Since the definition of technical KPIs is rather straightforward, the discussion mostly centered around the approach that can be followed for measuring medical/operational KPIs by considering concrete indicators of performance and defining an evaluation methodology from a medical and MCI viewpoint,

Legal, ethical and social aspects Workshop

Firstly, the objectives of the legal, societal and ethical branch of the project are to ensure clarity, to act in transparency, and wherever possible and needed, to encourage harmonization between different standards to agree on minimum common denominators (e.g., on definitions). In particular the toolkit will be operational in differing legal national and EU frameworks. The legal, ethical and social aspects branch focuses on identifying existing applicable law and where novel legal, ethical and social aspects apply. Furthermore, the objective is to identify risks at an early stage of the project in view of proposing ways to mitigate risk. A Human Rights Due Diligence framework is the proposed normative framework to apply in view of preventing and correcting any violations that may result from the use of the toolkit in MCIs.

States bear responsibility to implement regulation to protect from misuse or double-use, technical partners (designers of the toolkit) bear responsibility to abide by their national legislation and to act transparently in view of respecting both legal and ethical requirements - in this way creating greater social acceptance of the toolkit in MCI situations. Training, as well as periodic review, will ensure standardisation and good compliance.

Specific emphasis was given to several issues, including the inherent legal implications of triage in MCIs (prioritising life-saving treatment or evacuation to the hospital to receive adequate treatment);

the importance of applicability of existing legal and ethical norms even to new situations and interpreting them correctly; the aim of the project is not to replace human judgment but to enhance it; the first responders will apply their good judgement at all times; liability for advanced technology lies with designing the technology, making its capacity and limits transparent (wherever inaccuracy exists) and the obligation to use it according to designer instructions.

Finally, it is important to genuinely address the question of innovation in view of recognising potential normative gaps, risks and ways by which to minimise risk.

6 Report from the 1st NIGHTINGALE Table-top Exercise (TTX)

Event: 1st NIGHTINGALE TTX

Date: 21-23 March 2022

Venue: Karolinska Instituter, Stockholm, Sweeden

Organiser: The workshop was organised in collaboration between the International MRMID-association, the Nightingale Project, the Karolinska Hospital and the Stockholm Health Care.

Participants: Totally 52 delegates from the Nightingale project participated together with 22 international MRMI-instructors and 92 Swedish Health Care providers from pre-hospital and hospital organisations, acting in different roles in the exercises, where also members of the Nightingale project could participate.

Background and aims

The aim of this workshop was to illustrate the whole chain of MCI-response with the use of simulation exercises, in order to (a) identify components with a need and potential for improvement and (b) facilitate the technical partners of the project to adapt their methods to the different steps in the chain of response. An additional goal was to find out if, and if so how, simulation techniques could be used for scientific analysis and comparison of different methods in MCI response, of potential benefit for the project.

Methodology

The simulation system used for the exercises /demonstrations in this workshop was the MACSIM® system (MAss Casualty SIMulation) (http://www.macsim.se/), originally developed for scientific analysis and comparison of methods in MCI-response, but also from 2009 successfully used in the international MRMI-courses (Medical Response to Major Incidents & disasters) for training, where its accuracy had been scientifically validated in a large international study. The MRMI courses are normally highly standardized courses with a uniform program, including one day of introductory lectures/training followed by two days of full- scale simulation exercises, one each day with different scenarios. The exercises are fully interactive with all participants acting in their real roles. The aim is to train decision making in the whole chain of management (scene, transport, emergency department, OR, ICU, wards and also local, regional and national command and communication). This is made possible with the advanced simulation system (Figure 6), which supplies the trainee with all and the same data he/she has on each point in real life as a base for the decisions. It also supplies the trainee with a complete feed back to the decisions with regard outcome (preventable mortality and complications) and accuracy in alerting and using resources, as a necessary base for accurate learning. The whole chain of management is trained simultaneously, because one of the most common reasons for failure is deficiencies in communication and coordination between different actors. This means involvement also of non- medical rescue staff, police, military and administrative staff.

The plan was to base the workshop on a modified MRMI- course, specially designed for demonstration, and with opportunity for Nightingale delegates to participate in the exercises on voluntary base, and also test NIGHTINGALE methods that could fit into the simulation programme. The scenarios for these exercises were designed according to the requests from the Nightingale project management.

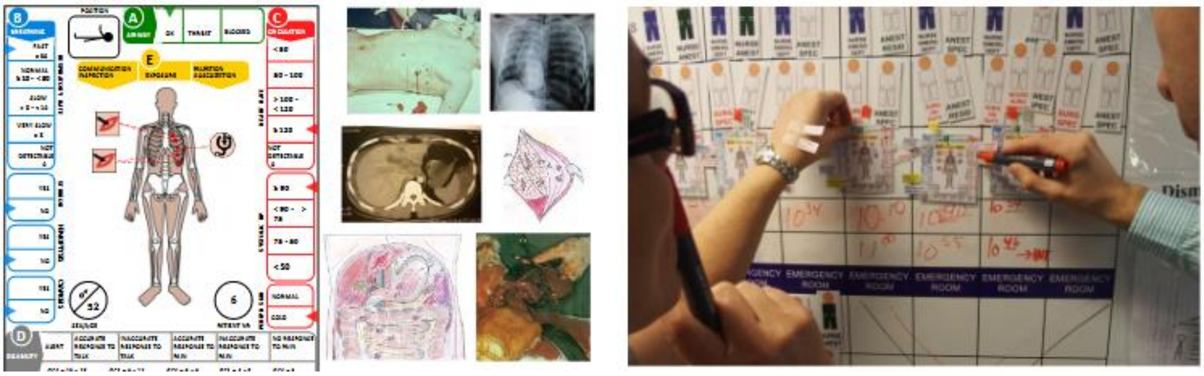

Figure 6. The MACSIM® simulation system.[5]

The workshop included three days, starting at lunch day one and ending in the afternoon day three, to save extra days for travelling. The first day was used to introduce the used simulation model with emphasis on the key points in training of mass casualty management to avoid potential failures in the response. Examples of use of the simulation model for scientific analysis of methodology were also illustrated, for example in comparison of triage methods and studies on health care capacity to handle mass casualties. Finally, all participants were given the opportunity to get acquainted to, and also train with, the simulation model.

Day two started with a presentation and a video recording from the terrorist attacks in Paris 2015, given by one of the MRMI- instructors, Olivier Stibbe, who also served as a medical incident commander during the attacks. This gave an illustrative background for the participants to “get in the mood” for the following exercises. This day were run two parallel scenarios in a fictive country, Anyland, described in detail with regard to structure, geography and all resources involved in an MCI. The first scenario was a terrorist attack in a tourist hotel far from nearest hospital with two bombs, causing 360 injured and dead and requiring many of the country’s resources for rescue, transport

[5] To the left: The magnetic casualty cards in the simulation system were based on real scenarios. Along the margins of the cards the physiological parameters indicating the patient ́s condition, in the center description of injuries with a simple symbol system. The trainee could, on relevant points in the chain, get access to data files with findings at X-ray and in surgery, as base for decisions. To the right: The cards were processed through the chain of response by the acting staff and all treatments indicated by tags. The exercises were run in real time with real resources. All treatments consumed the same time and the same resources as in reality. The instructors had access to what had to be done within a certain time if the patient should survive.

and health care (MCI level 3). The casualties in this scenario were taken from the Madrid terrorist attack 2004.

Parallel to this scenario occurred a mass-shooting event in the major airport of the capital of the same country, causing much pressure on security, rescue- and health care and also on the coordinating functions both on local, regional and national level. This scenario included 110 injured and dead, with injuries taken from US civilian mass shootings.

About twenty of the Nightingale delegates participated on a voluntary base as acting in different positions in the chain of response, see image below. The rest of the delegates could follow the exercise on large screens in a streaming study, where live pictures could be switched between two mobile video teams and five permanent cameras, altogether covering the whole response, with comments from an instructor. They could also visit all the different stations, where special space was made for observers. Finally, they all took part in the thorough evaluation with all participants after the exercise.

The second day started with a terrorist attack during an ongoing rock-festival in a sport arena in the capital in Anyland with 120 injured, partly from shooting with machine guns, partly by congestion because of panic movement in the arena. Soon after this attack had started, a run-over scenario occurred in the center of the same city, ending with explosion from a truck carrying a bomb with the intention to blow up the convention center. The injuries were taken from run over scenarios, civilian mass shootings and blasts.

The Nightingale delegates could take active part in the exercises, or watch as observers on all stations, but also get an overview from a special streaming study, from which the exercises were continuously recorded by two mobile TV-teams and five permanent video-cameras; here commented by the president of MRMID, Sten Lennquist.

Figure 7. Continuous streaming and commenting of the exercise

Incorporation of NIGHTINGALE tools in the exercises

Although the main objective of this exercise was to identify and discuss improvements of weak points in the chain of MCI-response, it should also give an opportunity to perform pilot tests of methods suitable to test in these kinds of exercises. One such method was tracking casualties through the chain of response using QR-codes connected to all casualties, connected to ID-data. These codes could then be scanned on all positions in the chain of response as a base for registration of patients, but also giving continuous information about the flow and distribution of patients.

For this purpose, small size QR-codes were produced by ICCS for all the used casualty-cards. Every card was also given an ID including full name, date of birth, security number and medical record. All data were designed in a way that they could not be mixed with, or mistaken to be, real data.

Digital registration was performed by using a smartphone application developed by ICCS, and the information was sent to the NIGHTINGALE IMS system under development by ASTRIAL. This was done in parallel with manual registration in transport cards following the patients, and logs to fill in at every position in the chain. One finding was that it required time and training of the staff to do it, but it had a great potential to give valuable information. The manual registration was even more time-consuming, and it was very difficult to get time to fill in full data in the transport cards without unacceptable delay in evacuation. This is in total agreement with experiences from real MCIs. Development of alternative methods is therefore important and should be given priority.

Technical mock-up session

The Nightingale delegates did not take part in the evaluation session of the exercise, but proceeded to a mock – up session for technical partners with special emphasis on the input from, and ideas generated by, the exercises. The discussions held were lengthy and very fruitful, and it was therefore decided, since the available time was limited, to hold an additional online meeting to continue the interactions. This took place on 7 April 2022 and focused on those NIGHTINGALE technologies that we identified as requiring more extensive interaction.

Day 3 ended for the Nightingale group with a discussion of identified points for improvement in the chain of MCI response, and how such improvements could be done. Many of the technical partners in the project announced that the exercises had given them ideas to modify their techniques and adapt them to the reality and real needs in an MCI. Also, some new ideas came up.

7 Planning of NIGHTINGALE Full-scale Exercises (FSX)

7.1 Planning the FSX1 in M30 – Cengio, Savona, Italy

The First Full scale NIGHTINGALE exercise will be held in Italy, in Cengio, in the Savona province, in M30. The scenario is one of a train derailment with hazmat release from a rail-tank with multiple consequences. At present, the ASL2 of Savona is finalizing the selection of one most promising site: the premises of the now dismantled Acna di Cengio industrial site. The site is particularly suitable, because it is huge in extension and it is completely enclosed, so that ensuring the privacy and security needed to test sensible scenarios with multiple victims. The site is now owned by ENI Rewind: a very large Company, whose representatives expressed their interest in hosting the FSX1 and started in earnest the internal authorization process (still to be finalized).

The site that has been provisionally chosen for FSX1 is in Cengio to the north-west of Savona located in the Liguria region, at the border with the Piemonte region. The site is located at only 40 minutes by car from Savona, and allows for several different possibilities of scenarios. A map of the geographical location of the site is shown below.

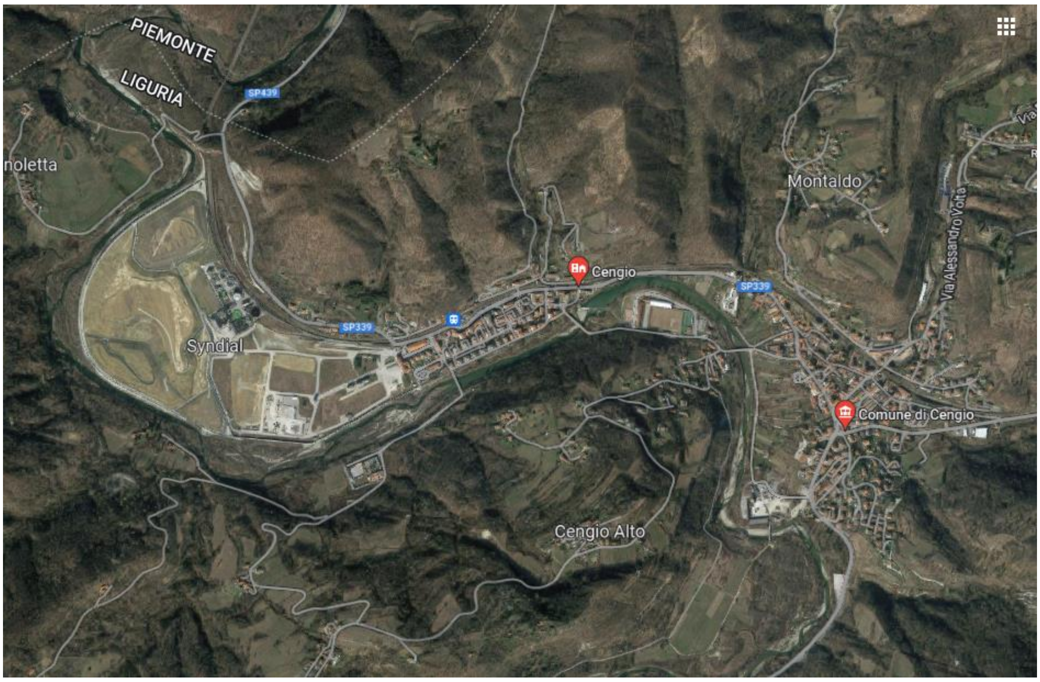

Figure 8. Map of the selected site location for FSX1

The whole area encloses some 49 hectares, so that it can host far more people than the project will be able to collect on site. Just outside the site, there is a large building “Palazzo Rosso”, which is in the availability of the Municipality of Cengio. The Cengio Mayor recognized the social importance of the project and committed at providing the whole building premises for the FSX1 needs. In fact, the ample availability of rooms of different sizes will be crucial to host the NIGHTINGALE systems servers and technicians, as well as to host the simulated Control Centres in the needed number. The site will be perfect too to host press conferences and meeting rooms for observers, as well as for catering and logistics.

Figure 9. Palazzo Rosso

The site has the possibility of simulating several disasters: It include rail tracks belonging to the former private rail.

Figure 10. Rail tracks available at the site

It includes too a residual plant which can easily simulate a large industrial site (whose concrete availability for the FSX is still to be decided) and some two-level buildings which can simulate part of a urban settlement.

Figure 11. Residual plant – Two-level buildings

Within the site there is a quite extensive internal road network particularly suitable to stage road accidents as additional scenarios. Moreover, the extensive nature of the site will facilitate the deployment of UAV, while complying to the applicable safety rules.

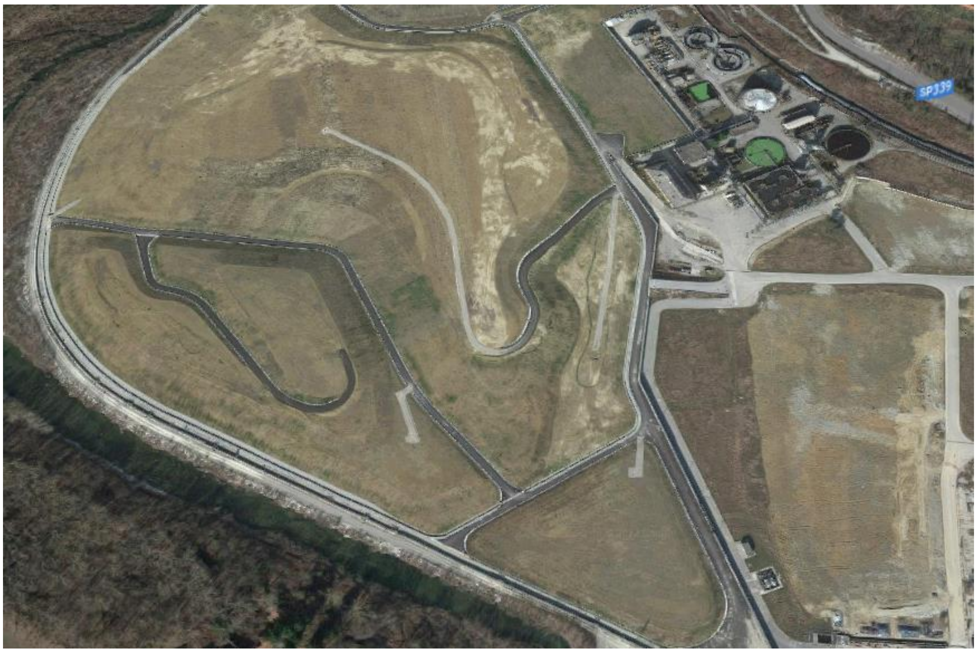

Figure 12. Internal road network

Figure 13. Internal road network

The scenario envisaged will take the move from a chemical toxic release and explosion (e.g., from a rail-tank carrying Ammonia). In fact, a purely toxic release would generate too homogeneous “victim types”, while adding the explosion, it will be possible to stage a wide variety of trauma victims, so as to provide a sufficiently challenging scenario for the NIGHTINGALE solutions. Moreover, the availability of the three cited buildings will allow the extension of the solution trial to indoor environment, and urban environment (with limited field of view).

7.2 Planning the FSX2 in M34 - Villejust

The Second Full scale NIGHTINGALE exercise will be held in France, in the Paris Region, in M34. The scenario is one of a terrorist attack at multiple sites. At present, the SAMU de Paris has been looking at two potential sites. Clearly there are sensibilities regarding the simulation of a terrorist attack and in particular with regard to the making up of actors who simulate injuries. These sensibilities mean that the exercise must be held on a site where discretion and privacy are in unlimited supply.

The advantages of staging the FSK within Paris are related to logistical facilitation of the FSX; accommodation, meeting rooms and restoration is more accessible in Paris than in remoter locations outside. On the other hand, space is at less of a premium outside Paris and there are sites which have been used over the years that will allow more freedom to organize in a remote location.

The site that has been provisionally chosen for the Second FSX is in Villejust to the south of Paris located in the Department of the Essonne (91). The principality is responsible for the maintenance and running of the site which has several different possibilities of scenarios. A map of the geographical location of the site is shown below.

<u>**Villejust**</u>

Transport
35 minutes by car from the SAMU de Paris by car

2 hotels near the site

Figure 14.Villejust site on the map

It is possible to accommodate 300 people on site and there are two hotels situated close to the site with possibilities for providing food for the NIGHTINGALE partners. The site is easily accessible from the hotels on foot. A buffet lunch would be provided on site for the partners and the participants.

The site has the possibility of simulating several disasters. Above ground there are several areas that simulate fallen buildings due to explosions or earthquakes see below.

Figure 15. Rubble piles

There is also a building which can be used can be used to simulate a hostage situation, see below, and it is possible to erect tents to form a makeshift hospital.

Figure 16. Building that can be used to simulate a hostage situation. Possibility to erect tents

As with any potential site there are advantages and disadvantages. One of the disadvantages is the presence of the airport at Orly some kilometres to the East and the presence of several power lines that are illustrated in the image below. This may represent a difficulty for the use of drones.

Figure 17. Power lines

The scenario envisaged is one of a terrorist attack on multiple sites. The advantage of the site at Villejust is that several different scenarios can be realised at the same time. An explosion and a hostage situation with shootings in an open site can be organised at the same time. What is also interesting is that each scenario can have an interaction with another. For instance, the evacuation of the injured from the site of the explosion can be complicated by the ongoing hostage situation in the building.

What is equally important is the possibility of testing the entirety of the tool kit. The presence of power cables may represent a hindrance with respect to the use of drones at the site. Whist Villejust is currently the proposed site for the FSX the SAMU de Paris is continuing to investigate other sites that may potentially offer other advantages.

8 Conclusions

The scenarios and use cases will lead to development of the methodology that will be used in the testing, consolidation and validation of the NIT-MR toolkit over the course of this project. The scenarios are illustrative of two real MCIs and one Full-Scale Exercise whilst the use cases detail the sequences of interactions and procedures that the toolkit will need to have to perform in an MCI environment to achieve our goals.

This work will facilitate the translation of the toolkit from the laboratory to the field tests, and in particular, the final Full-Scale Exercises. As such, we have included sections related to the final Full-Scale Exercises that will be held in Savona and probably in Villejust towards the end of the project. These illustrate the current 'state of play' whilst giving an overall direction to the project.

Finally, this document is not intended to be static but to be enhanced and revised during the course of the project with a view to learning from experience and integrating new ideas and opinions. This is a dynamic process that will enable us to retain the best elements whilst improving and updating all the time.

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